FOREWORD

DNV GL rules for classification contain procedural and technical requirements related to obtaining and retaining a class certificate. The rules represent all requirements adopted by the Society as basis for classification.

© DNV GL AS January 2016

Any comments may be sent by e-mail to rules@dnvgl.com

If any person suffers loss or damage which is proved to have been caused by any negligent act or omission of DNV GL, then DNV GL shall pay compensation to such person for his proved direct loss or damage. However, the compensation shall not exceed an amount equal to ten times the fee charged for the service in question, provided that the maximum compensation shall never exceed USD 2 million.

In this provision "DNV GL" shall mean DNV GL AS, its direct and indirect owners as well as all its affiliates, subsidiaries, directors, officers, employees, agents and any other acting on behalf of DNV GL.
CHANGES – CURRENT

This document supersedes the October 2015 edition.
Changes in this document are highlighted in red colour. However, if the changes involve a whole chapter, section or sub-section, normally only the title will be in red colour.

Main changes January 2016, entering into force 1 July 2016

• Sec.2 System Design
  — [9.4]: The battery installation requirements have been changed to distinguish between vented and valve regulated batteries. The limit for valve regulated batteries has been increased from 2 kW to 8 kW.

Editorial corrections

In addition to the above stated changes, editorial corrections may have been made.
## CONTENTS

**Changes – current**

- Section 1 Service Description
  - 1 Application
    - 1.1 General
  - 2 Verification Scheme
    - 2.1 General
    - 2.2 Documentation requirements
    - 2.3 Equipment certification
    - 2.4 Onboard survey

- Section 2 System Design
  - 1 General
    - 1.1 Design principles
    - 1.2 System voltages and frequency
  - 2 Main Electric Power Supply System
    - 2.1 General
    - 2.2 System functionality
  - 3 Emergency Power Supply System
    - 3.1 General
    - 3.2 Transitional source
    - 3.3 Emergency generators
  - 4 Battery Systems
    - 4.1 General
  - 5 Starting Arrangement for Engines with Electric Starter
    - 5.1 General
  - 6 Electric Power Distribution
    - 6.1 Distribution in general
    - 6.2 Lighting
    - 6.3 Power supply to control and monitoring systems
    - 6.4 Low voltage shore connections
  - 7 Protection
    - 7.1 System protection
    - 7.2 Circuit protection
    - 7.3 Generator protection
    - 7.4 Transformer protection
7.5 Motor protection.......................................................................................... 46
7.6 Battery protection....................................................................................... 47
7.7 Harmonic Filter protection..........................................................................47

8 Control of Electric Equipment....................................................................... 47
8.1 Control circuits........................................................................................... 47
8.2 Control of generator sets and main switchboards..................................... 48
8.3 Control of emergency generator set and emergency switchboard..............50
8.4 Control of switchgear and controlgear.................................................... 51
8.5 Motor control.............................................................................................51
8.6 Emergency stop......................................................................................... 53

9 Vessel Arrangement...................................................................................... 54
9.1 General.......................................................................................................54
9.2 Switchboard arrangement.......................................................................... 55
9.3 Rotating machines..................................................................................... 56
9.4 Battery installations.................................................................................... 56
9.5 Cable routing............................................................................................. 59
9.6 Lightning protection................................................................................... 60
9.7 Earthing of aluminium superstructures on steel vessels......................... 60

10 Cable Selection............................................................................................ 60
10.1 General..................................................................................................... 60
10.2 Cable temperature.................................................................................... 62
10.3 Choice of insulating materials................................................................. 62
10.4 Rating of earth conductors....................................................................... 63
10.5 Correction factors.................................................................................... 64
10.6 Parallel connection of cables.................................................................. 65
10.7 Additional requirements for AC installations, and special DC installations........................ 66
10.8 Rating of cables....................................................................................... 66

Section 3 Equipment in General............................................................................. 69
1 General Requirements................................................................................... 69
1.1 References................................................................................................ 69

2 Environmental Requirements........................................................................ 69
2.1 Inclination................................................................................................ 69
2.2 Vibration and acceleration....................................................................... 69
2.3 Temperature and humidity....................................................................... 69

3 Equipment Ratings.......................................................................................... 70
3.1 Electrical parameters.................................................................................. 70
3.2 Maximum operating temperatures............................................................71
4 Mechanical and Electrical Properties ......................................................... 71
  4.1 Mechanical strength ........................................................................ 71
  4.2 Cooling and anti-condensation ....................................................... 72
  4.3 Termination and cable entrances ..................................................... 73
  4.4 Equipment protective earthing ....................................................... 74
  4.5 Enclosures ingress protection ....................................................... 74
  4.6 Clearance and creepage distances ................................................... 75
5 Marking and Signboards .......................................................................... 75
  5.1 General.......................................................................................... 75
6 Insulation ................................................................................................... 76
  6.1 Insulation materials ........................................................................ 76
7 Inspection and testing ............................................................................... 77
  7.1 General.......................................................................................... 77
Section 4 Switchgear and controlgear assemblies ........................................... 79
  1 Construction ...................................................................................... 79
      1.1 General........................................................................................ 79
  2 Power Circuits ..................................................................................... 83
      2.1 Power components in assemblies ................................................ 83
      2.2 Additional requirements for high voltage assemblies ................. 86
  3 Control and Protection Circuits .......................................................... 88
      3.1 Control and instrumentation ....................................................... 88
  4 Inspection and Testing ........................................................................ 89
      4.1 General........................................................................................ 89
Section 5 Rotating machines ......................................................................... 93
  1 General .............................................................................................. 93
      1.1 References................................................................................... 93
      1.2 Requirements common to generators and motors ..................... 93
      1.3 Instrumentation of machines ..................................................... 96
  2 Additional Requirements for Generators ............................................. 96
      2.1 General........................................................................................ 96
      2.2 Voltage and frequency regulation ............................................. 97
      2.3 Generator short circuit capabilities ............................................ 98
      2.4 Parallel operation ....................................................................... 98
  3 Inspection and Testing ........................................................................ 98
      3.1 General........................................................................................ 98
Section 6 Power transformers ........................................................................ 103
  1 General .............................................................................................. 103
2 Inspection and Testing .................................................. 104
  2.1 General ........................................................................ 105

Section 7 Semi-conductor assemblies ........................................ 107
  1 General Requirements .................................................. 107
    1.1 General ....................................................................... 107
    1.2 Design and construction requirements ......................... 108
  2 Inspection and Testing .................................................. 111
    2.1 General ....................................................................... 111

Section 8 Miscellaneous equipment ....................................... 114
  1 General ........................................................................ 114
    1.1 Socket outlets and plugs .............................................. 114
    1.2 Lighting equipment .................................................... 114
    1.3 Heating equipment ..................................................... 114
    1.4 Cooking and other galley equipment ......................... 116

Section 9 Cables .................................................................. 117
  1 Application ....................................................................... 117
    1.1 General ....................................................................... 117
  2 General Cable Construction ............................................ 117
    2.1 General ....................................................................... 117
    2.2 Fire properties ............................................................ 118
    2.3 Conductors ................................................................. 118
    2.4 Insulating materials ...................................................... 118
    2.5 Wire braid and armour ................................................ 119
    2.6 Protective sheaths ....................................................... 119
  3 Low Voltage Power Cables .............................................. 120
    3.1 Construction of cables rated 0.6/1 kV ......................... 120
    3.2 Switchboard wires ....................................................... 121
  4 High Voltage Cables ....................................................... 121
    4.1 Construction of cables rated 1.8/3 kV ......................... 121
    4.2 Construction of high voltage cables rated above 1.8/3 kV ... 122
  5 Control and Instrumentation Cables ................................... 122
    5.1 Construction of control and instrumentation cables rated 150/250 V ... 122
  6 Data Communication Cables ............................................. 123
    6.1 General ....................................................................... 123
    6.2 Lightweight electrical cables ....................................... 123
### 7 Flexible electrical cables

7.1 General ......................................................... 123

### 8 Inspection and Testing

8.1 General ......................................................... 124

#### Section 10 Installation

1 General Requirements ........................................... 125

2 Equipment .......................................................... 125

2.1 Equipment location and arrangement ..................... 125

2.2 Equipment enclosure, ingress protection ................. 126

2.3 Batteries .......................................................... 129

2.4 Protective earthing and bonding of equipment .......... 129

2.5 Equipment termination, disconnection, marking ....... 130

2.6 Neon lighting .................................................... 131

2.7 Lighting fixtures ................................................ 131

3 Cables ...................................................................... 132

3.1 General .......................................................... 132

3.2 Routing of cables ............................................... 133

3.3 Penetrations of bulkhead and decks ...................... 133

3.4 Fire protection measures ...................................... 134

3.5 Support and fixing of cables and cable runs .......... 135

3.6 Cable expansion ............................................... 138

3.7 Cable pipes ...................................................... 138

3.8 Splicing of cables .............................................. 139

3.9 Termination of cables .......................................... 140

3.10 Trace or surface heating installation requirements ... 141

4 Inspection and Testing .............................................. 141

4.1 General .......................................................... 142

4.2 Equipment installation ......................................... 142

4.3 Wiring and earthing ............................................ 142

4.4 Electric distribution and power generation ............. 143

#### Section 11 Hazardous areas installations

1 General .......................................................... 146

2 Documentation .................................................. 146

2.1 General .......................................................... 146

3 Equipment Selection ............................................. 147
3.1 General........................................................................................................... 147
3.2 Ex protection according to zones................................................................. 147
3.3 Additional requirements for equipment and circuit design.................... 149

4 Installation Requirements............................................................................... 150
4.1 General............................................................................................................ 150
4.2 Cable types, cabling and termination......................................................... 151

Section 12 Electric propulsion........................................................................... 154
1 General........................................................................................................... 154
1.1 General........................................................................................................ 154
1.2 System design............................................................................................ 154
1.3 System capacity........................................................................................ 155
1.4 Electric supply system................................................................................ 155
1.5 System protection and controls................................................................. 155
1.6 Control systems......................................................................................... 156

2 Verification.................................................................................................. 159
2.1 Survey and testing upon completion........................................................ 159

Section 13 Definitions....................................................................................... 160
1 Definitions.................................................................................................... 160
1.1 General......................................................................................................... 160
1.2 Operational conditions............................................................................ 160
1.3 Services....................................................................................................... 160
1.4 Installation.................................................................................................. 162
1.5 Area definitions........................................................................................ 162
1.6 Hazardous area........................................................................................ 162
1.7 Sources of power, generating station and distribution............................ 164
1.8 Switchboard definitions............................................................................ 166
1.9 Expressions related to equipment and components................................. 166

Appendix A List of alarms and monitoring parameters.................................... 169
1 General........................................................................................................... 169
1.1 General......................................................................................................... 169

Changes – historic............................................................................................ 174
SECTION 1 SERVICE DESCRIPTION

1 Application

1.1 General

1.1.1 Purpose

a) The rules in this chapter apply to electrical installations for assignment of main class. The requirements in this chapter dealing with safety for personnel, fire and explosion hazards do apply to all types of electrical installations that are installed on board. The technical requirement to equipment applies even if DNV GL product certificate or DNV GL type approval certificate is not required.

b) The requirements dealing with availability of electrical power supply apply to electrical installations serving essential or important services, see Sec.13.

c) For installations of less than 100 kVA total main generator capacity, the Society may apply modified rules for both technical requirements and for the verification process. Modified requirements shall be agreed upon in each case and shall be made available for the operational phase.

d) Portable electric appliances are not covered by the scope of classification.

1.1.2 Supplementary requirements

Supplementary requirements will be enforced for vessels according to its ship type and additional class notations, as required by the respective parts of the rules.

1.1.3 IEC standards

a) The requirements in this chapter are generally based on applicable standards for ships as issued by IEC (the International Electrotechnical Commission).

b) Where direct reference is made to such standards, it is meant the standard(s) in force at the time of contract between Builder and owner.

Guidance note:
This implies primarily the IEC 60092 series for ships.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.4 Other standards

a) The Society will consider the use of alternative standards if they are found to represent an overall safety concept equivalent to that of the rules.

b) Acceptance of the use of other standards may be given without Builder’s or owner's or operator’s consent. An application for acceptance of other standards shall be submitted. Upon request, a copy of an English version of the standard shall be submitted.

Guidance note:
Special care should be taken when requirements from different standards are used within the same system.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.5 Alternative solutions

a) Alternative solutions to the requirements in the rules will be accepted by the Society when found to represent the same level of safety and availability as the solutions required by these rules. Such an acceptance may be given without Builder’s, owner’s or operator’s consent.

b) Verification additional to that required by the rules may be necessary when alternative solutions are proposed. It is the obligation of the party applying for using alternative solution to ensure Builder’s agreement to additional verification onboard.
2 Verification Scheme

2.1 General

2.1.1 Work processes

a) As a basis for assignment of class, the Society will verify that the electrical installation complies with the relevant rule requirements. This verification process is organised as follows:
   — approval of system design
   — equipment certification
   — onboard survey

b) The verification process is carried out on a spot check basis. The full responsibility for compliance with the applicable rules lies with the Builder or any other contractually bound party.

c) The verification process includes requirements to approval of:
   — systems (including distribution systems)
   — equipment
   — components

For standard designs the case by case approval may be replaced by the type approval scheme.

2.2 Documentation requirements

2.2.1 Documentation related to system design shall be submitted as required by Table 1. Additional documentation will be required if deemed necessary.

Table 1 System design, documentation requirements

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI) On request (R)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric power system, general</td>
<td>E010 - Overall single line diagram</td>
<td></td>
<td>AP</td>
</tr>
<tr>
<td></td>
<td>E050 - Single line diagrams/consumer list for switchboards</td>
<td>For: AC power systems, DC battery systems, UPS systems</td>
<td>AP</td>
</tr>
<tr>
<td></td>
<td>E040 - Electrical load balance</td>
<td>For: AC power systems, DC battery systems, UPS systems</td>
<td>AP</td>
</tr>
</tbody>
</table>
| E220 - Electrical system philosophy | — For electrical propulsion systems with description of all operating modes.  
— For general power supply systems with description of all operating modes unless the “overall single line diagram” is sufficient to give necessary understanding of the operation and relevant operation modes of the system.          | FI |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>E200 - Short circuit calculations</td>
<td>Calculation of single phase fault against earth shall be included for systems with earthed neutral.</td>
<td>FI</td>
</tr>
<tr>
<td>E210 - Harmonic distortion calculations</td>
<td>Required when more than 20% of connected load is by semi-conductor assemblies, in relation to connected generating capacity.</td>
<td>FI</td>
</tr>
<tr>
<td>E100 - Voltage drop calculations</td>
<td>Upon request and when a motor rated above 30% of the feeding generator(s) or transformer(s) rated power is started direct on line.</td>
<td>FI, R</td>
</tr>
</tbody>
</table>
| E080 - Discrimination analysis     | The document shall cover:  
— generator protection  
— main switchboard circuits (Sec.13 [1.8.1])  
— emergency switchboard circuits (Sec.13 [1.8.2])  
— battery and UPS systems  
— downstream discrimination between different voltage levels under all operating conditions. | AP |
| Z030 - Arrangement plan            | Including locations of power sources, switchboards and distribution boards for main and emergency power, UPSs and batteries. Arrangement of access doors, fire divisions and high fire risk areas related to the above. | FI |
| Z071 - Failure mode and effect analysis | Required if separate emergency source of power is omitted in accordance with Sec.2 [3.1.4].  
Upon request for other systems. | AP |
| Z253 - Test procedure for quay and sea trial | Redundancy and failure modes based on FMEA. Required if separate emergency source of power is omitted in accordance with Sec.2 [3.1.4].  
Upon request for other systems. | AP |
| Main electric power - motor starters | E170 - Electrical schematic drawing | AP |

**Rules for classification:** Ships — DNVGL-RU-SHIP-Pt4Ch8. Edition January 2016

**Electrical installations**
### Part 4 Chapter 8 Section 1

**Main electric power - semi-conductor assemblies**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E130 - Electrical datasheet, semiconductor assemblies</td>
<td>For essential services A DNV GL Type Approval certificate is accepted as an alternative to the datasheet.</td>
<td></td>
<td>FI</td>
</tr>
</tbody>
</table>

**Cables and umbilicals**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E030 - Cable selection philosophy</td>
<td></td>
<td>Applicable for:</td>
<td>AP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Vessels following the HSLC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Passenger vessels</td>
<td></td>
</tr>
</tbody>
</table>

**Emergency stop system**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E170 - Electrical schematic drawing</td>
<td>Emergency stop of electrical propulsion motors, pumps and fans, showing fail to safe functionality.</td>
<td></td>
<td>AP</td>
</tr>
</tbody>
</table>

**Explosion (EX) protection**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E090 - Table of Ex-installation</td>
<td>Based on approved area classification drawing and ESD philosophy (if relevant).</td>
<td></td>
<td>AP</td>
</tr>
</tbody>
</table>

**Hazardous area classification**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>G080 - Hazardous area classification drawing</td>
<td>An approved Area classification drawing where location of electric equipment in hazardous area is added (Except battery room, paint stores and gas bottle store).</td>
<td></td>
<td>FI</td>
</tr>
</tbody>
</table>

**Lighting arrangements**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E190 - Lighting description</td>
<td></td>
<td>Applicable for:</td>
<td>AP</td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Vessels following the HSLC</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Passenger vessels</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>— Vessels equipped with a bow loading system</td>
<td></td>
</tr>
</tbody>
</table>

**Emergency lights**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Z030 - Arrangement plan</td>
<td>Emergency lighting arrangement</td>
<td></td>
<td>AP</td>
</tr>
</tbody>
</table>

#### 2.2.2 Electrical equipment required to be delivered with DNV GL Product Certificate, see Table 3, shall be documented as described in Table 2. For equipment covered by a valid DNV GL type approval certificate, this certificate may specify exceptions to document approval. Additional documentation will be required if deemed necessary.

**Table 2 Component certification, documentation requirements**

<table>
<thead>
<tr>
<th>Object</th>
<th>Documentation type</th>
<th>Additional description</th>
<th>For approval (AP) or For information (FI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cable</td>
<td>E110 - Cable data sheet and design drawing</td>
<td>For cables not having a DNV GL type approval.</td>
<td>AP</td>
</tr>
<tr>
<td>Electric rotating machines</td>
<td>C030 - Detailed drawing</td>
<td>Shafting for electric propulsion motors and generators in mechanical propulsion line.</td>
<td>AP</td>
</tr>
<tr>
<td></td>
<td>C060 - Mechanical component documentation</td>
<td>For permanent magnet machines only. Relevant drawings for assessment of mechanical strength of rotor, permanent magnet fixation and stator core fixation.</td>
<td>AP</td>
</tr>
<tr>
<td>Main- and emergency switchboards</td>
<td>E120 - Electrical data sheet, general</td>
<td>FI</td>
<td></td>
</tr>
<tr>
<td>----------------------------------</td>
<td>----------------------------------------</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E140 - Assembly schedules and technical data</td>
<td>AP</td>
<td></td>
</tr>
<tr>
<td>E150 - Strength calculation with respect to short circuit</td>
<td>When designed sub-transient short circuit strength exceeds 50 kA r.m.s.</td>
<td>FI</td>
<td></td>
</tr>
<tr>
<td>E160 - Internal arc withstanding report</td>
<td>High voltage assemblies only.</td>
<td>FI</td>
<td></td>
</tr>
<tr>
<td>E170 - Electrical schematic drawing</td>
<td></td>
<td>AP</td>
<td></td>
</tr>
<tr>
<td>E180 - Layout of electrical assembly</td>
<td></td>
<td>FI</td>
<td></td>
</tr>
<tr>
<td>E240 - Functional description for electrical assemblies</td>
<td>When software based control units are used.</td>
<td>FI</td>
<td></td>
</tr>
<tr>
<td>Z252 - Test procedure at manufacturer</td>
<td>For high voltage switchgear and controlgear</td>
<td>AP</td>
<td></td>
</tr>
<tr>
<td>Z262 – Report from test at manufacturer</td>
<td>For high voltage switchgear and controlgear. Type test certificate or report.</td>
<td>FI</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical assemblies (Distribution switchboards, motor starters, motor control centres, etc.)</th>
<th>E120 - Electrical data sheet, general</th>
<th>FI</th>
</tr>
</thead>
<tbody>
<tr>
<td>E140 - Assembly schedules and technical data</td>
<td></td>
<td>AP</td>
</tr>
<tr>
<td>E150 - Strength calculation with respect to short circuit</td>
<td>When designed sub-transient short circuit strength exceeds 50 kA r.m.s.</td>
<td>FI</td>
</tr>
<tr>
<td>E160 - Internal arc withstanding report</td>
<td>High voltage assemblies only.</td>
<td>FI</td>
</tr>
<tr>
<td>E170 - Electrical schematic drawing</td>
<td></td>
<td>AP</td>
</tr>
<tr>
<td>E180 - Layout of electrical assembly</td>
<td></td>
<td>FI</td>
</tr>
<tr>
<td>E240 - Functional description for electrical assemblies</td>
<td>When software based control units are used.</td>
<td>FI</td>
</tr>
<tr>
<td>Z252 - Test procedure at manufacturer</td>
<td>For high voltage switchgear and controlgear</td>
<td>AP</td>
</tr>
<tr>
<td>Z262 – Report from test at manufacturer</td>
<td>For high voltage switchgear and controlgear. Type test certificate or report.</td>
<td>FI</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Semiconductor assemblies</th>
<th>E120 - Electrical data sheet, general</th>
<th>AP</th>
</tr>
</thead>
<tbody>
<tr>
<td>E130 - Electrical data sheet, semiconductor assemblies</td>
<td></td>
<td>FI</td>
</tr>
<tr>
<td>E140 - Assembly schedules and technical data</td>
<td></td>
<td>AP</td>
</tr>
<tr>
<td>E180 - Layout of electrical assembly</td>
<td></td>
<td>FI</td>
</tr>
<tr>
<td>E240 - Functional description for electrical assemblies</td>
<td></td>
<td>FI</td>
</tr>
<tr>
<td>Z252 - Test procedure at manufacturer</td>
<td></td>
<td>AP</td>
</tr>
</tbody>
</table>
2.2.3 For general requirements to documentation, see Pt.1 Ch.3 Sec.2.

2.2.4 For a full definition of the documentation types, see Pt.1 Ch.3 Sec.3.

2.3 Equipment certification

2.3.1 Required certificates

a) All electrical equipment serving essential or important services shall be delivered with DNV GL Product certificate and/or DNV GL Type Approval Certificate as required by Table 3.

b) All cables shall be delivered with DNV GL Product certificate or DNV GL Type Approval Certificates as required by Table 3. Exempted cables are listed in the note 2 of Table 3. Lightweight cables are only accepted based on a DNV GL Type Approval Certificate.

c) Additional requirements for certification may be given by other relevant parts of the rules.

d) Equipment covered by a valid DNV GL Type Approval Certificate is generally accepted without design assessment, unless otherwise stated in the certificate. A copy of the type approval certificate will substitute the required documentation for DNV GL design assessment. A product certificate may be issued based on the DNV GL Type Approval Certificate and a product survey, unless otherwise stated in the DNV GL Type Approval Certificate.

Guidance note:
Type test reports may be requested for important components in d) not having a valid DNV GL Type Approval certificate. Type Approved products have been verified to be suitable for the marine environment.

---end---of---g-u-i-d-a-n-c-e---n-o-t-e---
### Table 3 Electrical equipment

<table>
<thead>
<tr>
<th>Object</th>
<th>Certificate type</th>
<th>Issued by</th>
<th>Certification standard*</th>
<th>Continuous rating</th>
<th>Additional description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main and Emergency switchboard</td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical assemblies (Distribution switchboards, motor starters, motor control centres, sliprings, starting transformers, braking resistors, etc.)</td>
<td>PC</td>
<td>Society</td>
<td>≥100 kW/kVA</td>
<td></td>
<td>Product certification of switchgear with a smaller clearance distances than given in Sec.4 Table 1 shall be based on the manufacturer’s type test report as required by Sec.4 [1.1.8] b).</td>
</tr>
<tr>
<td>Standardized switchgear units manufactured in series with smaller clearance distances than given in Sec4 table 1</td>
<td>PC</td>
<td>Society</td>
<td>≥100 kW/kVA</td>
<td></td>
<td>Equipment not having valid type approval certificate may be accepted on the basis of a DNV GL product certificate.</td>
</tr>
<tr>
<td>Generators and transformers</td>
<td>PC</td>
<td>Society</td>
<td>≥300 kVA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generators and transformers</td>
<td>TA</td>
<td>Society</td>
<td>≥100 kVA and &lt;300 kVA</td>
<td></td>
<td>Equipment not having valid type approval certificate may be accepted on the basis of a DNV GL product certificate.</td>
</tr>
<tr>
<td>Electric motors</td>
<td>PC</td>
<td>Society</td>
<td>≥300 kW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric motors</td>
<td>TA</td>
<td>Society</td>
<td>&gt;100 kW and &lt;300 kW</td>
<td></td>
<td>Equipment not having valid type approval certificate may be accepted on the basis of a DNV GL product certificate.</td>
</tr>
<tr>
<td>Semi-conductor converters/assemblies for motor drives</td>
<td>PC</td>
<td>Society</td>
<td>&gt;100 kW</td>
<td></td>
<td>Certification of semi-conductor converters for motor drives may partly be based on Type Approval of power modules.</td>
</tr>
<tr>
<td>Semi-conductor converters/assemblies for power supply</td>
<td>PC</td>
<td>Society</td>
<td>&gt;50 kVA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cables</td>
<td>TA</td>
<td>Society</td>
<td></td>
<td></td>
<td>Equipment not having valid type approval certificate may be accepted on the basis of a DNV GL product certificate.</td>
</tr>
<tr>
<td>Sealing compound and packing systems for bulkhead- and deck penetrations</td>
<td>TA</td>
<td>Society</td>
<td></td>
<td></td>
<td>For penetrations in fire rated or water- or gas tight bulkheads.</td>
</tr>
<tr>
<td><strong>Busbar trunking systems</strong></td>
<td>TA</td>
<td>Society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>----</td>
<td>---------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cable trays/protective casings made of plastic materials</strong></td>
<td>TA</td>
<td>Society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Control and monitoring system - remote and/or automatic control of power system</strong></td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Monitoring-, protection- and management systems of battery systems</strong></td>
<td>PC</td>
<td>Society</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Unless otherwise specified the certification standard is DNV GL Rules.

1) Equipment not having valid type approval certificate may be accepted on the basis of a DNV GL product certificate.

2) All cables, except:
   a) cables for internal use in electrical assemblies
   b) short cable lengths on mechanical packages
   c) communication cables for non-important equipment
   d) radio frequency coaxial cables.

3) Certificates for shafts shall be issued as required by Ch.4. This is only applicable for shafts part of the main mechanical propulsion line.

2.3.2 For general certification requirements, see Pt.1 Ch.3 Sec.4.

2.3.3 For a definition of the certification types, see Pt.1 Ch.3 Sec.5.

2.3.4 Product survey

a) A product survey is performed as part of the certification process. The survey normally includes:
   — review of the manufacturers documentation
   — documentation of results from type tests shall, if performed, be available.
   — visual inspection
   — testing

b) Visual inspection shall verify that:
   — manufacturing and installation is in accordance with the approved design information as required by Table 2
   — the product manufacturing is in accordance with the requirements in the relevant equipment section of the rules
   — general craftsmanship is acceptable.

c) The extent of the manufacturer’s testing shall be as required by applicable sections of the rules. The testing shall be performed in accordance with approved test program(s) when required by Table 2. Test results shall be recorded and filed.
2.4 Onboard survey

2.4.1 General
Onboard survey shall be performed as part of the classification process, and focuses on the installation on board as well as on the functionality of the electrical system.

2.4.2 Onboard inspections
Onboard inspections shall be performed in order to evaluate that:
— the electrical installation is in accordance with the accepted or approved information
— the electrical installation is in accordance with the requirements in the rules
— the craftsmanship is acceptable.

2.4.3 Function tests
Function tests are part of the Society’s verification of the installation’s compliance with the requirements in the rules and approved documentation.

2.4.4 Available documentation
During onboard survey, the following documentation shall be available for the Society’s surveyor:
— approved design documentation and documentation submitted for information as required by [2.2]
— DNV GL certificates for equipment as required
— approved area classification drawing and ESD philosophy where relevant
— applicable Ex certificates
— manufacturer’s declaration for non-certified equipment that is installed in a hazardous area
— additional documentation where deemed necessary to assess the installations’ compliance with the rules
— cable routing arrangement.
SECTION 2 SYSTEM DESIGN

1 General

1.1 Design principles

1.1.1 General requirements

a) Electrical installations shall be such that the safety of passengers, crew and ship, from electrical hazards, is ensured. (Interpretation of SOLAS Ch. II-1/40.1.3)

b) There shall be two mutually independent electric power supply systems on board:
   - main electric power supply system
   - emergency electric power supply system.

   Exceptions are given in [3.1.1] and [3.1.4]. (Interpretation of SOLAS Ch. II-1/40.1.2 and 43.1.1)

c) Services required for normal operation of the vessel shall be operable with the emergency electrical power generation and distribution system being unavailable, unless mandatory requirements permit such services to be powered by emergency electrical power supply only.

d) All consumers that support functions required to be available in normal operation, shall be supplied from distribution systems independent of the emergency electrical power supply system. Exemptions are made for consumers for which mandatory requirements permit emergency power only and for one of redundant consumers necessary for dead ship recovery.

e) All consumers required to be available in emergency operation shall be supplied from distribution systems independent of the main electric power supply system.

f) Consumers required having both main and emergency supply shall be supplied as required by relevant rules applicable for these consumers. The primary supply shall be from the main system.

g) Vessels without a dedicated emergency electric power supply system are accepted upon compliance with requirements in [3.1.4].

Guidance note:
Requirements to arrangements of main and emergency power supply systems with respect to fire, flooding or other casualty are given in [9.1.2].

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.2 Environmental conditions

a) The electrical installations shall be suitable for operation in those environmental conditions given in Sec.3 [2], and have an ingress protection rating as given in Sec.10 [2.2], except as stated in b) and c).

b) Where electrical equipment is installed within environmentally controlled spaces the ambient temperature for which the equipment shall be suitable may be reduced from 45°C and maintained at a value not less than 35°C provided:
   - the equipment is not for use for emergency services, and shall not be in operation after Emergency Shut-Down (ESD) has been activated
   - temperature control is achieved by at least two cooling units so arranged that in the event of loss of one cooling unit, for any reason, the remaining unit(s) is capable of satisfactorily maintaining the design temperature
   - the equipment can be started in a 45°C ambient temperature and kept in operation until the lesser ambient temperature may be achieved
   - the cooling equipment shall be rated for a 45°C ambient temperature
   - malfunction of, or loss of a cooling unit shall be alarmed at a manned control station.
In accepting a lesser ambient temperature than 45°C, it shall be ensured that electrical cables for their entire length are adequately rated for the maximum ambient temperature to which they are exposed along their length.

c) The equipment used for cooling and maintaining the lesser ambient temperature is an important service, in accordance with Sec.13 [1.3.2] and shall comply with the relevant rules. (IACS UR E19)

Guidance note:
For the requirements for ventilation and air conditioning, see [9.1.1].

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.3 System earthing

a) System earthing shall be effected by means independent of any earthing arrangements of the non-current-carrying parts.

b) Any earthing impedances shall be connected to the hull. The connection to the hull shall be so arranged that any circulating current in the earth connections do not interfere with radio, radar, communication and control equipment circuits. (IACS UR E11 2.1.4)

c) If the system neutral is connected to earth, suitable disconnecting links or terminals shall be fitted so that the system earthing may be disconnected for maintenance or insulation resistance measurement. Such means shall be for manual operation only.

d) If the system neutral is connected to earth at several points, equalising currents in the neutral earthing exceeding 20% of the rated current of connected generators or transformers is not acceptable. Transformer neutrals and generator neutrals shall not be simultaneously earthed in the same distribution system at same voltage level. On distribution transformers with star connected primary side, the neutral point shall not be earthed.

e) In any four wire distribution system the system neutral shall be connected to earth at all times when any consumer is connected.

f) Combined PE (protective earth) and N (system earth) is allowed between transformer /generator and N-busbar in first switchboard where the transformer secondary side/generator is terminated i.e. TN-C-S-system. There shall be no connection between the N- and PE-conductor after the PEN-conductor is separated.

g) In case of earth fault in high voltage systems with earthed neutral, the current shall not be greater than full load current of the largest generator on the switchboard or relevant switchboard section and not less than three times the minimum current required to operate any earth fault protection relay.

h) Electrical equipment in directly earthed neutral or other neutral earthed systems shall withstand the current due to single phase fault against earth for the time necessary to trip the protection device.

i) It shall be assured that at least one source neutral to ground connection is effective whenever the system is in the energised mode. For divided systems, connection of the neutral to the earth shall be provided for each section. (IACS UR E11 2.1.5 and 2.1.2)

j) For earthing of aluminium superstructures on steel vessels see [9.7].

1.1.4 Types of distribution systems

a) AC power: The following distribution systems can be used (for exemptions see [1.1.5]):

   — three-phase three-wire with high-resistance earthed neutral
   — three-phase three-wire with low-resistance earthed neutral
   — three-phase three-wire with directly earthed neutral
   — three-phase three-wire with insulated neutral.

b) In addition for all voltages up to and including 500 V AC:

   — three-phase four-wire with neutral earthed, but without hull return
   — single-phase two-wire with insulated neutral
c) DC power: The following distribution systems can be used (for exemptions see [1.1.5]):
   — two-wire insulated
   — two-wire with one pole earthed at the power source (without hull return)
   — single-wire with hull return as accepted in [1.1.5].

1.1.5 Hull return systems

a) The hull return system of distribution shall not be used, except as stated in b) and c). (Interpretation of SOLAS Ch. II-1/45.3.1)

b) Provided that any possible resulting current does not flow directly through any gas hazardous spaces, the requirements of a) does not preclude the use of:
   — impressed current cathodic protective systems
   — limited and locally earthed systems
   — insulation level monitoring devices provided the circulation current does not exceed 30 mA under the most unfavourable conditions
   — intrinsically safe circuits. (Interpretation of SOLAS Ch. II-1/45.3.2)

c) Where the hull return system is used for distribution of DC power, one of the busbars of the distribution board shall be connected to the hull. Outgoing final sub circuits i.e. all circuits fitted after the last protective device shall be with insulated two-wires or two-core cables. (Interpretation of SOLAS Ch. II-1/45.3.3)

1.1.6 Special requirements for non-metallic craft

a) All metal parts of a non-metallic craft shall be bonded together, in so far as possible in consideration of galvanic corrosion between dissimilar metals, to form a continuous electrical system, suitable for the earth return of electrical equipment and to connect the craft to the water when water-born. The bonding of isolated components inside the structure is not generally necessary, except in fuel tanks.

b) Each pressure refuelling point shall be provided with a means of bonding the fuelling equipment to the craft.

c) Metallic pipes capable of generating electrostatic discharges, due to the flow of liquids and gases shall be bonded so they are electrically continuous throughout their length and shall be adequately earthed.

d) Secondary conductors provided for the equalisation of static discharges, bonding of equipment, etc., but not for carrying lightning discharges shall have a minimum cross section of 5 mm² copper or equivalent surge current carrying capacity in aluminium.

e) The electrical resistance between bonded objects and the basic structure shall not exceed 0.02 Ohm except where it can be demonstrated that a higher resistance will not cause a hazard. The bonding path shall have sufficient cross-sectional area to carry the maximum current likely to be imposed on it without excessive voltage drop.

f) A main earth bar shall be defined and fitted at a convenient place on board. This earth bar shall be connected to a copper plate with a minimum area of 0.25 m² attached to the hull and so located that it is immersed under all conditions of heel.

1.2 System voltages and frequency

1.2.1 Special requirements for non-metallic craft

a) Electric distribution systems shall operate within the voltage and frequencies given in [1.2.1] to [1.2.7]. This also applies to distribution systems where one or more generator prime movers are driving other equipment. When the main propulsion engine is used as a generator prime mover, variations caused by the wave motion or sudden manoeuvres including crash stop, shall not exceed the given limitations.
b) Voltage variations deviating from the standard values are accepted in systems if these are intentionally designed for the actual variations.

c) All voltages mentioned are root mean square values unless otherwise stated.

### 1.2.2 Maximum system voltages

a) Except as stated in b) and c), the following maximum voltages in distribution systems apply:

- connected by permanent wiring: 17 500 V
- for portable appliances, which are not hand-held during operation, and with connection by flexible cable and socket outlet: 1000 V
- supply for lighting (including signal lamps), space heaters in accommodation spaces, and hand-held portable appliances: 250 V. Phase voltage of a system with neutral earthed may be used for this purpose.

b) For High Speed, Light Craft and Naval Surface Craft, the maximum distribution voltage is limited to 500 V, except for crafts with electric propulsion systems, where higher voltages are accepted.

c) Where necessary for special application, higher voltages may be accepted by the Society.

(IACS UR E11 1.2)

### 1.2.3 Maximum control voltages

For control equipment being a part of power and heating installations (e.g. pressure or temperature switches for start and stop of motors), the maximum voltage is 1000 V. However, control voltage to external equipment shall not exceed 500 V.

### 1.2.4 Supply voltage variations

a) Electric AC distribution systems shall be designed and installed so that the voltage variations on main switchboards are maintained within these limits:

- **Steady state**
  
  ±2.5% of nominal AC system voltage.

- **Transient state**
  
  from −15% to +20% of nominal AC voltage.

b) Electric DC battery powered systems shall be designed and installed so that the voltage variations on the main distribution board are maintained within these limits:

- **Voltage tolerance:**
  
  -12% to +30% of nominal DC system voltage

- **Voltage cyclic variation:**
  
  max 5%

- **Voltage ripple:**
  
  max 10%.

c) The requirement for maximum transient voltage shall also be complied with in case of load shedding or tripping of consumers. The requirement for maximum transient voltage is not applicable to failure conditions.

d) After a transient condition has been initiated, the voltage in a main distribution AC system shall not differ from nominal system voltage by more than ±3% within 1.5s. In an emergency distribution system the voltage shall not differ from nominal system voltage by more than ±4% within 5s.

e) In AC installations designed for variable system voltage, equipment and its protection devices shall be rated to operate within the design limits throughout the voltage range.
1.2.5 Voltage variations in the distribution system

a) An AC distribution system shall be designed and installed so that the stationary voltage drop in supply to individual consumers, measured from the main switchboard to the consumer terminals does not exceed 6% of system nominal voltage.

b) A DC distribution system shall be designed and installed so that the stationary voltage variation in supply to individual consumers, measured from the battery distribution to the consumer terminals, does not exceed ±10% of system nominal voltage. Voltage ripple and cyclic variation deviation as stated in [1.2.4].

c) Specific requirements for transient voltages on consumer terminals during start or stop are not given. However, the system shall be designed so that all consumers function satisfactorily.

1.2.6 System frequency

a) The frequency variations in AC installations with fixed nominal frequency shall be kept within the following limits:
   — 95 to 105% of rated frequency under steady load conditions
   — 90 to 110% of rated frequency under transient load conditions.

b) In AC installations designed for variable system frequency, equipment and its protection devices shall be rated to operate within the design limits throughout the frequency range.

Guidance note:
See Ch.3 regarding the prime movers' speed governor characteristics.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.2.7 Harmonic distortion

a) Equipment producing transient voltage, frequency and current variations shall not cause malfunction of other equipment on board, neither by conduction, induction or radiation.

b) In distribution systems the acceptance limits for voltage harmonic distortion shall correspond to IEC 61000-2-4 Class 2. In addition, no single order harmonic shall exceed 5%.

Guidance note:
IEC 61000-2-4 Class 2 implies that the total voltage harmonic distortion shall not exceed 8%.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

c) The total harmonic distortion may exceed the values given in b) under the condition that all consumers and distribution equipment subjected to the increased distortion level have been designed to withstand the actual levels. The system and components ability to withstand the actual levels shall be documented.

d) When filters are used for limitation of harmonic distortion, special precautions shall be taken so that load shedding or tripping of consumers, or phase back of converters, do not cause transient voltages in the system in excess of the requirements in [1.2.4]. The generators shall operate within their design limits also with capacitive loading. The distribution system shall operate within its design limits, also when parts of the filters are tripped, or when the configuration of the system changes.

Guidance note:
The following effects should be considered when designing for higher harmonic distortion, refer to c):

— additional heat losses in machines, transformers, coils of switchgear and controlgear
— additional heat losses in capacitors for example in compensated fluorescent lighting
— resonance effects in the network
— functioning of instruments and control systems subjected to the distortion
— distortion of the accuracy of measuring instruments and protective gear (relays)
— interference of electronic equipment of all kinds, for example regulators, communication and control systems, position- finding systems, radar and navigation systems.

A declaration or guarantee from system responsible may be an acceptable level of documentation.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
2 Main Electric Power Supply System

2.1 General

2.1.1 Capacity

a) The main power supply system shall have the capacity to supply power to all services necessary for maintaining the ship in normal operation without recourse to the emergency source of power. (Interpretation of SOLAS Ch. II-1/40.1.1)

b) There shall be component redundancy for main sources of power, transformers and power converters in the main power supply system so that with any source, transformer or power converter out of operation, the power supply system shall be capable of supplying power to the following services:

— those services necessary to provide normal operational conditions for propulsion and safety
— starting the largest essential or important electric motor on board, except auxiliary thrusters, without the transient voltage and frequency variations exceeding the limits specified in [1.2]
— ensuring minimum comfortable conditions of habitability which shall include at least adequate services for cooking, heating, domestic refrigeration (except refrigerators for air conditioning), mechanical ventilation, sanitary and fresh water
— for a duplicated essential or important auxiliary, one being supplied non-electrically and the other electrically (e.g. lubricating oil pump No. 1 driven by the main engine, No. 2 by electric motor), it is not expected that the electrically driven auxiliary is used when one generator is out of service
— For dead ship recovery, see [2.2.4]. (Interpretation of SOLAS Ch. II-1/41.1)

Guidance note:

Those services necessary to provide normal operational conditions of propulsion and safety do not normally include services such as:

— thrusters not forming part of the main propulsion or steering
— mooring
— cargo handling gear
— refrigerators for air conditioning.
— ballast water treatment system

However, additional services required by a class notation will be added to the list of important services.

In regard to non-important load, the capacity of all generators can be taken into consideration.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.2 Generator prime movers

a) Each generator required according to [2.1.1] shall normally be driven by a separate prime mover, i.e. each generator shall be driven by one engine, and one engine shall only drive one generator.

b) If a prime mover for a generator is also used for driving other auxiliary machinery in such a way that it is physically possible to overload the engine, an interlock or other effective means for preventing such overloading shall be arranged. The availability of the generator shall be at least as for separately driven generators.

c) When generators driven by reciprocating steam engines or steam turbines are used, and the operation of the boiler(s) depends on electric power supply, there shall be at least one generator driven by an auxiliary diesel engine or gas turbine on board, enabling the boiler plant to be started.

d) A generator or generator system, having the ship’s main propulsion machinery as its prime mover, may be accepted as a main source of electrical power, provided that it can be used in all weather conditions and operating modes for the vessel, including standstill of propeller.

e) There shall be at least one generator driven by a separate prime mover. The capacity of separately driven generators shall be sufficient to supply all essential and important services that can be expected
to be simultaneously in use, regardless of the operational mode of the vessel, including stopped. This shall be possible without utilising any emergency power source. (Interpretation of SOLAS Ch. II-1/41.1.3)

f) Shaft generator installations which do not comply with the requirement given in d), may be fitted as additional source(s) of power provided that:

— on loss of the shaft generator(s) or upon frequency variations exceeding ±10%, a standby generating set is automatically started and connected to the main switchboard. Synchronisation shall be possible within frequency variations of ±10%.
— the capacity of the standby set is sufficient for the loads necessary for propulsion and safety of the vessel.

g) Generator prime movers shall comply with the requirements in Ch.2 Sec.4.

Guidance note:
Shaft generators and generators based on variable speed drives will be evaluated in each case. As a minimum, the following should be evaluated:

— availability in all operating modes
— stability of output voltage and frequency
— short circuit capability and protection
— auxiliary systems, e.g. ventilation, cooling system, and control power distribution.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2.2 System functionality

2.2.1 Start of generator sets
At least two generator sets, connected to separate main busbar sections, shall be arranged with systems for starting in a blackout situation. However, only one standby generator may be permitted if this generator is not intended to be used for normal operation of the ship.

2.2.2 Energy for starting

a) The energy used for starting in a blackout situation shall be arranged as required in [5.1].

b) Control power supply to electronic governors, automatic voltage regulators (AVRs) and necessary control power for auxiliary engines shall, if dependent on external power, be arranged as required for starting arrangement in [5.1.2].

c) Where prime movers and/or generators arranged as standby generators depend upon auxiliary machinery systems being available in a blackout situation, these auxiliaries shall be arranged with at least two independent sources of power. At least one of the sources of power shall be from stored energy located within the engine room. The capacity of the power sources shall correspond to the required number of starting attempts and/or last for at least 30 minutes.

d) Where prime movers and/or generators arranged as standby generators depend upon auxiliary machinery systems during standby mode in order to start in a blackout situation, auxiliaries for at least one generator shall be supplied from the main switchboard in order to comply with [1.1.1].

e) When a single, dedicated, standby generator is used, this generator set alone shall be arranged in accordance with this paragraph, i.e. two sources of energy for starting, control power and auxiliaries. As above, one of the sources for auxiliaries shall be from stored energy located within the machinery space.

Guidance note:
Example of auxiliary system that must be available in a blackout situation may be fuel oil booster pump, and lubrication oil pump if start blocking is activated within 30 minutes after blackout.
Example of auxiliary system that must be supplied in standby mode may be pre lubrication pump and jacket water heating.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
2.2.3 Load shedding and automatic restoration of power
Where electrical power is necessary for propulsion and steering of the ship, the system shall be so arranged that the electrical supply to equipment necessary for propulsion and steering, and to ensure safety of the vessel, will be maintained or immediately restored in case of loss of any one of the generators in service. This means:
— The power system shall be equipped with automatic load shedding or other automatic means to prevent sustained overload of any generator, ref. [7.1.1].
— Upon loss of power, provision shall be made for automatic starting and connecting to the main switchboard of standby generator(s) of sufficient capacity, and automatic restarting of the essential auxiliaries, in sequential operation if required. Starting and connection to the main switchboard of the standby generator is to be preferably within 30 seconds, but in any case not more than 45 seconds, after loss of power. Either restart of the previous running auxiliary, or start of a standby auxiliary system is accepted.
— Where prime movers with longer starting time are used, this starting and connection time may be exceeded upon approval from the society.
— Where several generator units in parallel operation are required to cover the ship's power supply, the failure of one of the units shall cause the immediate trip of non-important equipment and, where necessary, the important equipment, where this is the only way to ensure that the remaining units can supply the essential equipment. Load reduction may be one solution to achieve this.

(Interpretation of SOLAS Ch.II-1/41.5.1.1)

2.2.4 Start from dead ship
a) The requirement for start from dead ship is given in Ch.1 in the Rules for Classification of Ships.
b) In addition, the generating sets shall be such as to ensure that with any one generator, transformer or power converter out of service, the remaining generating sets, transformers and power converters shall be capable of providing the electrical services necessary to start the main propulsion plant from a dead ship condition. The emergency source of electrical power may be used for the purpose of starting from a dead ship condition if its capability either alone or combined with that of any other source of electrical power is sufficient to provide at the same time those services required to be supplied by [3.1.3], except fire pumps and steering gear, if any.

Guidance note:
On installations without a dedicated emergency generator in accordance with [3.1.4], only one engine room is considered to be in dead ship conditions, since there should be redundancy in starting arrangement for each engine room as required for emergency generator sets. However, necessary energy for auxiliaries needed for start (fuel, lubrication oil priming, etc.) must have the same arrangement as the source for starting energy.
For vessels with two or more independent engine rooms but not complying with [3.1.4], the requirements for dead ship starting still applies, i.e. dead ship condition in both/all engine rooms simultaneously. Necessary energy for auxiliaries needed for start (fuel, lubrication oil priming, etc.) must have the same arrangement as the source for starting energy.
In cases where only electric starting is arranged for engines driving generators and the main propulsion engines, an additional battery for “dead ship” starting may be installed. This battery shall then be dedicated for this purpose and always kept fully charged and monitored.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.2.5 Regeneration
Regenerated power caused by e.g. water milling of propellers shall not cause any alarms, neither in planned operating modes nor during emergency manoeuvres. Where necessary, braking resistors for absorbing or limiting such energy shall be provided.
3 Emergency Power Supply System

3.1 General

3.1.1 Emergency power source

a) A self-contained emergency source of electrical power shall be provided.

b) The emergency source of power, associated transforming equipment, emergency switchboard, emergency lighting switchboard and transitional source of emergency power shall be located above the uppermost continuous deck and be readily accessible from open deck. It shall not be located forward of the collision bulkhead. (Interpretation of SOLAS Ch. II-1/43.1.2).

c) The emergency source of electrical power may be either a generator or an accumulator battery. (Interpretation of SOLAS Ch. II-1/43.3).

d) The emergency source of power shall be automatically connected to the emergency switchboard in case of failure of the main source of electric power. If the power source is a generator, it shall be automatically started and within 45 s supply at least the services required to be supplied by transitional power as listed in Table 1. (Interpretation of SOLAS Ch. II-1/43.3.1.2, 43.3.2.2 and 43.3.2.3).

e) Ventilation of the space containing the emergency source of electrical power or ventilators for radiator of emergency generator engine, shall comply with the requirements in Pt.3 Ch.12 Sec.9 [5] and it shall not be necessary with any closing arrangement. If any closing arrangements are installed, they shall fail to open position.

f) Cooling arrangement for the emergency source of power, e.g. pipes, pumps and heat exchangers, shall be located in the same space as the emergency generator. Heat exchangers may be accepted outside, in close vicinity to the emergency source of power.

g) If the emergency source of power is not automatically connected to the emergency switchboard, a transitional source of emergency electrical power, suitably located for use in an emergency, with sufficient capacity of supplying the consumers listed in Table 1, may be accepted. (Interpretation of SOLAS Ch. II-1/43.3.1.3).

h) The emergency source of power shall not be used for supplying power during normal operation of the vessel. Exceptionally, and for short periods, the emergency source of power may be used for blackout situations, starting from dead ship, short term parallel operation with the main source of electrical power for the purpose of load transfer and for routine testing of the emergency source of power. (Interpretation of SOLAS Reg. II-1/43.3.1.3).

Exception for high speed light craft

For a craft applying the HSC Code, location of emergency supply system below uppermost continuous deck may be accepted provided easy access from a normally manned area. However, the emergency source of power shall always be located above worst damage waterline.

Exception for ships

The requirement for emergency source of power applies to all cargo vessels with the following exemptions:

— ships with one of the service restrictions notations R2, R3 and R4
— ships of less than 500 gross tonnage
— fishing vessels less than 24 m.

Guidance note:
Concerning requirements for an emergency generator, see [3.3].
Concerning requirements for a transitional source of emergency electrical power, see [3.2].
### 3.1.2 Capacity

a) The electrical power available shall be sufficient to supply all services essential for safety in an emergency, due regard being paid to such services as may have to be operated simultaneously, also taking into account starting currents and transitory nature of certain loads. (Interpretation of SOLAS Ch. II-1/43.2)

b) Where the emergency source of electrical power is an accumulator battery it shall be capable of carrying the emergency electrical load without recharging while maintaining the voltage of the battery as required by [1.2]. (Interpretation of SOLAS Ch. II-1/43.3.2.1)

c) When non-emergency consumers are supplied by the emergency source of power, it shall either be possible to supply all consumers simultaneously, or automatic disconnection of non-emergency consumers upon start of the generator shall be arranged. The system shall be so arranged that the largest consumer connected to the emergency power supply system can be started at all times without overloading the generator unless automatically disconnected upon start of the emergency generator. (Interpretation of SOLAS Ch. II-1/43.5.5)

d) Starting air compressors, preheaters and lubrication oil pumps for the main engine or auxiliary engines may be equipped for automatic disconnection from the emergency switchboard. Such consumers necessary for starting from dead ship, if supplied from the emergency source of power, shall be possible to connect manually at the emergency switchboard also when the emergency generator is running. If they may cause overloading of the emergency generator, warning signs shall be fitted also stating the load of the consumers.

**Guidance note:**
The emergency generator rating shall be based upon the consumed power for all consumers that may be in simultaneous operation. Non-emergency motors, which will not automatically start, are considered to be automatically disconnected.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

### 3.1.3 Services to be supplied

a) For High Speed and Light Craft see HSLC Pt.5

b) For additional class notations, additional requirements may apply.

c) For ships the list of services in Table 1 shall be supplied by an emergency source of power and by a transitional source of power, if any, for the period listed.

d) For a ship engaged regularly in voyages of short duration, a period shorter than the 18 hour period specified in Table 1 may be accepted, but not less than 12 hours. (Interpretation of SOLAS Ch. II-1/43.2.6.2)

e) The emergency source of electrical power shall be capable of supplying simultaneously at least the services listed in Table 1 for the periods specified, if they depend upon an electrical source for their operation. (Interpretation of SOLAS Ch. II-1/43.2.1 to 43.2.6.1)

f) For fishing vessels the following services shall be supplied for a period of 3 hours for vessels below 45 m and 8 hours for vessels of 45 m and above:

- VHF radio installation as required by Torremolinos Convention reg. IX/6(1)(a) and (b)
- Internal communication equipment
- Fire detecting system
- Signals which may be required in an emergency
- Navigation lights if solely electrical
- Emergency lighting:
  - of launching stations and over side of the vessel
  - in all alleyways, stairways and exits
  - in spaces containing machinery or the emergency source of power
  - in control station
  - in fish handling and fish processing space
- Electrical driven emergency fire pump if any.
If applicable:
— The MF radio installation required by Torremolinos Convention IX/8(1)(a) and (b) and reg. IX/9(1)(b) and (c)
— The ship earth station required by Torremolinos Convention regulation IX/9(1)(a)
— MF/HF radio installation required by Torremolinos Convention IX/9(2)(a) and (b) and reg. IX/10(1).

Table 1 Services to be supplied by an emergency source and by a transitional source, including required duration for main class

<table>
<thead>
<tr>
<th>Service</th>
<th>Emergency power consumers in ships</th>
<th>Duration of emergency power, ( \text{(h)} )</th>
<th>Duration of transitional power (^4), ( \text{(h)} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency lighting</td>
<td>At every muster and embarkation station, for survival craft and their launching appliances, and at the area of water into which it shall be launched.</td>
<td>3</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>In all service and accommodation alleyways, stairways and exits, personnel lift cars and personnel lift trunks.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>In the machinery spaces and main generating stations including their control positions.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>In all control stations, machinery control rooms, steering gear and at each main and emergency switchboard.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>At all stowage positions for firemen’s outfits.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>At the fire pump referred to in this table and its starting position.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>At the sprinkler pump and its starting position, if any.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>At the emergency bilge pump and its starting position, if any.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td></td>
<td>In all cargo pump-rooms of tankers.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td>Navigation lights</td>
<td>The navigation lights and other lights required by the International Regulations for Preventing Collisions at Sea in force.</td>
<td>18</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td>Fire pumps</td>
<td>One of the fire pumps required by SOLAS Ch. II-10.2.2 (Ch.11 of the Rules for Classification of Ships) if dependent upon the emergency generator for its source of power. (SOLAS Ch. II-1/43.2.5)</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Firefighting systems, e.g. total flooding systems</td>
<td>Firefighting systems required to be supplied by emergency power in accordance with relevant IMO regulations.</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Steering gear</td>
<td>The steering gear if required to be so supplied by Ch.10. (SOLAS Ch. II-1/43.2.6.1) (For a ship of less than 10 000 gross tonnage the duration shall be at least 10 minutes.)</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>Watertight doors and hatches</td>
<td>The power, control and indicators for watertight doors and hatches.</td>
<td>0.5</td>
<td>0.5 (^2)</td>
</tr>
<tr>
<td>Life boat</td>
<td>Second means of launching of free fall life boat, ref. LSA Code.</td>
<td>6)</td>
<td></td>
</tr>
<tr>
<td>----------</td>
<td>------------------------------------------------------------------</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>Stabilisers (if any)</td>
<td>Means to bring the stabiliser wings inboard and indicators on the navigating bridge to show the position of the stabiliser wings if there is a danger of the survival craft being damaged by the ship's stabiliser wings (as required by Pt.3 Ch.3 Sec.9 of the Rules for Classification of Ships)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Communication 3)</td>
<td>The VHF radio installation required by SOLAS Ch. IV/7.1.1 and IV/7.1.2.</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If applicable: the MF radio installation required by SOLAS Ch.'s IV/9.1.1, IV/9.1.2, IV/10.1.2 and IV/10.1.3 the ship earth station required by regulation IV/10.1.1 the MF/HF radio installation required by regulations IV/10.2.1, IV/10.2.2, IV/10.1.2 and IV/11.1.</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All internal communication equipment, as required, in an emergency; shall include: means of communication between the navigating bridge and the steering gear compartment means of communication between the navigating bridge and the position in the machinery space or control room from which the engines are normally controlled means of communication between the bridge and the positions fitted with facilities for operation of radio equipment.</td>
<td>18 1) 0.5 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intermittent operation of the daylight signalling lamp, the ship's whistle, the manually operated call points, and all internal signals that are required in an emergency.</td>
<td>18 1) 0.5 2)</td>
<td></td>
</tr>
<tr>
<td>Navigation</td>
<td>Navigation equipment as required by statutory requirements. For ships seeking compliance with NAUT(OSV), see Pt.6 Ch.3.</td>
<td>18 1)</td>
<td></td>
</tr>
<tr>
<td>Alarm systems 5)</td>
<td>The fire detection and alarm systems.</td>
<td>18 1) 0.5 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Power supply to the alarm sounder system when not an integral part of the detection system 7)</td>
<td>18 1) 7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The gas detection and alarm systems</td>
<td>18 1) 0.5 2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The general alarm system.</td>
<td>18 1) 0.5 2)</td>
<td></td>
</tr>
</tbody>
</table>
1) Unless such services have an independent supply for the period of 18 hours from an accumulator battery suitably located for use in an emergency.

2) Unless such equipment has an automatically charged battery with adequate capacity, suitably located for use in an emergency.

3) Means of communication according to relevant SOLAS requirements and DNV GL Statutory Interpretations apply for mandatory internal communications systems.

4) A transitional source of power is required for:
   — vessels where the emergency source of power is not automatically connected to the emergency switchboard within 45 s
   — class notations **Passenger ship**, and **Ferry**.

5) Only when the service or function is required by other applicable rules.

6) Power for launching of the life boat shall be available on demand with duration of 10 minutes for each lifeboat.

7) The alarm sounder system utilised by the Fixed Fire Detection and Fire Alarm System shall be powered from no less than two sources of power, one of which shall be an emergency source of power. In vessels required by SOLAS regulation II-1/42 or 43 to be provided with a transitional source of emergency electrical power the alarm sounder system shall also be supplied from this power source. (IACS SC35)

### 3.1.4 Independent installation of power sources

When the IMO HSC Code is applicable, or when alternative emergency power arrangement has been accepted by the authorities of the flag state the following may apply:

Where the main source of electrical power is located in two or more spaces which have their own systems, including power distribution and control systems, completely independent of the systems in the other spaces and such that a fire or other casualty in any one space will not affect the power distribution from the others, or to the services in Table 1, the requirements for self-contained emergency power source may be considered satisfied without an additional emergency source of electrical power, provided that:

1) There are at least two generator sets meeting the inclination design requirements for emergency installations in Sec.3 [2.1.1].

2) Each set has capacity to meet the requirements in item [3.1.2].

3) These generator sets are located in each of at least two spaces.

4) A casualty in any one space will not affect the control system for automatic start and connection of both/all these generator sets.

5) Power to all required emergency services, as listed in Table 1 are to be automatically available within 45 seconds when power is automatically restored after a black-out, including those supplied from main distribution systems. (These consumers may be supplied from main switchboards or sub distribution boards).

6) Load shedding/trip is arranged to prevent overload of these generator sets.

7) Transitional source of power is installed when required in [3.2.1].

8) The location of each of the spaces referred to in this paragraph is such that one of these generator sets remains operable and readily accessible in the final condition of damage. Further, the boundaries shall meet the provisions of [9.1.2], except that contiguous boundaries shall consist of an A-60 bulkhead and a cofferdam or a steel bulkhead insulated to class A-60 on both sides.

9) Bus tie breakers between the spaces have short circuit protection providing discrimination.

10) The arrangements of these generating sets comply with the requirements given in:
   — [3.1.5] c), i.e. bus-tie breakers shall open automatically upon blackout
   — [3.1.5] h)
   — [3.3.1]
   — [3.3.3] (see guidance note).
Guidance note:

1) The second source of energy for starting may be located outside the machinery space. In case of a fire or other casualty in any one space a total of at least two sources of starting energy for the remaining generator(s) have to be available.

2) The system philosophy for the electrical power supply system should describe how this paragraph is complied with. In addition it should include description of physical location of main components and cable routings. The test program for onboard testing should describe in detail how this functionality shall be tested.

3) A vessel built in accordance with this paragraph will not have any dedicated emergency power system, since the two (or more) independent main power systems are considered to ensure power supply to emergency consumers at all times. Compliance with [3.3.2] is not required.

---end---of---guidance---note---

3.1.5 Emergency switchboard

a) The emergency switchboard shall be installed as near as is practicable to the emergency source of electrical power. (Interpretation of SOLAS Ch. II-1/43.5.1)

b) Where the emergency source of electrical power is a generator, the emergency switchboard, the emergency transformers (if any) and the emergency lighting switchboard shall be located in the same space unless the operation of the emergency switchboard would thereby be impaired. (Interpretation of SOLAS Ch. II-1/43.5.2)

c) In normal operation, the emergency switchboard shall be supplied from the main switchboard by an interconnecting feeder. This feeder shall be protected against overload and short circuit at the main switchboard, and shall be disconnected automatically at the emergency switchboard upon failure of the supply from the main source of electrical power. (Interpretation of SOLAS Ch. II-1/43.5.4)

d) Where the emergency switchboard is arranged for the supply of power back to the main distribution system, the interconnecting cable shall, at the emergency switchboard end, be equipped with switchgear suitable for at least short circuit protection.

e) The emergency switchboard and emergency distribution boards shall not be considered as part of the main distribution system, even though supplied from such during normal operation.

f) Technical requirements for functionality and construction for main switchboards, apply to emergency switchboards.

g) Provision shall be made for the periodic testing of the complete emergency system and shall include the testing of automatic starting arrangements. (Interpretation of SOLAS Ch. II-1/43.7)

h) No accumulator batteries, except the starting battery for the emergency generator prime mover and control and monitoring for the emergency system, shall be installed in the same space as the emergency switchboard. (Interpretation of SOLAS Ch. II-1/43.5.3)

i) Cables between equipment installed in the emergency generator room, shall be run inside the boundary of the room.

Guidance note:

It is accepted that there are dividing bulkheads within the A60 boundary of the emergency generator space provided that there is access through the dividing bulkheads.

---end---of---guidance---note---

3.2 Transitional source

3.2.1 Transitional source of emergency electrical power

a) A transitional source of power is required where the emergency source of power is not arranged for automatic connection to the emergency switchboard within 45 s, or if required by other applicable rules, e.g. class notation Passenger ship, or Ferry.

b) The transitional source of electrical power shall consist of an accumulator battery suitably located for use in an emergency as required for emergency power in [3.1.1], unless it supplies power to consumers within the same space as the transitional source itself.
c) The battery source shall be charged by the emergency power distribution system and be able to operate, without recharging, while maintaining the voltage of the battery throughout the discharge period as required by [1.2]. The battery capacity shall be sufficient to supply automatically, in case of failure of either the main or the emergency source of electrical power, for the duration specified, at least the services required by Table 1, if they depend upon an electrical source for their operation. See notes to Table 1. (Interpretation of SOLAS Ch. II-1/43.4)

3.3 Emergency generators

3.3.1 Prime mover for emergency generator

a) Where the emergency source of electrical power is a generator, it shall be driven by a suitable prime mover having independent supply of fuel with a flashpoint (closed cup) of not less than 43°C and shall have auxiliary systems e.g. cooling system, ventilation and lubrication operating independently of the main electrical power system. (Interpretation of SOLAS Ch. II-1/43.3.1.1)

b) The prime mover shall be started automatically upon failure of the main source of electrical power supply. (Interpretation of SOLAS Ch. II-1/43.3.1.2)

c) Where automatic start of the emergency generator is required and the emergency source of power is not ready for immediate starting, an indication shall be given in the engine control room.

3.3.2 Protective functions of emergency generating sets

a) The protective shutdown functions associated with emergency generating sets shall be limited to those necessary to prevent immediate machinery breakdowns i.e. short circuit. If overcurrent protection release is implemented, the setting of this release shall be so high that under no circumstances the supply to emergency consumers is impaired. For prime mover, see Ch.3 Sec.1.

b) Generator circuit breaker shall have undervoltage release with a time delay longer than the respective short circuit time delay and clearance time.

c) A shut down or stop signal to the prime mover shall cause disconnection signal to the generator circuit breaker if a generator runs in parallel with any other source of power.

d) Other protective functions such as overcurrent, high temperature etc. shall, if installed, give alarm only. It is recommended that such alarms are given to the main alarm system.

e) For use as a harbour generator, see [3.3.4].

3.3.3 Starting arrangements for emergency generating sets

a) An emergency generating set shall be capable of being readily started in its cold condition at a temperature of 0°C. If this is impracticable, or the vessel is intended for operation at lower ambient temperatures, provisions shall be made for heating arrangements to ensure ready starting of the generating sets. (Interpretation of SOLAS Ch. II-1/44.1)

b) Emergency generating set shall be equipped with starting device with a stored energy capability of at least three consecutive starts. A second source of energy shall be provided for an additional three starts within 30 minutes, unless manual starting can be demonstrated to be effective within this time. One starting motor is sufficient. The duration of each starting attempt shall be minimum 10 s. (Interpretation of SOLAS Ch. II-1/44.2)

c) Stored energy for starting shall be maintained at all times, and shall be powered from the emergency switchboard. All starting, charging and energy storing devices shall be located in the emergency generator space. Compressed air starting systems may however be maintained by the main or auxiliary compressed air system through a suitable non-return valve fitted in the emergency generator space. (Interpretation of SOLAS Ch. II-1/44.3)

d) If accumulator batteries are used for starting of the emergency generator prime mover, every such prime mover shall have separate batteries that are not used for any purpose other than the operation of the emergency generating set.
e) If the emergency generator set is equipped with an electronic governor, electronic AVR, priming pumps or other auxiliaries dependent upon electric power supply for a successful start, two independent sources of power, located in the same space as the emergency source of power, shall be provided.

### 3.3.4 Emergency generator used in port

a) The emergency source of power may be used during time in port for the supply of the ship's main electrical system, provided the requirements for available emergency power is adhered to at all times.

b) To prevent the generator or its prime mover from becoming overloaded when used in port, arrangements shall be provided to shed sufficient non-emergency loads to ensure its continued safe operation.

c) The prime mover shall be arranged with fuel oil filters and lubrication oil filters, monitoring equipment and protection devices as required for the prime mover for main power generation and for unattended operation.

d) The fuel oil supply tank to the prime mover shall be provided with a low level alarm, arranged at a level ensuring sufficient fuel oil capacity for the emergency services for the required period.

e) Fire detectors shall be installed in the location where the emergency generator set and emergency switchboard are installed.

f) Means shall be provided to readily change over to emergency operation.

g) Control, monitoring and supply circuits, for the purpose of the use of the emergency generator in port shall be so arranged and protected that any electrical fault will not influence the operation of the main and emergency services. When necessary for safe operation, the emergency switchboard shall be fitted with switches to isolate the circuits.

h) Instructions shall be provided on board to ensure that when the vessel is under way all control devices (e.g. valves, switches) are in a correct position for the independent emergency operation of the emergency generator set and emergency switchboard. These instructions are also to contain information on required fuel oil tank level, position of harbour or sea mode switch if fitted, ventilation openings etc.

### 4 Battery Systems

#### 4.1 General

**4.1.1 Capacity of accumulator batteries**

Batteries that shall be used for power supply required by these rules shall be dimensioned for the time required for the intended function at an ambient temperature of 0°C, unless heating is provided.

**4.1.2 Battery powered systems**

a) Every battery system shall have its own dedicated charging device (I.E. in order to constitute a battery system).

b) Battery systems shall be so rated that they can supply the consumers for the required period, in accordance with the energy balance, when charged to 80 % of their rated capacity.

c) Each charging device is, at least, to have sufficient rating for recharging to 80% of rated battery capacity, within 10 hours, while the system has normal load.

d) The battery charger shall be suitable to keep the battery in full charged condition, (float charge), taking into account battery characteristics, temperature and load variations. If the battery requires special voltage regulation to obtain effective recharging, then this is to be automatic. If manual boost charge is provided, then the charger is to revert to normal charge automatically.

e) The type of UPS unit employed, whether off-line or on-line, is to be appropriate to the power supply requirements of the connected load.

f) Additional requirements for batteries used for propulsion, and requirements to other battery technologies than NiCd and Lead Acid batteries are covered by Pt.6 Ch.2.
Guidance note:
When the charging dynamo is an AC generator (alternator), particular attention should be paid to ensure that no damage would occur if the connection with the battery is broken. Provisions shall be made for preventing reverse current from the battery through the charging dynamo.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.3 Battery monitoring
An alarm shall be given at a manned control station if the charging of a battery fails, alternatively an alarm shall be given if the battery is being discharged. Requirements for ventilation of battery spaces are given in [9.4.8]. Additional requirements for the battery charger are given in Sec.7 [1.2.10].

Guidance note:
A single common alarm signal to a central alarm system may be accepted for the two alarms listed in this paragraph. If other alarms are included in the common alarm signal, it must be ensured that an active alarm will not prevent initiation of any new alarm with its audible and visual indication.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.4 Battery arrangement
Battery installations shall comply with the requirements in [9.4].

5 Starting Arrangement for Engines with Electric Starter

5.1 General

5.1.1 Starting arrangements for propulsion engines
a) When electric starting arrangement for propulsion engines is used, there shall be at least two separately installed batteries, connected by separate electric circuits arranged such that parallel connection is not possible. Each battery shall be capable of starting the main engine when in cold and ready to start condition.

b) When two batteries are serving a single propulsion engine, a change-over switch or link arrangement for alternative connection of the starter motor with its auxiliary circuits to the two batteries shall be provided.

c) Starting arrangements for two or more propulsion engines shall be divided between the two batteries and connected by separate circuits. Arrangements for alternative connection of one battery to both (or all) engines can be made, if desired.

d) Batteries for starting shall be installed in the same space as the engine.

e) Each battery shall have sufficient capacity for at least the following start attempts of the engines being normally supplied:

- 12 starts for each reversible engine
- 6 starts for each non-reversible engine connected to a reversible propeller or other devices enabling the engine to be started with no opposing torque.

The duration of each starting shall be taken as minimum 10 s. If the starting batteries are also used for supplying other consumers, the capacity shall be increased accordingly.

It shall be possible to perform the required number of starts within 30 minutes without recharging.

f) For multi-engine propulsion plants the capacity of the starting batteries shall be sufficient for 3 starts per engine. However, the total capacity shall not be less than 12 starts and need not exceed 18 starts.
5.1.2 Starting arrangement for auxiliary engines

a) Electric starting arrangement for a single auxiliary engine not for emergency use, shall have a separate battery, or it shall be possible to connect it by a separate circuit to one of the main engine batteries, when such are used according to [5.1.1].

b) When the starting arrangement serves two or more auxiliary engines, there shall at least be two separate batteries, as specified for main engines in [5.1.1]. The main engine batteries, when such are used, can also be used for this purpose.

c) Each starting battery shall have sufficient capacity for at least three start attempts of each of the engines being normally supplied. The duration of each starting shall be taken as minimum 10 s. If the starting batteries are also used for supplying other consumers, the capacity shall be increased accordingly.

Guidance note:
Alternatively it may be accepted that one of the required batteries is located outside the engine room. In this case a changeover (manually operated and normally kept open) shall be arranged between the two battery systems.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

6 Electric Power Distribution

6.1 Distribution in general

6.1.1 General

a) All switchboards shall be provided with switchgear for outgoing circuits so that isolation for maintenance is possible. See Sec.4 [1.1.5].

b) Consumers for essential or important services shall be connected to a main switchboard, distribution board or motor control centre by separate circuits.

c) Two units supplied from the main generators and serving the same essential or important purpose shall have a separate supply circuit from different sections of the main switchboard(s) or shall be divided between at least two distribution switchboards, each having a separate supply circuit from either side of the bus tie (if such is provided). In instances where more than two units are used and the switchboard has only two sections, the circuits are to be evenly divided between the two sections.

d) When a component or system has two or more power supply circuits with automatic change over, an alarm shall be initiated at a manned control station upon loss of any of these power supplies.

e) For converters serving as AC power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual electrically independent bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.

Guidance note:
To a): Equipment suitable for isolation is defined in IEC 60947-1 clause 7.1.7. Contactors are therefore normally not accepted as suitable for isolation.

To d): Requirement to alarms applies even if two or more power supplies are not required.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

6.1.2 Consequence of single failure

a) The failure of any single circuit or busbar section shall not endanger the services necessary for the vessel's manoeuvrability. The failure of any single circuit shall not cause important services to be out of action for long periods. Any single failure shall not render duplicated consumers serving essential or important services inoperable.

b) When the secondary distribution is arranged as two separate systems each fed from one transformer or converter, duplicated essential or important consumers shall be divided between the two systems.

c) Each transformer required according to [2.1.1] shall be installed as a separate unit, with a separate enclosure.
Guidance note:
Single failure means failure in any single circuit, feeder, transformer or part of switchboard within one bus tie section.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

6.1.3 Division of main busbars

a) For low voltage distribution systems where the main source of electrical power is necessary for propulsion of the ship, the main busbar shall be subdivided by at least a multi-pole no-load switch-disconnector complying with IEC 60947. For other systems, other approved means may be accepted. So far as is practicable, the connection of generating sets and other duplicated equipment shall be equally divided between the parts. (Interpretation of SOLAS Ch. II-1/41.5.1.1 and 41.5.1.3)

b) The division of the main busbar in high voltage distribution systems shall be achieved with a circuit breaker complying with IEC 62271-100.

c) Where two separate switchboards are provided and interconnected with cables, a circuit breaker with protection as required by [7.1.2] and breaking capacity as required by [7.2.2] shall be provided at each end of the cable. See Sec.4 [2.1.6].

(IACS UR E11 2.1.1)

d) If the low-voltage main switchboard is supplied from a high voltage system a circuit breaker for the division of the low voltage main busbar shall be provided. The bus bar sections shall be supplied by circuit breakers suitable for isolation.

Guidance note:
The requirement for division of main busbars applies to all voltage levels where services necessary for propulsion of the ship are supplied from. The emergency electrical power supply system should not be used to comply with this requirement.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

Guidance note:
Other approved means can be achieved by:
Circuit breaker without tripping mechanism; or disconnecting link or switch by which busbars can be split easily and safely. Bolted links, for example bolted busbar sections, are not accepted.
Additional class notations may require that each part of the main busbars with its associated generators is arranged in separate compartments.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

6.1.4 Generator circuits

a) Each generator shall be connected by a separate circuit to the corresponding switchboard.

b) When a generator is used for direct supply to single consumers, or can be connected to more than one busbar section, more than one generator breaker is acceptable. In such cases, additional requirements to protection of the circuits between the generator terminals and the generator circuit breakers are given in [7.3.1] f).

6.2 Lighting

6.2.1 Lighting system arrangement

a) The lighting system shall be based on the following separation of the system:

— main lighting system supplied from the main power supply system
— emergency lighting system supplied from the emergency power supply system
— escape (transitional) lighting system supplied from a battery backup (transitional) source of electrical power (when required).
b) The main electric lighting system shall provide illumination throughout those parts of the ship normally accessible to, and used by, passengers or crew, and shall be supplied from the main source of electrical power. (Interpretation of SOLAS Ch. II-1/41.2.1)

c) The emergency lighting system shall provide illumination throughout those parts of the ship listed in Table 1, and shall be supplied from the emergency source of electrical power. Upon loss of main source of power, all required emergency lighting shall be automatically supplied from the emergency source of power. Emergency exterior lighting may however be controlled by switch on the bridge.

d) The escape (transitional) lighting system shall provide illumination throughout those parts of the unit listed in Table 1, supplied by integrated or centralised batteries. These batteries shall have supply from an emergency distribution system. The escape lighting system shall be switched on automatically in the event of failure of the main and emergency power supply system.

e) If the main lighting is arranged as two separate secondary systems, each fed from a separate transformer or converter, then the main lighting shall be divided between the two systems so that with one system out of operation, there remains sufficient lighting to carry out all functions necessary for the safe operation of the vessel.

f) Redundancy requirement for generators and transformers supplying the main lighting system is given in [2.1.1].

g) For vessels meeting the requirements in [3.1.4], i.e. those which do not have a dedicated emergency source of power, c) do not apply. However, sufficient lighting to carry out all functions necessary for the safe operation of the vessel and in all areas where emergency light is required according to Table 1, shall be divided between at least two circuits from the independent power sources.

h) For vessels where emergency source of power is not required, b) does not apply. However, the following lighting shall be divided between at least two circuits from different parts of the main switchboard:

— engine room lighting
— switchboard room lighting
— lighting in control room and of control positions
— lighting in alleyways, stairways leading up to the boat deck and in saloons.

Guidance note:
Requirements to arrangement of the two lighting systems are located in [9.1.2].

6.2.2 Navigation light controller

The navigation lights shall be connected to a dedicated navigation light controller placed on the bridge or in the chart room/pace. This navigation light controller shall not be used for other purposes, except that signal lights required by canal authorities can be supplied.

Guidance note:
According to IMO MSC.253(83) navigation lights means the following lights:

— masthead light, sidelights, stern light, towing light, all-round light, flashing light as defined in Rule 21 of COLREG
— all-round flashing yellow light required for air-cushion vessels by Rule 23 of COLREG; and
— manoeuvring light required by Rule 34(b) of COLREG.

6.2.3 Power supply to navigation lights

a) The navigation light controller shall be supplied by two alternative circuits, one from the main source of power and one from the emergency source of power. A changeover switch shall be arranged for the two supply circuits. Upon failure of either power supply, an alarm shall be given.

b) For vessels without emergency power the navigation lighting shall have a battery backed up supply.
6.2.4 Navigation light circuits

a) A separate circuit shall be arranged for each light connected to this controller with a multi-pole circuit breaker, multi-pole fused circuit breaker or with a multi-pole switch and fuses in each phase.

b) The overload and short circuit protection for each of these circuits shall be correlated with the supply circuit to ensure discriminative action of the protection devices.

c) Each light circuit shall be provided with an automatic monitoring device when the light circuit is switched on, giving alarm in the event of bulb failure, and in the event of a short circuit.

d) When duplication is required, each navigation light or lamp shall be fed by a separate circuit.

6.3 Power supply to control and monitoring systems

6.3.1 General

This part of the rules defines the principal requirements to power supply arrangement for control and monitoring systems. Other power supply arrangements may be required for specific applications in other parts of the rules.

6.3.2 Power supply

The power supply shall in general be supplied from the same distribution board as the consumer or the system being served.

Guidance note:
The general principle is that the power supply to the control and monitoring systems shall reflect the general segregation in the power supply arrangement to the consumers or equipment under control.

6.3.3 Independent power supplies

When independent power supplies are required, these supplies shall be from separate sections of the main switchboard or from distribution boards supplied from separate sections of the main switchboard.

For single control and monitoring systems where independent power supplies are required, an automatic change-over for the two power supplies shall be arranged as close as possible to the consumer.

Guidance note:
Two supplies from a common power distribution board are not considered to be independent, even if the distribution board itself is fed from independent supplies.

Single control and monitoring systems in this category shall be equipped with two terminals for connection of the external power supply cables. The change-over arrangement shall then be located on the consumer side of these terminals.

6.3.4 Additional emergency supply

For control and monitoring systems where supply from both main and emergency source of power are required, but not requiring independent supplies, the power may be supplied by a single circuit from a power distribution board provided that this distribution board is supplied from both the main- and emergency distribution systems. Such a distribution board shall be located in the same space as the system being served.

Guidance note:
The emergency switchboards alone are not considered to comply with the above, even if supplied from main switchboard during normal operation.

6.3.5 Uninterruptible power supply (UPS)

For control and monitoring systems where both uninterruptable and independent power supplies are required, at least one of the supplies shall be provided with stored energy. The operation of the UPS shall not depend upon external services or auxiliary systems.
Guidance note:
A UPS alone is not considered to provide the required independency, even if the UPS itself is fed by two independent supplies and equipped with static bypass. An electrically independent bypass is required.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

6.3.6 Monitoring of power supplies

a) Upon failure of the power supply to essential and important services, an alarm shall be initiated unless loss of function will otherwise be alarmed. In case of duplicated or independent power supplies, both supplies shall be monitored.

b) When a control system has duplicated or independent power supplies, both supplies shall be monitored, and an alarm given at a manned location upon failure of any of them.

6.4 Low voltage shore connections

6.4.1 General

a) When supply from shore is used, the connection of the supply cable from shore shall generally be carried out by suitable terminals placed in a switchboard or in a shore-connection box or a socket outlet with a permanent cable connection to a receiving switchboard. In the shore-connection box, switchgear and protection as required for feeder circuits shall be installed. For circuits rated maximum 63 A, the circuit may have short circuit and overcurrent protection in the receiving switchboard only.

b) The connection shall provide means for connection of a protective earthing between vessel and shore.

c) In the receiving switchboard, the circuit shall, at least, be provided with a switch - disconnector.

d) If the shore connection is supplying power via the emergency switchboard, the following applies:
   — [3.1.5] d) shall be complied with.
   — Undervoltage disconnection of the power supply from shore shall be arranged so that the shore connection supply is disconnected upon loss of power in order to enable automatic start and connection of the emergency generator.

e) For AC systems with earthed neutral, terminals for connection between the shore and ship’s neutrals shall be provided.

f) Failure in interlock circuits of the shore connections shall not impair operation of the main switchboard and generators while at sea.

Guidance note:
National authorities may require changeover or interlocking system, so arranged that the connection to shore cannot be fed from the vessel's generators.
Other requirements may be applicable if the vessel has class notation Shore power as given in Pt.6 Ch.7.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

7 Protection

7.1 System protection

7.1.1 Overload protection

a) Load shedding or other equivalent automatic arrangements shall be provided to protect the generators, required by these rules, against sustained active/reactive overload. (Interpretation of SOLAS Ch. II-1/41.5.1.2)

b) In power distribution systems that might operate in different system configurations, the load shedding shall be such arranged that necessary system protection is functioning in all system configurations.
c) A load shedding, or load reduction system, if installed, shall be activated at a load level suitably below 100% of the rated current of the generator.

Guidance note:
Overload protection may be arranged as load reduction or as the tripping of non-important consumers. Where more than one generator is necessary to cover normal load at sea, important consumers may be tripped, if necessary.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

7.1.2 Insulation fault

a) Each insulated or high resistance earthed primary or secondary distribution system shall have a device or devices to continuously monitor electrical insulation to earth. For insulated distribution systems, the circulation current generated by each device for insulation monitoring shall not exceed 30 mA under the most unfavourable conditions. In case of abnormally low insulation values the following is required:
   — for low voltage systems: An audible or visual indication
   — for high voltage systems: An alarm at a manned control station (I.e. both visual and audible signal).
   (IACS E11 2)
   Audible or visual indication for low voltage systems can be omitted provided automatic disconnection is arranged. (Interpretation of SOLAS Ch. II-1/45.4.2)

b) The requirements in a) shall be applied on all galvanic isolated circuits, except for:
   — dedicated systems for single consumers
   — galvanic separated local systems kept within one enclosure.

c) On high voltage systems automatic disconnection shall be arranged for operation at 1/3 or less of the minimum earth fault current. However, for systems with high-resistance earthed neutral or isolated neutral, this disconnection can be replaced with an alarm when the distribution system and equipment are dimensioned for continuous operation with earth fault. Concerning requirements for voltage class of high voltage cables dependent of system behaviour with earth fault, see [10.1.3].

d) On systems with low-resistance earthed neutral automatic disconnection of circuits having insulation faults shall be arranged. This earth fault protection shall be selective against the feeding network. For low resistance earthed neutral systems the disconnection shall operate at less than 20% of minimum earth fault current.

e) Test lamps or similar without continuous monitoring are accepted for:
   — battery systems not extending their circuits outside a single panel
   — battery system for non-important systems below 50 V and
   — battery systems serving one function only.

f) For direct-earthed systems (i.e. TN-S, TN-C-S and TT) the single or three phase effective overcurrent and short circuit protection is acceptable as earth fault protection.

Guidance note:
EMC filters or line to earth capacitors installed at distribution boards or consumers may mislead insulation monitoring devices and initiate false alarms. Suitable devices should be selected taking this into account.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

7.1.3 Overvoltage protection

a) At overvoltage an alarm shall be given at a manned control station. Settings shall not be higher than 130% $U_N$ with a time delay less than 5s.

b) The following measures shall be installed to protect against overvoltage:
   — Overvoltage protection shall be arranged for lower-voltage systems supplied through transformers from high-voltage systems.
— For high voltage distribution systems with insulated neutral (IT), protection against transient overvoltages caused by intermittent earth faults shall be installed. Normally overvoltage arresters shall be installed on the cable side of circuit breakers installed in the main switchboard.

Guidance note:
Overvoltage protection and alarm is normally a part of the generator protection, or busbar protection on the generator system voltage level.
Direct earthing of the lower voltage system, or the use of voltage limitation devices, are considered as adequate protection. Alternatively, an earthed screen between the primary and secondary windings may be used. See Sec.3 [4.4] regarding current and voltage transformers.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.1.4 Discrimination

a) The electric distribution system and electrical consumers shall be fitted with short circuit, overcurrent and earth fault protection as required in [7.1.2] and [7.2].

b) The short circuit, overcurrent and earth fault protection of essential and important equipment shall be selective and shall ensure that only the switching device nearest to the fault initiates disconnection of the defective circuit. Exceptions may be permitted in the case of circuits feeding only non-important equipment if selectivity relative to the upstream circuit breaker is maintained. The protective devices shall provide complete and co-ordinated protection through discriminative action in order to ensure:
   — Continuity of supply to essential consumers and emergency consumers.
   — Continuity of service to important consumers. Supply to healthy circuits shall be automatically re-established.
   — Elimination of the fault to reduce damage to the system and hazard of fire.

c) Other protection equipment, if installed, shall not interfere with this selectivity concept.

d) Discrimination is to be ensured in all designed operating modes of the distribution system (in all grid configurations).

e) Current transformers used for protection devices shall be suitable for the overcurrent range expected.

f) For high voltage distribution systems the required bus tie breaker shall have short circuit protection which is selective towards the generators’ circuit breakers.

g) For UPS and DC power supplies, short circuit and overload discrimination on the secondary side is required in normal operating mode (with the primary power supply present). Ref. Sec.7 [1.2.7].

Guidance note:
Continuity of supply is the condition for which during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured.
Continuity of service is the condition for which after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established.
Current transformers used for protection devices will normally be suitable when class P10 is selected.
For UPS and DC power supplies in battery operation, short circuit discrimination may not be achieved.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.2 Circuit protection

7.2.1 General

a) Each separate circuit shall be protected against short circuit with the protection in the feeding end. For generators smaller than 1500 kVA, the protection may be at the switchboard side of the cables.
b) Each circuit shall be protected against overcurrent.
c) All consumers shall be separately protected, except as noted below.
d) Loss of control voltage to protective functions shall either trip the corresponding equipment or give an alarm on a manned control position, unless other specific requirements apply.

e) No fuse, switch or breaker shall be inserted in earthing connections or conductors. Earthed neutrals may be only be disconnected provided the complete circuit is disconnected at the same time by means of multi-pole switch or breaker.

f) The circuit breaker control shall be such that “pumping” (i.e. automatically repeated breaking and making) cannot occur.

g) Circuits for heating cables, tapes, pads, etc. shall be supplied through a circuit breaker with earth fault protection (Residual-current device (RCD)). Sec.10 [3.10].

Exceptions:
— For special requirements for protection of steering gear circuits, see Ch.10.
— For emergency generator see [3.3.2].
— Circuit supplying multiple socket outlets, multiple lighting fittings or other multiple non-important consumers is accepted when rated maximum 16 A in 230 V systems, or 30 A in 110 V systems.
— Non-important motors rated less than 1 kW, and other non-important consumers, rated less than 16A, do not need separate protection.
— Separate short circuit protection may be omitted for consumers serving non-important services. Each motor shall have separate overcurrent protection and controlgear.
— Common short circuit protection for more than one consumer is acceptable for non-important consumers, and for important consumers constituting a functional service group (i.e. when the important function cannot be ensured by a single consumer of the group).
— Common overload or overcurrent protection for more than one consumer is acceptable when the protection system adequately detects overload/overcurrent or other malfunction origin at individual consumer. Cables connected to individual consumer shall be sized to settings adjusted at the common protection.
— Separate short circuit protection may be omitted at the battery or busbar end of short circuit proof installed cables.

7.2.2 Capacity

a) The breaking capacity of every protective device shall be not less than the maximum prospective short circuit at the point where the protective device is installed. The rated breaking capacity shall be not less than the r.m.s value of the AC component of the short-circuit Iac (t) at the moment

\[
t = \frac{T}{2}
\]

where

\[= t \text{ time duration from the beginning of a short circuit}
= T \text{ one period of one cycle}

For high voltage systems it is acceptable to use calculated rms value of the AC component of the short-circuit Iac (t) at the moment where the contacts start to open (ref. IEC 61363-1 clause 9.3).

b) The making capacity of every circuit breaker or switch intended to be capable of being closed, if necessary, on short circuit, shall not be less than the maximum value of the calculated peak short circuit current at the point of installation.

c) For non-important circuits, circuit breakers with insufficient breaking capacity can be used, provided that they are co-ordinated by upstream fuses, or by a common upstream circuit breaker or fuses with sufficient breaking capacity protecting the circuit breaker and connected equipment from damage.
d) Circuit breakers in main switchboards are generally to be selected according to their rated service short circuit breaking capacity. ($I_{CS}$ according to IEC 60947-2 Clause 4)

e) If the main switchboard is divided by a switch disconnector (IEC 60947-3) or a circuit breaker (IEC 60947-2) the feeder breakers in the main switchboard may be selected according to their rated ultimate breaking capacity. ($I_{CU}$ according to IEC 60947-2 Clause 4)

f) Provided that the main switchboard is divided by a bus tie circuit breaker and that total discrimination (total selectivity) of generator circuit breaker and bus tie breaker are obtained, all circuit breakers in the main switchboard may be selected according to their rated ultimate breaking capacity. ($I_{CU}$ according to IEC 60947-2 Clause 4)

g) Generator circuit breakers and other circuit breakers with intentional short-time delay for short circuit release shall have a rated short-time withstand current capacity not less that the prospective short circuit current. ($I_{CW}$ according to IEC 60947-2 Clause 4)

h) Every protective device or contactor not intended for short circuit interruption shall be co-ordinated with the upstream protection device.

i) When a switchboard has two or more incoming feeders, necessary interlocks shall be provided against simultaneously closing of both feeders when the parallel connected short circuit power exceeds the switchboards' short circuit strength. A short time parallel feeding as a "make before break" arrangement is accepted when arranged with automatic disconnection of one of the parallel feeders within 30 s.

7.2.3 Fuses

a) Fuses above 320 A rating shall not be used as overload protection, but may be used for short circuit protection if otherwise acceptable according to these rules.

b) When used for short circuit protection, fuses can be rated higher than the full-load current, but not higher than expected minimum short circuit current.

c) In high voltage equipment, fuses shall not be used for overcurrent protection of power feeder circuits. Fuses may be used for short circuit protection provided they can be isolated and replaced without any danger of touching live parts.

7.2.4 Short circuit protection

The general requirements for circuit protection in [7.2.1], [7.2.2] and [7.2.3] apply with the following exceptions:

— separate short circuit protection may be omitted for motors serving different functions of the same non-important equipment for example the engine room crane may include hoisting, slewing and luffing motors. Each motor should have separate overload protection and controlgear

— separate short circuit protection may be omitted at the battery or busbar end of short circuit proof installed cables. However, short circuit proof connections to busbars shall not be longer than 3 m, see Sec.4 [2.1.6]).

7.2.5 Overcurrent protection

a) Overcurrent protection shall not be rated higher or adjusted higher (if adjustable) than the cable's current-carrying capacity, or the consumer's nominal current, whichever is less.

b) The general requirements for circuit protection in [7.2.1], [7.2.2] and [7.2.3] apply.

However, overcurrent protection may be omitted for circuits supplying consumers having overcurrent protection in their controlgear. This also applies to a circuit supplying a distribution switchboard with consumers having overcurrent protection in their controlgear, provided that the sum of the rated currents of the controlgears does not exceed 100% of the supply cable's rating.

7.2.6 Control circuit protection

The general requirements for circuit protection in [7.2.1], [7.2.2] and [7.2.3] apply with the following exceptions:

— protection may be omitted for monitoring circuits of automatic voltage regulators

— secondary side of current transformers shall not be protected
— the secondary side of the single phase supply transformers for control circuits shall be protected unless primary side protection is proved sufficient, see Sec.4 [4.1.3]. The protection may be in one pole (phase) only. See also [8.1.1] b).
— separate protection may be omitted for control circuits branched off from a feeder circuit with nominal rating limited to 16 A
— separate protection may be omitted for control circuits branched off from a feeder circuit with nominal rating limited to 25 A and when the control circuit consists of adequately sized internal wiring only.
— for voltage transformers in high voltage switchgear, see [7.4.1] d).

Guidance note:
Adequately sized wiring means that the wiring withstands normal load and short circuit without reaching extreme temperatures.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

7.3 Generator protection

7.3.1 Generator protection

a) Generators shall be fitted with short circuit and overcurrent protection as well as undervoltage release.

b) The overcurrent protection shall normally be set so that the generator breaker trips at 110% to 125% of nominal current, with a time delay of 20 s to 120 s. Other settings may be accepted after confirmation of discrimination.

c) The short circuit trip shall be set at a lower value than the generator’s steady state short circuit current and with a time delay as short as possible, taking discrimination into account. Maximum 1 s. The undervoltage release shall have a time delay longer than the respective short circuit setting.

d) Other forms for generator overload protection, for example winding over-temperature combined with power relays (watt metric relays), may substitute overcurrent protection provided the generator cables are sufficiently protected.

e) Generators having a capacity of 1500 kVA or above, and all high voltage generators, shall be equipped with suitable protection, which in the case of short circuit in the generator or in the supply cable between the generator and its circuit breaker will de-excite the generator and open the circuit breaker. Emergency generators are exempted.

f) When a generator is used for direct supply to single consumers, more than one generator breaker is acceptable. In such cases, the generator shall be de-excited and all the generator's breakers opened, in case of short circuit between the generator's terminals and the generator’s breakers.

g) When a generator is installed outside the space where the switchboard with the generator circuit breaker is installed, the generator cable shall have short circuit protection at both ends. Alternatively, the generator shall be de-excited and the switchboard generator breaker opened, in case of short circuit between the generator's terminals and the generator breaker. An environmental enclosure for the main switchboard, such as may be provided by a machinery control room situated within the main boundaries of the engine room, is not considered as separating the switchboard from the generator.

h) Each generator arranged for parallel operation shall be provided with reverse-power protection with settings in accordance with engine manufacturer’s recommendation. If no manufacturer’s recommendation is provided, setting values shall be:

— time delay between 3 s and 10 s
— tripping the generator circuit breaker at:
  — maximum 15% of the rated power for generators driven by piston engines
  — maximum 6% of the rated power for generators driven by turbines.

The release power shall not depart from the setpoint by more than 50% at voltage variations down to 60% of the rated voltage, and on AC installations at any power factor variation.

Reverse power protection maybe omitted where damage to the engine and drive train is impossible.

i) Generator circuit breakers shall be tripped at undervoltage. This undervoltage protection shall trip the breaker when the generator voltage drops within the range 70% to 35% of its rated voltage.
j) The undervoltage protection shall have a time delay allowing for correct operation of the short circuit protection (i.e. longer time delay than the short circuit protection.)
k) The undervoltage protection shall allow the breaker to be closed when the voltage and frequency are 85% to 110% of the nominal value.
l) See Sec.5 [1.3.1] for requirements for temperature detectors in windings.
m) For emergency generators special requirements apply. See [3.3.2].

7.4 Transformer protection

7.4.1 Transformer protection

a) Transformers shall be fitted with circuit protection as required by [7.2].
b) If the primary side of transformers is protected for short circuit only, overcurrent protection shall be arranged on the secondary side.
c) For liquid filled transformers see Sec.6 [1.2.2].
d) High voltage distribution transformers and high voltage propulsion transformers shall be equipped with temperature monitors and high temperature alarms.

Guidance note:
When choosing the characteristics of protection devices for power transformer circuits it may be necessary to take current surge into consideration.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

7.4.2 High voltage control transformers

— In high voltage systems having high resistance earthed neutral, voltage transformers in switchgear and controlgear may be installed without primary side protection when installed between phase and earth. The thermal withstand capacity shall be adequate to prospective fault current and the transformers shall not be based on a single core (i.e. phase to phase short circuit is impossible).
— In three phase systems with neutral insulated, voltage transformer primary side protection will not be required providing that transformer is not formed based on single common core.

7.5 Motor protection

7.5.1 Motor protection

a) The general requirements for circuit protection in [7.2] apply.
b) Overcurrent protection for motors may be disabled during a starting period.
c) Overcurrent relays shall normally be interlocked, so that they must be manually reset after a release.
d) Short circuit and overload protection shall be provided in each insulated phase (pole) with the following exemptions:
   — for DC motors, overcurrent relay in one pole can be used, but this cannot then substitute overcurrent release at the switchboard
   — for AC motors supplied by three-phase electric power with insulated neutral, overload protection in any two of the three phases is sufficient
   — overcurrent release may be omitted for essential or important motors, if desired, when the motors are provided with overload alarm (for steering gear motors, see Ch.10 Sec.1 [5.4])
   — overcurrent release in the controlgear may be omitted when the circuit is provided with a switchboard circuit breaker with overcurrent protection
   — overcurrent protection may be omitted for motors fitted with temperature detectors and being disconnected upon over temperature, provided the feeding cable is sufficiently protected.
e) If fuses are used for short-circuit protection, a phase-failure supervision is required to prevent the system be started if one phase fails.

f) See Sec.5 [1.3.1] for requirements for temperature detectors in windings.

7.6 Battery protection

7.6.1 Battery circuits

a) Circuits connected to batteries above 12 V or above 1 Ah capacity shall have short circuit and overcurrent protection. Protection may also be required for smaller batteries capable of posing a fire risk. Short circuit protection shall be located as close as practical to the batteries, but not inside battery rooms, lockers, boxes or close to ventilation holes. The connection between the battery and the charger is also to have short circuit protection.

b) Connections between cells and from poles to first short circuit protection shall be short circuit proof, i.e. one of the methods described in Sec.13 [1.4.1] must be used.

c) The main circuit from a battery to a starter motor may be carried out without protection. In such cases, the circuit shall be installed short circuit proof, and with a switch for isolating purposes. Auxiliary circuits, which are branched off from the starter motor circuit, shall be protected as required in a).

7.7 Harmonic Filter protection

7.7.1 Harmonic filters

Each harmonic filter shall be protected against overcurrent and short circuit. Circuit protection in filter circuits shall be monitored and provided with alarm in a manned control station.

Guidance note:
Harmonic filters connected as network units (not as integrated parts of a converter) shall have isolating switchgear as required for important consumers in [6.1.1].

8 Control of Electric Equipment

8.1 Control circuits

8.1.1 General

— All consumers other than motors shall be controlled by, at least, multi-pole switchgear, except that single pole switches can be used for luminaries or space heaters in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material.

— If one pole or phase of the control voltage source is earthed, the control wiring and interlocks (if any) shall be installed on the non-earthed side of any relay coils.

Guidance note:
Multi-pole disconnection means that all active poles are disconnected simultaneously. However, any N-conductor is not regarded as an active pole, and need not be disconnected.

8.1.2 Power supply to control circuits

a) Power supply to control circuits for steering gear shall be branched off from the motor power circuit.

b) The power supply for control circuits to switchgear and controlgear and their circuit protection shall generally be branched off from the main supply circuit (e.g. generator side for the generator breaker).
c) The power supply to those in b. may have control voltage from UPS or a battery supported dc distribution systems as described in [8.1.3] provided:

- Consumers serving duplicated essential or important services are supplied by independent power supplies in accordance with [6.3.3].
- Supplies to consumers serving non-duplicated essential services and where the rules require two independent power supplies (main and back-up), are arranged in accordance with [6.3.3].
- The UPS or battery supported dc distribution systems are located in the same space as systems served.
- The control circuit to each consumer has separate short circuit protection

d) The interlocking circuit and protection relays shall be arranged so that a circuit breaker is not dependent of external power sources except for external power supplies mentioned in [8.1.3].

e) If shunt trip coils are used for high voltage switchgear, the continuity of the tripping circuit has to be monitored (i.e. wire break monitoring). When the wire breakage alarm is activated, the switching on shall be interlocked. The power supply to the tripping circuit has to be monitored.

8.1.3 Battery supplied control power

a) When power supply to switchgear and controlgear is from battery installations, as allowed by 8.1.2 c), generator circuit breakers and other duplicated essential and important equipment shall be supplied from independent power supplies as described in [6.3.3].

b) An independent control power supply system shall be arranged for each of the switchboard sections and be arranged with change over possibilities.

c) Each switchboard cubicle shall have a separate circuit from the control voltage distribution, with separate short circuit protection.

d) Each auxiliary control power supply system shall have sufficient stored energy for at least two operations of all the components connected to its section of the switchboard. For switching off circuit breakers this applies for all circuit breakers simultaneously, and without excessive voltage drop in the auxiliary circuits.

8.2 Control of generator sets and main switchboards

8.2.1 General

a) Where a switchboard is arranged for operation from an automation system, the switchboard shall in addition be arranged for local operation at the front of the switchboard or at a dedicated control position within the space where it is installed. This local operation shall be independent of remote parts of the automation system. For systems not used for propulsion and steering e.g. process plant, an alternative arrangement may be accepted.

b) The following alarms shall be arranged at a manned control station:

- power failure to the control system
- high and low frequency on the main busbars
- high and low voltage on the main busbars.

8.2.2 Manual operation

All generator prime movers and generator circuit breakers shall have means for manual operation.

8.2.3 Automatic operation

Where start, stop and/or load sharing between generators are controlled by an automation system the following requirements apply:

a) The following alarms shall be arranged at a manned control station:

- starting failure of prime mover
— difference in loads (kVA or alternatively both kW and kVar) taken by the generators, with the necessary time delay, when in symmetrical load sharing mode.

b) Automatic starting attempts which fail shall be limited to restrict consumption of starting energy.

c) The generator circuit breaker shall be provided with automatic wind up of the closing spring of the breaker.

d) Simultaneous connection of generators on to the same bus shall not be possible.

e) Automatic connection of a generator during blackout shall only be possible when auxiliary contacts on all generator circuit breakers show directly that all generators are disconnected from the main switchboard and the bus is dead. A single synchronising device shall not be relied upon for blackout detection.

f) When a generator unit is standby, this shall be indicated on the control panel.

g) No more than one attempt of automatic connection per standby generator is permitted to a de-energised switchboard.

h) Systems with automatic start of the standby unit at heavy load on running units shall be arranged with adequate delay to prevent false start attempts, e.g. caused by short load peaks.

i) If the generator breaker has a “test” position, this shall be recognised by the control system as not available.

j) Automatic connection of generator shall not take effect before the voltage of the generator is stable and at normal level.

k) It shall be possible to select a minimum number of running generator sets or to deselect functions for automatic stop of generator sets at low load.

l) For requirements to system functionality, see [2.2].

8.2.4 Generator circuit breaker control

a) Any casualty within one generator compartment of the main switchboard should not render more than this generator’s circuit breaker, nor its instrumentation and signals, inoperative.

b) Requirements for automatic operation of generator breakers are given in [8.2.2].

c) A shut down or stop signal to the prime mover shall cause disconnection signal to the generator circuit breaker.

8.2.5 Generator instrumentation

a) At any control position for manual operation of a generator breaker, including operator stations, the following information and control signals shall be easily and simultaneously observed by the operator:
   — control and indication of breaker open and breaker close
   — generator power (kW)
   — generator current. Three separate simultaneous readings or alternatively one reading with a changeover switch for connection to all phases. If changeover switch is used, the current reading shall be supplied by separate current transformers, not used for protection. At an operating station one reading is sufficient.
   — generator voltage
   — generator frequency
   — busbar voltage
   — busbar frequency
   — adjustment device for speed of generator prime mover. (Not required at operator stations if load sharing is controlled by the automation system.)
   — a temperature indicator for directly reading the temperature of the stator windings of generators shall be located in the control room if the vessel has electric propulsion.

b) It shall be possible to synchronise each generator intended for parallel operation with two different devices. Alternatively, one independent synchronising device for each generator will be accepted. Each
generator shall be able to be synchronised to its busbar by a synchronising device independent of any other sections of the switchboard.

c) **Exception:**
Synchronisation of generators driven by propulsion engines may be achieved by adjusting the busbar frequency, i.e. by adjusting the speed/frequency setpoint(s) of the running generator(s).

**Guidance note:**
If one synchronising device fails, it shall still be possible to synchronise all generators, except one (the one with a failing device).

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

### 8.2.6 Auxiliary generators and main switchboard in different locations

For generators installed in a space that does not have direct access to the space where the generator breaker is installed, the generator and generator driver shall be equipped with remote control and alarms as required by class notation **E0**.

A generator installed in accordance with this will generally not be taken into account with respect to total generator capacity, see [2].

### 8.2.7 Sectioning of busbars

a) Switchgear for sectioning of busbars shall have sufficient making and breaking capacity for the service for which it is intended. If wrong operation may cause damage, then instructions for correct operation shall be given by signboard on the switchboard. It shall be clearly indicated whether such switchgear is open or closed.

b) Undervoltage release of sectioning switchgear is accepted as long as the switchgear has sufficient capacity for breaking the prospective fault current at the point of installation.

### 8.3 Control of emergency generator set and emergency switchboard

#### 8.3.1 Control of emergency generator sets

a) Alarms shall be arranged at a manned control station where automatic start of the emergency generator is required and the emergency source of power is not ready for immediate starting (Given in [3.3.1] c), including power failure to the control system. If the generator breaker has a "test" position, this shall be recognised by the control system as not available.

b) The emergency generator set shall have means for manual operation. The generator circuit breaker shall be provided with automatic wind up of the closing spring of the breaker.

c) Automatic connection of the generator during blackout shall only be possible when auxiliary contacts on the incoming feeder breaker show directly that all power supply is disconnected from the emergency switchboard and the bus is dead.

d) Automatic connection of generator shall not take effect before the voltage of the generator is stable and at normal level.

e) For requirements to system functionality, see also [3.3].

f) Any casualty within one compartment of the emergency switchboard should not render both the incoming feeder breaker and the generator’s circuit breaker, nor their instrumentation and signals, inoperative.

g) For emergency generators, a trip of a control circuit protection shall not lead to uncontrolled closing of the generator breaker against a live bus.

h) A shut down or stop signal to the prime mover shall cause disconnection signal to the generator circuit breaker.

#### 8.3.2 Generator instrumentation

At the control position for manual operation of the generator breaker, the following information and control signals shall be easily and simultaneously observed by the operator:

— control and indication of breaker open and breaker close
— generator power (kW)
— generator current. Three separate simultaneous readings or alternatively one reading with a changeover switch for connection to all phases. If changeover switch is used, the current reading shall be supplied by separate current transformers, not used for protection. At an operating station one reading is sufficient.
— generator voltage
— generator frequency
— busbar voltage
— busbar frequency
— adjustment device for speed of generator prime mover.

8.4 Control of switchgear and controlgear

8.4.1 Parallel incoming feeders

a) Switchboards that are arranged for supply by two (or more) alternative circuits shall be provided with interlock or instructions for correct operation by signboard on the switchboard. Positive indication of which of the circuits is feeding the switchboard shall be provided.
b) When a secondary distribution switchboard has two or more supplies, each supply circuit shall be provided with multipole switchgear.
c) In high voltage installations, the incoming feeders in the low voltage main switchboards shall be equipped with voltmeters and ampere-meters. It shall be possible to display the currents and voltages of all three phases. Where instrumentation switches for voltage or ampere meter are used it shall be ensured that a failure in measuring circuit doesn’t impair or disable any protection function of this circuit.
d) Parallel operation of high voltage ship service transformers is only permissible for load transfer in maximum 10 sec, if also the high voltage sides of the transformers are connected. A forced splitting, independent of the automation system shall be provided.
e) Switchboards supplied from low voltage power transformers shall be arranged with interlock or signboard as in a) unless the power transformers are designed for parallel operation.
f) Interlocking arrangements shall be such that a fault in this interlocking system cannot put more than one circuit out of operation.
g) In the case where a secondary distribution system is supplied by parallel operated power transformers, supplied by different, non-synchronous systems, necessary interlocks shall be arranged to preclude parallel operation of the transformers when the primary sides are not connected.
h) Transformers shall not be energised from the secondary side, unless accepted by the manufacturer. For high voltage transformers, secondary side switchgear shall generally be interlocked with the switchgear on the primary side. This to ensure that the transformer will not be energised from the secondary side when the primary switchgear is opened. If back feeding through transformers is arranged, special warning signs shall be fitted on the primary side switchgear. Different generators shall not feed the different sides of transformers simultaneously to avoid locking of generators in synchronism via a transformer.

Guidance note:
Temporary back-feeding as part of a dead ship starting procedure may be accepted.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

8.5 Motor control

8.5.1 Controlgear for motors

a) Each motor shall normally be provided with at least the following controlgear, functioning independent of controlgear for other motors:
— each motor rated 1 kW or above: a multipole circuit breaker, fused circuit breaker or contactor, with overcurrent release according to [7.5], if necessary combined with a controller for limiting the starting current
— each motor rated 1 kW or above: control circuits with undervoltage release so that the motor does not re-start after a blackout situation
— each motor rated less than 1 kW: a multipole switch.
For exemptions and additions regarding steering gear motors, see Ch.10.

b) All motors shall have indication when switched on, either by a running light or by the circuit breaker position. This requirement doesn’t apply to remote control boxes, unless stated otherwise in other parts of the rules.
c) Undervoltage release shall not inhibit intended automatic restart of motor upon restoration of voltage after a blackout.
d) Common starting arrangements for a group of motors (e.g. a group of circulating fans for refrigerated cargo holds) are subject to consideration in each case.
e) Controlgear for motors shall be designed for the frequency of making and breaking operations necessary for the respective motor.
f) Switchgear for feeder circuits shall not be used as motor controlgear unless:
   — the switchgear is designed for the frequency of making and breaking operations necessary for the respective motor
   — the requirements for motor controlgear otherwise are complied with
   — the switchgear shall be of the withdrawable type if low voltage.
g) For requirements to emergency stop, see [8.6].

8.5.2 Local control for motors
A local/remote selector switch shall be implemented at the motor starter for all essential and important consumers when remote control is arranged from an electronic/programmable system and for all essential consumers when remote control is arranged from outside of the engine room.

Guidance note:
If pump-side control is enabled when starter is in REMOTE mode, control transfer mechanism between this pump-side control and remote control positions should be arranged in accordance with Ch.9 Sec.3 [1.3]. Exceptions to this may be accepted provided that the remote control system does not automatically execute commands in conflict with the pump-side control. An alarm should be released in the remote control system/Integrated Alarm System (IAS) if the pump is started or stopped from pump-side while being in remote mode.
If pump-side control is enabled when starter is in LOCAL mode and disabled when starter is in remote mode, there will not be command conflicts with remote control systems.

8.5.3 Interlock for motor starting
a) If the starting of a motor requires that two or more generators are run in parallel, an interlock shall be provided, ensuring that this circuit can only be switched on when a sufficient number of generators are connected.
b) The interlock may, however, be omitted when signboards giving necessary instructions are fitted at the starters.

8.5.4 Instruments for electric propulsion motors
a) A temperature indicator for directly reading the temperature of the stator windings of electric propulsion motors shall be located in the control room.
b) The following values shall be displayed in the control room or on the applicable converter:
   — stator current in each motor
— field current in each motor (if applicable).

8.6 Emergency stop

8.6.1 Arrangement of emergency stop circuits
When emergency stop of a consumer is required by the rules, the following principles apply:
— The arrangement of the emergency stop system shall be such that no single failure will cause loss of duplicated essential or important equipment. The emergency stop shall have fail-to-safe functionality upon wire break or loss of power.
— The control circuits for emergency stop of duplicated equipment shall be arranged as two separate circuits with separate cables. A common stop button with several contacts (separate for each consumer) will be accepted.
— The emergency stop signal shall act independently of any software based control system for the same consumer.
— A computer based emergency stop systems shall be independent from other computer based systems with control functions for the same consumers. It shall have facilities to detect failures that will set the system inoperable, and give alarm to the main alarm system. See Ch.9.
— Alarm for loss of power shall be provided for normally open emergency stop circuits.

Guidance note:
Emergency stop systems may be based on both normally open (NO) and normally closed (NC) circuits, depending on the arrangement and the function of the system to be stopped. Systems, which can be stopped without any hazard, should be based on NC circuits, emergency stop of systems having effect on propulsion motors and thruster should be based on NO circuits.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

8.6.2 Emergency stop of oil pumps and fans
a) Emergency stops of at least the following pumps and fans shall be arranged from an easily accessible position outside the space being served. These positions should not be readily cut off in the event of a fire in the spaces served:
— fuel oil transfer pumps
— fuel oil feed and booster pumps
— nozzles cooling pumps when fuel oil is used as coolant
— fuel and lubrication oil purifiers
— pumps for oil-burning installations
— fans for forced draught to boilers
— all ventilation fans
— all electrical driven lubrication oil pumps
— thermal oil circulating pumps
— hydraulic oil pumps in machinery space.
— Auxiliary blowers for combustion engines
(Interpretation of SOLAS Reg. II-2/5.2.2)

b) The means provided for stopping the power ventilation of the machinery spaces shall be entirely separate from the means provided for stopping ventilation of other spaces.

Guidance note:
Emergency stop will not be required for the following:
— fans not capable of supplying outside air to the space such as fans in HVAC temperature control units, fans for heating coils, ventilation fans for cabinets and switchboards, etc.
— pumps for systems containing less than 500 litre of flammable oil.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
9 Vessel Arrangement

9.1 General

9.1.1 Ventilation

a) Rooms where electrical equipment is located shall be sufficiently ventilated in order to keep the environmental conditions within the limits given in Sec.3 [2.3].

b) The heat generated by the electrical equipment itself, by other machinery and equipment, and the heat caused by sun radiation on bulkheads and decks should not lead to operating ambient temperatures in excess of the limits listed in Sec.3 Table 1.

c) The air supply for internal cooling of electrical equipment (i.e. “ventilated equipment”) shall be as clean and dry as practicable. Cooling air shall not be drawn from below the floor plates in engine and boiler rooms.

d) If mechanical cooling is required by a piece of electrical equipment, the same redundancy requirement applies to the cooling system as to the equipment and its power supply.

e) Where the actual ambient air temperatures will clearly exceed the limits listed in Sec.3 Table 1, the equipment shall be designed for the actual operating ambient temperatures concerned.

9.1.2 Arrangement of power generation and distribution systems

a) The arrangement of the main electric lighting system shall be such that fire, flooding or other casualty in spaces containing the main source of electrical power, associated transforming equipment, if any, the main switchboard and the main lighting switchboard will not render the emergency electric lighting system inoperative. (Interpretation of SOLAS Ch. II-1/41.2.2)

b) The arrangement of the emergency electric lighting system shall be such that fire, flooding or other casualty in spaces containing the emergency source of electrical power, associated transforming equipment, if any, the emergency switchboard and the emergency lighting switchboard will not render the main electric lighting system inoperative. (Interpretation of SOLAS Ch. II-1/41.2.3)

c) The integrity of the main electrical supply shall be affected only by fire, flood or other damage conditions, in one space. The main switchboard shall be located as close as is practicable to the main generating station. (Interpretation of SOLAS Ch. II-1/41.3)

d) The main generating station shall be situated within the engine room, i.e. within the extreme main transverse watertight bulkheads forming the engine room. Where essential services for steering and propulsion are supplied from transformers, converters and similar appliances constituting an essential part of electrical supply system they shall also satisfy the foregoing.

e) The integrity of the emergency electrical supply and the transitional source of power shall not be affected by fire, flood or other casualty in the main electrical supply, or in any machinery space of category A. The emergency switchboard shall be located in the same space as the emergency generating station. (Interpretation of SOLAS Ch. II-1/43.1.3 and 43.1.4)

f) Normally, the space containing the emergency source of power and associated electrical distribution shall not be contiguous to the boundaries of machinery space of category A or those spaces containing the main source of electrical power and associated electrical distribution. (Interpretation of SOLAS Ch. II-1/43.1.4)

g) Where it is required to divide a ship into fire zones distribution switchboards for essential or important equipment shall be installed in the same fire zone as the equipment itself.

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

The requirements in a) do not preclude the installation of supply systems in separate machinery spaces, with full redundancy in technical design and physical arrangement.
This paragraph implies that battery systems for emergency supply shall not be installed in the same cabinet or battery room as battery systems for other consumers.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

9.2 Switchboard arrangement

9.2.1 Installation of switchboards

a) Switchboards shall be placed in easily accessible and well-ventilated locations, well clear of substantial heat sources such as boilers, heated oil tanks, and steam exhaust or other heated pipes. Ventilation and air conditioning systems shall be so arranged that possible water or condensation cannot reach any switchboard parts.

(Interpretation of SOLAS Ch. II-1/45.2)

b) Pipes shall not be installed so that switchgear may be endangered in the event of leaks. If installation of pipes close to the switchgear is unavoidable, the pipes should not have any flanged or screwed connections in this area.

c) Switchboards shall not be located immediately above spaces where high humidity or high concentrations of oil vapours can occur (e.g. bilge spaces), unless the switchboard has a tight bottom plate with tight cable penetrations.

d) The arrangement and installation of switchboards shall be such that operation and maintenance can be carried out in a safe and efficient way. When switchgear is located close tobulkheads or other obstructions, it shall be possible to perform all maintenance from the front.

e) For water-cooled electrical equipment seawater pipes shall be routed away from the equipment, so that any leakage in flanges do not damage the equipment.

9.2.2 Installation and arrangement of high voltage switchgear and controlgear

a) The space where high voltage switchgear and controlgear are installed shall be so arranged that hot gases escaping from the switchboard in case of an internal arc are led away from an operator in front of the switchboard. Rooms where high voltage switchgear and controlgear are installed shall not be used for regular work spaces unless the installation meets the type test requirement of IEC 62271-200 clause 6.106 (Internal arc test). If the gas pressure resulting from accidental arcs within the switchboard is to be vented via pressure-release flaps, the installation space shall be as specified by the switchgear manufacturer and shall have an sufficient volume.

b) If the switchboard is designed so that the gas pressure caused by accidental arcs is also, or only, released downwards, the floor shall be constructed so that it can withstand this pressure. Care shall be taken to ensure that sufficient volumes of space are available below the floor for the expansion of the accidental-arc gases. Combustible materials and low-voltage cables are not admissible in the endangered area.

c) The partitioning of gas insulated switchboards and busbar systems shall correspond with the requirements of an air insulated switchboard. The different switchboard sections shall have separate gas insulation so that a gas leak only affects one section.

d) SF6 insulated switchboards and busbar systems shall only be installed in spaces which are adequately ventilated. An exhaust fan shall be provided. It shall be ensured that SF6 is prevented from flowing down to lower spaces.

e) Gas bottles with SF6 gas shall be stored in a separate space with its own ventilation arrangements. Measures shall be taken to ensure that, in the event of leakage, no gas can flow unnoticed into any lower spaces.

Guidance note:
The overpressure created by an arc should be taken into account for the structural design of the room. It is recommended to lead the accidental-arc gases by ducts of sufficient cross-section out of the place of operation.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
9.2.3 Passage ways for main and emergency switchboards

a) Passages in front of main switchboards shall have a height of minimum 2 m. The same applies to passages behind switchboards having parts that require operation from the rear.

b) The width of the front passage shall be as given in Table 2.

c) Where switchgear needs passage behind for installation and maintenance work the free passage behind the switchgear shall be as given in Table 2.

d) The free passageway in front of, or behind the switchboard, shall give unobstructed access to a door for easy escape in case of an emergency situation occurring in the space.

### Table 2

<table>
<thead>
<tr>
<th>System voltage</th>
<th>Width of front passage</th>
<th>Width of passage behind</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Unobstructed</td>
<td>With doors open or switchgear drawn out</td>
</tr>
<tr>
<td>Below 500 V</td>
<td>0.8 m</td>
<td>0.4 m</td>
</tr>
<tr>
<td>500 V ≤ and ≤ 1000 V</td>
<td>0.8 m</td>
<td>0.4 m</td>
</tr>
<tr>
<td>Above 1000 V</td>
<td>1 m</td>
<td>0.5 m</td>
</tr>
</tbody>
</table>

9.2.4 Distribution switchboards

a) Distribution switchboards shall be placed in accessible spaces with enclosures as specified in Sec.10.

b) Alternatively switchboards may be placed in cupboards made of or lined with material that is at least flame-retardant, and with door, cable entrances and other openings (e.g. for ventilation) arranged so that the cupboard in itself complies with the protection required in Sec.10.

c) The front of the switchboard, inside such a cupboard, shall comply with enclosure type IP 20 with exemption for fuses as specified in Sec.4 [1.1.3].

9.2.5 Controlgear for equipment in pipe tunnels, bunker and cargo spaces

All lighting and power circuits terminating in a pipe tunnel, bunker or cargo space shall be provided with a multiple pole switch outside the space for disconnecting such circuits. (Interpretation of SOLAS Ch. II-1/45.8)

9.3 Rotating machines

9.3.1 General

a) Generating sets with horizontal shaft shall generally be installed with the shaft in the fore-and-aft direction of the vessel.

b) Where a large machine is installed athwartships, it should be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling specified in of the Rules for Classification of Ships. The manufacturer should be informed when a machine for installation athwartships is ordered.

c) Normally water pipes or oil or fuel pipes shall not be installed above generators. If this is unavoidable, additional screening of flanges shall be required in order to protect the generator against splash, spray or leakage. Such screening shall be provided with drains, if necessary.

9.4 Battery installations

9.4.1 Application

These requirements are applicable to all types of rechargeable NiCd and Lead Acid batteries. Other rechargeable battery technologies are covered by Pt.6 Ch.2.
Guidance note:
Installation of battery types which may not produce explosive gasses but which may require other safety precautions will be evaluated on a case-by-case basis. Installation and ventilation recommendations from the manufacturer should always be followed.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

9.4.2 Equipment in cabinets and battery rooms
Requirements for installation of electrical equipment in battery rooms, lockers or boxes are given in Sec.11 [3.2.4].

9.4.3 Arrangement
a) Accumulator batteries shall be suitably housed, and compartments shall be properly constructed and efficiently ventilated.
b) Batteries shall be so located that their ambient temperature remains within the manufacturer’s specification at all times
c) Battery cells shall be placed so that they are accessible for maintenance and replacement
d) Batteries shall be so installed that battery poles are covered/protected such that a short circuit is prevented in case of falling objects or other incidents.
e) Batteries shall not be located in sleeping quarters. Exemptions shall be justified and will be specially considered.
f) Batteries shall not be located in a battery box at open deck exposed to sun and frost. Batteries may exceptionally be accepted located at open deck on the conditions that the box is white in colour, are provided with ventilation and heating, and that the charger is provided with temperature compensation capability.

9.4.4 Ventilation of spaces containing batteries
Requirements to ventilation of spaces containing batteries are based on the possible gassing of batteries. The amount of gassing depends on charging power and type of battery. Calculations of ventilation rate shall be based on the following calculations:

a) Calculation of battery charging power (P).

\[ P = U \cdot I \]

\[ P = \text{Calculated battery charging power [W]} \]

\[ U = \text{Rated battery voltage [V]} \]

\[ I = \text{Charging current [A]} \] where

\[ I = 8 \cdot K/100 \text{ for lead acid batteries} \]

\[ I = 16 \cdot K/100 \text{ for NiCd- batteries} \]

\[ K = \text{Battery capacity [Ah]} \]

If several battery sets are used, the sum of charging power shall be calculated.

b) Calculation of required ventilation flow rate:

\[ Q = f \cdot 0.25 I \cdot n \]

\[ Q = \text{Ventilation flow rate [m}^3/\text{h]} \]

\[ n = \text{Number of battery cells in series connection} \]

\[ f = 0.03 \text{ for VRLA (valve-regulated lead-acid battery) batteries} \]

\[ f = 0.11 \text{ for vented batteries} \]

If several battery sets are installed in one room, the sum of ventilation flow rate shall be calculated.

c) Calculation of required cross section of ventilation ducts, assuming an air speed of 0.5 m/s:
\[ A = 5.6 \cdot Q \]
\[ A = \text{Cross-section [cm}^2\text{]} \]

9.4.5 **VRLA batteries installed in switchboards with calculated battery charging power up to 0.2kW**

Such batteries may be installed in switchboards without separation to switchgear and without any additional ventilation, if:

— the battery cases are not closed completely (IP 2X is suitable)
— the charger is regulated automatically by an IU- controller with a maximum continuous charging voltage of 2.3 V/cell

9.4.6 **Batteries installed in spaces with calculated battery charging power up to 2 kW for vented batteries and 8 kW for VRLA batteries**

Such batteries shall be installed in ventilated cabinets or containers arranged in ventilated spaces. The free air volume of the space shall be larger than required volume calculated as follows:

\[ V = 2.5 \cdot Q \]
\[ V = \text{Free air volume in the room [m}^3\text{]} \]
\[ Q = \text{Ventilation flow rate [m}^3\text{/h]} \]

If the space free air volume is not sufficient or the ventilation duct does not have the required cross-section, mechanical ventilation shall be provided. The air quantity Q shall be calculated, and the air speed shall not exceed 4 m/s. Wherever possible exhaust fans shall be used.

9.4.7 **Batteries installed in spaces with calculated battery charging power more than 2 kW for vented batteries and 8 kW for VRLA batteries**

Such batteries shall be installed in closed cabinets, containers or battery rooms with mechanical ventilation to open deck area.

Vented Lead acid batteries up to 3 kW calculated charging power may be ventilated by natural ventilation to open deck area.

9.4.8 **Ventilation of battery spaces**

a) The ventilation system shall be independent of the ventilation systems serving other rooms

b) Ventilation inlet and outlet openings shall be so arranged to ensure efficient ventilation of the free air volume. The air inlet openings shall be arranged in the lower part and air outlet openings shall be arranged in the upper part, so that the total free air volume is ventilated.

c) Required cross section of air ducts for natural ventilation is given in the calculation in [9.4.3]. If mechanical ventilation is required, the air speed shall not exceed 4 m/s,

d) The inclination of air ducts shall not exceed 45° from vertical.

e) Where lockers are provided for batteries, the duct shall terminate not less than 0.9 m above the top of the battery enclosure. Devices which obstruct the free passage of air, e.g. fire dampers and safety screens, shall not be mounted in the ventilation inlet and outlet ducts of battery-rooms. However, battery room ventilators are to be fitted with a means of closing whenever:

— The battery room ventilation does not lead directly to an open deck, or
— The battery room is fitted with a fixed gas fire extinguishing system.

f) Where a battery room ventilation duct is fitted with a closing device, then a warning notice, stating for example “This closing device is to be kept open and only closed in the event of fire or other emergency – EXPLOSIVE GAS”, shall be provided at the closing device.
g) Fans shall be of non-sparking construction (Ref IACS Unified Requirements F29) The fan motors shall be either certified safe type with a degree of protection for gas group IIC and temperature class IIC T1 or located outside of the ventilation duct.

9.4.9 Charging station for battery powered fork lift

a) A charging station is defined as a separate room, only used for this purpose, or as a part of a large room, for example a cargo hold, based on the area occupied by the fork lift plus 1 m on all sides.

b) Socket outlets for the charging cables, mechanically or electrically interlocked with switchgear, can be placed in the charging station. Such socket outlets shall have at least enclosure IP 44 or IP 56, depending upon the location (see Table 1). In general no other electrical equipment, except explosion protected equipment (according to Sec.11) as specified for battery rooms may be installed.

c) Charging stations shall generally be arranged as battery rooms with charging power in accordance with the battery capacity of the fork lift, see [9.4.4]. For charging stations in cargo holds having mechanical overpressure ventilation, an alternative arrangement shall provide a natural ventilation outlet duct of sufficient capacity from the upper part of the charging station to free air.

9.5 Cable routing

9.5.1 General

a) Cable runs shall be installed well clear of substantial heat sources such as boilers, heated oil tanks, steam, exhaust or other heated pipes, unless it is ensured that the insulation type and current rating is adapted to the actual temperatures at such spaces.

b) For installations in connection with hazardous areas, requirements for selection of cables, cable routing and fixing, see Sec.11. (Interpretation of SOLAS Ch. II-1/45.5.4)

c) Other requirements for cable routing and installation are located in Sec.10.

9.5.2 Separation of cables for emergency services, essential and important equipment

a) Where it is required to divide a ship into fire zones cable runs shall be arranged so that fire in any main vertical fire zone will not interfere with essential services in any other such zone. (Interpretation of SOLAS Ch. II-1/45.11)

b) Emergency consumers shall be supplied directly from the emergency switchboard or from distribution switchboards to which only consumers in their respective fire zones are connected.

c) The cables for duplicated steering gear motors shall be separated throughout their length as widely as is practicable. This also applies to control circuits for the steering gears motor starters, and to cables for remote control of the rudder from the bridge.

d) Cables and wiring serving essential, important or emergency equipment shall be routed clear of galleys, machinery space category A and other high fire risk areas, except for cables supplying equipment in those spaces. They shall not be run along fire zone divisions, so that heating through the division due to fire, jeopardise the function of the cables. Special attention shall be given to the protection and routing of main cable runs for essential equipment, for example between machinery spaces and the navigation bridge area, taking into account the fire risk existing in accommodation spaces. (Interpretation of SOLAS Ch. II-1/45.5.3)

e) Cables may exceptionally be routed through high fire risk area, but shall then have additional fire protection, e.g. by using cable tested in accordance with IEC 60331. The restrictions given in [10.1.2] has to be observed.

Guidance note:
Main cable runs are for example:
— cable runs from generators and propulsion motors to main and emergency switchboards
— cable runs directly above or below main and emergency switchboards, centralised motor starter panels, section boards and centralised control panels for propulsion and essential auxiliaries.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
9.5.3 Separation of main generators or main power converters cabling

a) Cables for generators, transformers and converters required according to RU SHIP Pt.4 Ch.8 Sec.2, shall be divided between two or more cable runs. As far as practicable, these cable runs shall be routed away from each other and away from areas required to be protected by Fixed Water-Based Local Application Fire-Fighting Systems, e.g. boiler fronts, purifiers for heated fuel oil, the fire hazard portions of internal combustion machinery and incinerators.

b) In areas where it is impossible to separate the cable runs, they shall be protected against direct exposure to fire (e.g. screens or ducts or fire-protecting coating) and mechanical damage.

9.6 Lightning protection

9.6.1 General

a) All vessels with masts or topmasts made of non-conductive material shall be provided with lightning protection.

b) A lighting conductor shall be fitted on all non-metal masts on craft with a non-metal hull.

c) Primary conductors provided for lightning discharge currents shall have a minimum cross section of 70 mm² in copper or equivalent surge carrying capacity in aluminium.

d) The conductor shall be fastened to a copper spike of minimum diameter 12 mm reaching a minimum of 300 mm above the mast. The conductor shall terminate to a copper plate with a minimum area of 0.25 m² attached to the hull and so located that it is immersed under all conditions of heel.

e) Craft with a metal hull shall be fitted with a lightning conductor on all non-metal masts. The conductor shall be as required in c) and be terminated to the nearest point of the metal hull.

9.7 Earthing of aluminium superstructures on steel vessels

9.7.1 General

Aluminium superstructures that are provided with insulating material between aluminium and steel in order to prevent galvanic action, shall be earthed to the hull. For this purpose, corrosion-resistant metal wires or bands shall be used. The sum of conductivities of all connections for one superstructure shall not be less than 50 mm² copper, and the conductivity of each connection shall not be less than 16 mm² copper.

Provisions shall be made for preventing galvanic action at the terminals of these connections (e.g. by using “Cupal” terminals when copper wires or bands are connected to the aluminium constructions).

10 Cable Selection

10.1 General

10.1.1 General

These technical requirements for cables and cable installations are considered relevant for the system design phase of a project as well as to the final installation on the vessel.

Other relevant requirements related to cables can be found elsewhere in the rules, especially:

— [9.5] - requirements for the routing of electric cables
— Sec.9 - technical requirements for cables as electrical components
— Sec.10 - requirements for the installation of cables
— Sec.11 - requirements for cables used in hazardous areas.

10.1.2 Fire resistant cables

a) Cables for services required to be operable under fire conditions shall be of fire resistant type where they pass through machinery spaces of category A and other high fire risk areas other than those which they...
serve. A fire resistant cable shall comply with the requirements of IEC 60331-1 for cables of greater than 20 mm overall diameter, otherwise 60331-21 or IEC 60331-2. For passenger vessels this requirement also applies for such cables passing through main vertical fire zones. (IACS UR E15)

b) Systems that are self-monitoring, fail safe or duplicated with runs as widely as is practicable may be exempted.

c) The following electrical services are required to be operable under fire conditions:
   — fire and general alarm system
   — fire extinguishing systems and fire extinguishing medium alarms
   — control and power systems to power operated fire doors and status indication for all fire doors
   — control and power systems to power operated watertight doors and their status indication
   — emergency lighting
   — public address system
   — low location lighting
   — emergency fire pump (IACS UI SC 165)
   — remote emergency stop/shutdown arrangements for systems which may support the propagation of fire and or explosion (IACS UR E 15).

d) Cables for emergency fire pump shall not pass through the machinery space containing the main fire pumps, their source of power or their prime movers.

Guidance note:
"High fire risk areas" in the context of above rules are:
   — machinery spaces of category A,
   — galleys and pantries containing cooking appliances,
   — laundries containing drying equipment,
   — saunas,
   — sale shops, barber shops and beauty parlours,
   — paint lockers and other store-rooms for flammable liquids.

10.1.3 Voltage rating

a) The rated voltage of a cable shall not be less than the nominal voltage of the circuits in which it is used.
b) Cables designed in accordance with Sec.9 [5.1] are only accepted for use in control and instrumentation systems up to 250 V.
c) In power distribution systems, with system voltage up to 250 V, 0.6/1 kV power cables in accordance with Sec.9 [4.1] shall be used.
d) In systems with high-resistance earthed neutral the rated phase to earth voltage \((U_0)\) of the cables shall not be less than given in Table 3.
e) In systems with insulated neutral (IT-systems), the rated phase to earth voltage \((U_0)\) of the cables shall be as for systems with high-resistance earthed neutral without automatic disconnection upon earth fault.

Guidance note:
1) It is recommended that cables used for semiconductor converters for motor drives are selected with increased voltage rating in order to withstand voltage transients. Maker’s recommendations should be followed.
2) Cables designed in accordance with IEC 60092-376 are not accepted as power cables, and can therefore not be used for light circuits etc., only instrumentation and control circuits cables.
3) 0.6/1 kV cables may be accepted in 690 V IT distribution systems.

3.6/6 kV cables may be accepted in 6.6 kV distribution systems with automatic disconnection upon earth fault if accepted by manufacturer.
Table 3 Rated voltage for high voltage cables and high voltage equipment

<table>
<thead>
<tr>
<th>Nominal system voltage (kV)</th>
<th>Highest system voltage (Um) or rated equipment voltage (kV) 1)</th>
<th>Minimum voltage rating for cables U0/U (Um) (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>High resistance earthed neutral systems with automatic disconnection upon earth fault</td>
</tr>
<tr>
<td>3.0 / 3.3</td>
<td>3.6</td>
<td>1.8/3 (3.6)</td>
</tr>
<tr>
<td>6.0 / 6.6</td>
<td>7.2</td>
<td>3.6/6 (7.2)</td>
</tr>
<tr>
<td>10.0 / 11.0</td>
<td>12.0</td>
<td>6.0/10 (12)</td>
</tr>
<tr>
<td>15.0 / 16.5</td>
<td>17.5</td>
<td>8.7/15 (17.5)</td>
</tr>
<tr>
<td>20 / 22</td>
<td>24.0</td>
<td>12.0/20 (24)</td>
</tr>
<tr>
<td>30 / 33</td>
<td>36.0</td>
<td>18.0/30 (36)</td>
</tr>
</tbody>
</table>

1) The rated voltage for switchgear and controlgear is equal to the maximum system voltage for which the equipment is designed.

10.1.4 Colour code on earthing cable
Colour code is not required on earthing cables. However if yellow/green colour code is used, it shall be used for protective earthing only.

10.1.5 Cable separation and protection
Separate cables shall be used for circuits provided with separate short circuit or over current protection except for:
- control circuits branched off from a main circuit may be carried in the same cable as the main circuit
- multi-core cables used for intrinsically safe circuits see Sec.11 [4.2.7]
- special cables such as umbilicals to be considered in each case.

10.2 Cable temperature

10.2.1 Cable temperature class
The temperature class of power cables shall be at least 10°C above the ambient temperature.

10.3 Choice of insulating materials

10.3.1 Short circuit and cable
The conductor cross-section of cables shall be sufficient to prevent the insulation from being damaged by high temperatures occurring by short circuits at the cable end. The conductor temperature classes are given in IEC 60092-360.

10.3.2 Switchboard wires
a) Switchboard wires without further protection may be used for installation in closed piping systems in accommodation spaces, when the system voltage is maximum 250 V.
b) Switchboard wires may be used for internal wiring of switchboards and other enclosures, and for control wiring installed in closed piping systems. Other types of flame retardant switchboard wires may be accepted for the same purpose. See Sec.9.
10.3.3 PVC insulated cables
Due to brittleness at low temperatures, cables with PVC outer sheath, shall normally not be installed in refrigerated chambers, and holds for temperatures below -20°C, or across expansion joints on weather decks.

10.3.4 Silicon rubber insulated cables
Due to poor mechanical strength, the use of silicon-rubber-insulated cables is limited to applications where a high temperature resistant cable is necessary (where the ambient temperature can be above 70°C).

10.4 Rating of earth conductors

10.4.1 Earthing connections and conductors
a) All earthing connections of copper shall have sufficient cross-section to prevent the current density exceeding 150 A/mm² at the maximum earth fault currents that can pass through them.
b) Minimum cross-section of protective earthing conductors (PE) shall be as listed in Table 4.
c) Bonding of the braid itself is not considered to be a protective earthing.
d) Additional requirements to earth conductor sizing for high voltage equipment is given in Sec.3 [4.4]

Table 4 Earthing connections and conductors

<table>
<thead>
<tr>
<th>Arrangement of earth conductor</th>
<th>Cross-section Q of associated current carrying conductor (one phase or pole) (mm²)</th>
<th>Minimum cross-section of earth conductor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Insulated earth conductor in cable for fixed installation</td>
<td>Q ≤ 16</td>
<td>Q</td>
</tr>
<tr>
<td>2) Copper braid of cable for fixed installation when the cable is provided with an insulating outer sheath. (For cables without insulating outer sheath, the braiding cannot be used as a protective earth conductor)</td>
<td>16 &lt; Q</td>
<td>1/2 of the current-carrying conductor, but not less than 16 mm²</td>
</tr>
<tr>
<td>3) Separate, insulated earth conductor for fixed installation in pipes in dry accommodation spaces, when carried in the same pipe as the supply cable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) Separate, insulated earth conductor when installed inside enclosures or behind covers or panels, including earth conductor for hinged doors as specified in Sec.10 [2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) Uninsulated earth conductor in cable for fixed installation, being laid under the cable's lead sheath, armour or copper braid and in metal-to-metal contact with this.</td>
<td>Q ≤ 2.5</td>
<td>1 mm²</td>
</tr>
<tr>
<td></td>
<td>2.5 &lt; Q ≤ 6</td>
<td>1.5 mm²</td>
</tr>
<tr>
<td></td>
<td>6 &lt; Q</td>
<td>Not permitted</td>
</tr>
<tr>
<td>3) Separately installed earth conductor for fixed installation other than specified in 1.</td>
<td>Q &lt; 2.5</td>
<td>Same as current-carrying conductor subject to minimum 1.5 mm² for stranded earthing connection or 2.5 mm² for unstranded earthing connection</td>
</tr>
</tbody>
</table>
2.5 < Q

1/2 of current-carrying conductor, but not less than 4 mm²

For IT distribution systems (and high resistance earthed systems) protective earthing conductors need not to be larger than 70 mm².

| Q ≤ 16 | Same as current-carrying conductor |
| 16 < Q | 1/2 but minimum 16 mm² |

10.5 Correction factors

10.5.1 Different temperature classes
If cables of different temperature classes are carried in the same bunch or pipe, the current ratings for all cables shall be based on the lower temperature class.

10.5.2 Multicore cables
For cables with more than 4 cores, the current ratings are given by the following equation:

\[ N = \frac{J_I}{\sqrt[3]{N}} \]

\( N \) = number of cores

\( J_I \) = the current rating for a single-core cable.

This applies by equal load on all cores. If some cores in such multi-core cables are not used, or are used for very small currents only, the current rating for the other cores may be increased after consideration in each case.

10.5.3 Ambient temperature
When the actual ambient air temperature clearly differs from 45°C, the correction factors as given in Table 7 apply.

10.5.4 Method of installation
Cable rating and method of installation shall provide conditions preventing cables to operate above their design temperature.

When installed in a single layer without free air circulation between the cables, the current ratings specified in the Table 5 and Table 6 can be used. However, these ratings are based on maximum 6 cables, which can be expected to be under full load simultaneously.

A correction factor of 0.85 shall be applied if more than 6 multi-core cables, are installed without spacing for free air circulation.

The reduction factor for more than 6 single core cables should be as given in IEC 60092-352 Annex A.

Free air circulation is achieved by a spacing equal the cable diameter when laid in a single layer. For three-foil formation, the distance shall be at least twice the cable diameter.

Guidance note:
A single-core cable is to be understood as one cable with respect to the use of reduction factor, i.e. reduction factor must be used when more than 6 single-core cables are bunched together.
10.5.5 Periodic load
For cables used for loads that are not continuous, i.e. operates for periods of half or one hour and the periods of no-load is longer than 3 times the cable time constant T (in minutes), the current rating may be increased by a duty factor, \( D_f \), calculated from:

\[
D_f = \frac{1.12}{\sqrt{1 - e^{-ts/T}}}
\]

\( ts \) = the service time of the load currents in minutes \\
\( T \) = cable’s time constant; 0.245 \( d^{1.35} \) \\
\( d \) = overall diameter of the cable in mm.

10.5.6 Intermittent load
Cables used for loads that are not continuous, are repetitive and have periods of no-load of less than 3 times the cable time constant T (in minutes), the current rating may be increased by an intermittent factor, \( I_f \), calculated from:

\[
I_f = \frac{1 - e^{-tp/T}}{\sqrt{1 - e^{-ts/T}}}
\]

\( Ts \) = the service time of the load currents in minutes \\
\( Tp \) = the intermittent period in minutes (i.e. the total period before of load and no-load before the cycle is repeated)

ts, T and d, see [10.5.5].

10.6 Parallel connection of cables
10.6.1 General
a) Parallel connection can be used for cables having conductor cross-section 10 mm\(^2\) or above. All cables that are parallel connected shall be of the same length, cross-section and construction. The current-carrying capacity is the sum of all parallel conductors’ current-carrying capacities.

b) A two, three or four-core cable, in which all cores are of the same cross-section, can be used as single-core cable by parallel connection of all cores in each end. The current-carrying capacity of such single-core cable is the sum of the cores’ current-carrying capacities.

c) With parallel connection of multi-core cables, one core of each cable shall be used for each phase and neutral connection, respectively.

d) With many parallel-connected cables, the current distribution may be uneven. However, no single cable shall, after installation, carry more than its capacity. This shall be demonstrated at full load of the consumer.
10.7 Additional requirements for AC installations, and special DC installations

10.7.1 General

a) Generally, multi-core cables shall be used on AC installations.
b) On three-phase, four-wire circuits, the cross-section of the neutral conductor shall be the same as for a phase conductor up to 16 mm$^2$, and at least 50% of that of a phase conductor for larger cross-sections, though not larger than 50 mm$^2$. The braiding in a cable shall not be used as the neutral conductor.
c) The neutral conductor shall normally be a part of the power supply cable. Separate neutral cable may be accepted for cross section above 16 mm$^2$, if the power cable not is provided with magnetic braiding.

10.7.2 Single-core cables

a) Single-core cables shall not have steel-wire braid or armour when used in AC systems and DC systems with a high “ripple” content.
b) See Sec.10 [3.2.4] and Sec.10 [3.5.6] for fixing of single core cables.

10.8 Rating of cables

10.8.1 Conductor current rating

The highest continuous load carried by a cable with temperature class 90 °C shall not exceed the current rating specified in Table 5 and Table 6, with consideration given to the installation method and correction factors given in [10.5]. The Table 5 and Table 6 is based on the assumption that the installation permits free airflow around the cables, e.g. supported by ladders, cleats, hangers or perforated trays where the holes occupy more than 30% of the area. For other installation methods, or other temperature classes, IEC 60992-352 Annex A is to be used.

For current rating of wires used inside switchgear and controlgear, see Sec.4 [2.1.6]

Guidance note: Cables used in circuits with non-sinusoidal currents should be de-rated in order to compensate for the additional heat losses. Maker’s recommendations should be followed.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

Table 5 Rating of cables with temperature class 90°C

<table>
<thead>
<tr>
<th>Nominal cross-section (mm$^2$)</th>
<th>Single-core (Based on ambient temperature 45°C)</th>
<th>2-core</th>
<th>3 or 4-core</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>18</td>
<td>15</td>
<td>13</td>
</tr>
<tr>
<td>1.5</td>
<td>23</td>
<td>20</td>
<td>16</td>
</tr>
<tr>
<td>2.5</td>
<td>30</td>
<td>26</td>
<td>21</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>34</td>
<td>28</td>
</tr>
<tr>
<td>6</td>
<td>52</td>
<td>44</td>
<td>36</td>
</tr>
<tr>
<td>10</td>
<td>72</td>
<td>61</td>
<td>50</td>
</tr>
<tr>
<td>16</td>
<td>96</td>
<td>82</td>
<td>67</td>
</tr>
<tr>
<td>25</td>
<td>127</td>
<td>108</td>
<td>89</td>
</tr>
<tr>
<td>35</td>
<td>157</td>
<td>133</td>
<td>110</td>
</tr>
</tbody>
</table>
### Table 6 Rating of cables with temperature class 95 °C

<table>
<thead>
<tr>
<th>Nominal cross-section (mm²)</th>
<th>Current rating (A) (Based on ambient temperature 45°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single-core</td>
</tr>
<tr>
<td>1, 5</td>
<td>26</td>
</tr>
<tr>
<td>2,5</td>
<td>32</td>
</tr>
<tr>
<td>4</td>
<td>43</td>
</tr>
<tr>
<td>6</td>
<td>55</td>
</tr>
<tr>
<td>10</td>
<td>76</td>
</tr>
<tr>
<td>16</td>
<td>102</td>
</tr>
<tr>
<td>25</td>
<td>135</td>
</tr>
<tr>
<td>35</td>
<td>166</td>
</tr>
<tr>
<td>50</td>
<td>208</td>
</tr>
<tr>
<td>70</td>
<td>256</td>
</tr>
<tr>
<td>95</td>
<td>310</td>
</tr>
<tr>
<td>120</td>
<td>359</td>
</tr>
<tr>
<td>150</td>
<td>412</td>
</tr>
<tr>
<td>185</td>
<td>470</td>
</tr>
<tr>
<td>240</td>
<td>553</td>
</tr>
<tr>
<td>300</td>
<td>636</td>
</tr>
<tr>
<td>DC</td>
<td>AC</td>
</tr>
<tr>
<td>400</td>
<td>760</td>
</tr>
<tr>
<td>500</td>
<td>875</td>
</tr>
<tr>
<td>630</td>
<td>1010</td>
</tr>
</tbody>
</table>
Table 7 Correction factors for ambient temperature

<table>
<thead>
<tr>
<th>Cable temperature class</th>
<th>Ambient temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>35 1)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>40 1)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>45 1)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>50 1)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>55 1)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>60 2)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>65 2)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>70 3)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>75 3)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>80 3)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
<tr>
<td>85 3)</td>
<td>1.00 0.84 0.77 0.71 0.63 0.55 0.45</td>
</tr>
</tbody>
</table>

1) Correction factors for ambient temperature below 40°C will normally only be accepted for:
   — cables in refrigerated chambers and holds, for circuits which only are used in refrigerated service
   — cables on vessel with class notation restricting the service to non-tropical water.

2) 60°C cables shall not be used in engine and boiler rooms.
SECTION 3 EQUIPMENT IN GENERAL

1 General Requirements

1.1 References

1.1.1 General

a) This section contains technical requirements for all electrical equipment in general. Additional requirements for special types of equipment can be found in Sec.4 to Sec.9.

b) Requirements for electrical systems as a whole can be found in Sec.2. Requirements for installation of equipment can be found in Sec.10.

1.1.2 Compliance with standards

The requirements in this section are based on the IEC standard system in general.

Guidance note:
IEC Standards covering the general requirements for electrical components for ships are: IEC 60092-101 "Definitions and general requirements", and parts of IEC 60092-201 "Systems design - General".

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2 Environmental Requirements

2.1 Inclination

2.1.1 General

The requirements in Ch.1 Sec.3 Table 3 applies.

2.2 Vibration and acceleration

2.2.1 General

a) Electrical equipment and components shall be constructed to withstand, without malfunctioning, or electrical connections loosening, at least the following values:
   — vibration velocity amplitude 20 mm/s in the frequency range 5 to 50 Hz.

b) For flexibly mounted equipment, special considerations shall be given to the construction of the equipment since larger vibrations may occur.

2.3 Temperature and humidity

2.3.1 Ambient temperature

a) Electrical equipment including components inside enclosures in switchboards etc., shall be constructed for continuous operation at rated load, at least within the ambient air temperature ranges listed in Table 1 and cooling water temperatures in [2.3.2].

b) Modifications of the equipment may be required if the actual ambient air temperatures will clearly exceed the limits in a).

c) If some equipment has a critical maximum ambient temperature by which it suddenly fails, this critical temperature should not be less than 10°C above the limits specified in the table.

d) For vessels with class notation restricting the service to non-tropical waters, the upper ambient air temperature limits according to Table 1 may be reduced by 10°C.
e) For electronic and instrumentation equipment the requirements in Ch.9 applies.

**Guidance note:**
These rules do not appraise ambient conditions for transport or storage of electrical equipment.

---end---of---guidance---note---

### Table 1 Ambient air temperature ranges

<table>
<thead>
<tr>
<th>Location</th>
<th>Minimum ambient air temperature range for continuous operation at rated capacity (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>From</td>
</tr>
<tr>
<td>1 Engine rooms, boiler rooms, galleys and similar spaces, accommodation spaces.</td>
<td>0</td>
</tr>
<tr>
<td>2 Open deck, dry cargo holds, steering gear compartments, deckhouses, forecastle spaces and similar spaces which are not provided with space heating.</td>
<td>-25</td>
</tr>
<tr>
<td>3a) Refrigerated chambers and holds, general.</td>
<td>The minimum temperature specified for the installation, but not above -20</td>
</tr>
<tr>
<td>3b) Refrigerated chambers and holds, for equipment which only is used in refrigerated service.</td>
<td>+35</td>
</tr>
</tbody>
</table>

1) Components and systems are to be designed to operate at ambient air temperature in the machinery spaces between 0°C and 55°C.

#### 2.3.2 Cooling water temperature

The requirements in Ch.1 Sec.3 [2.2.1] apply.

Electrical equipment on vessels with class notation restricting the service to non-tropical waters shall be constructed for continuous operation at a seawater temperature up to +25°C.

#### 2.3.3 Humidity

Electrical equipment shall be constructed to withstand, and function safely in relative humidity up to 95%.

### 3 Equipment Ratings

#### 3.1 Electrical parameters

##### 3.1.1 General

a) Equipment shall be rated for continuous duty unless otherwise clearly stated by the purchaser (see[5]).

b) All conductors, switchgear and accessories shall be of such size as to be capable of carrying, without their respective ratings being exceeded, the current which can normally flow through them. They shall be capable of carrying anticipated overloads and transient currents, for example the starting currents of motors, without damage or reaching abnormal temperatures.

##### 3.1.2 Voltage and frequency

a) Equipment connected to the system shall be constructed for the system's nominal frequency and voltage, voltage drop in distribution, and the tolerances described in Sec.2 [1.2].

b) Any special system, e.g. electronic circuits, whose function cannot operate satisfactorily within the limits given in Sec.2 [1.2] should not be supplied directly from the system but by alternative means, e.g. through stabilized supply.
3.1.3 Harmonic distortion

a) All equipment shall be constructed to operate at any load up to the rated load, with a supply voltage containing harmonic distortion as given in Sec.2 [1.2.7].

3.1.4 Electromagnetic compatibility (EMC)

Equipment producing transient voltage, frequency and current variations shall not cause the malfunction of other equipment on board, neither by conduction, induction or radiation.

**Guidance note:**
The vessel can be divided in three different EMC zones as defined in IEC 60533. Deck and bridge zone, General power distribution zone and Special power distribution zone. Equipment placed in the different zones shall have the corresponding compatibility level. For Deck and bridge zone the compatibility level is given in IEC 60533 or IEC 60945. For General power distribution zone the compatibility level is given in IEC 60533. It is also assumed that either the compatibility level given in the IEC product standards (covering EMC) or the generic EMC standards IEC 61000-6-2 (immunity) and IEC 61000-6-4 (emission) will be sufficient. For Special power distribution zone appropriate measures should be taken so that safe operation is assured.

---end---of---guidance---note---

3.2 Maximum operating temperatures

3.2.1 General

a) The temperature rise of enclosures and their different exterior parts shall not be so high that fire risk, damage to the equipment, adjacent materials or danger to personnel occurs. The temperature rise shall not exceed 50°C. Exemptions may be considered for equipment that is especially protected against touching or splashing of oil.
b) For enclosures installed in contact with flammable materials such as wooden bulkheads, the temperature rise limit is 40°C.
c) For luminaries, resistors and heating equipment, see Sec.8.
d) Maximum temperature for operating handles is:
   - handles and grips made of metal: 55°C
   - handles and grips made of insulating material (porcelain, moulded material, rubber or wood): 65°C.

**Guidance note:**
Higher temperatures may be accepted for parts which normally will not be handled with unprotected hands.

---end---of---guidance---note---

4 Mechanical and Electrical Properties

4.1 Mechanical strength

4.1.1 General

Equipment shall have sufficient mechanical strength to withstand the strains it is likely to be exposed to when installed.

4.1.2 Enclosures

a) Enclosures shall be resistant to weather, oil and chemicals and have sufficient mechanical strength when intended to be installed in an area where risk of mechanical damage exists.
b) Metallic enclosures installed on deck or in compartments where severe corrosion problems can be expected shall be made of especially corrosion resistant material or dimensioned with a suitable corrosion allowance.
c) Light metal alloys as i.e. aluminium shall be avoided as enclosure materials if not documented to be seawater resistant and installed so that local corrosion caused by contact does not occur.

d) Enclosures that are so placed that they are likely to be stepped or climbed on, shall be able to withstand the weight of a man. This applies for example to most electrical machines in the engine room, winch motors on deck, etc. A test to this effect, with a force of 1000 N applied by a flat surface 70 × 70 mm, may be carried out as type test or random test.

e) Enclosures shall withstand the ambient air temperatures which are specified in [2], with the equipment at full load. The temperature rise of enclosures shall not be so high that fire risk, damage to adjacent materials or danger to personnel occurs.

f) When enclosures of other materials than metal are used, they should at least withstand immersion in water at 80°C for 15 minutes, without showing signs of deterioration, and the material shall be flame retardant according to IEC 60092-101. A test to this effect may be carried out as type test or random test. This also applies to screens of luminaries, and to windows in other enclosures, if made of other material than glass.

4.1.3 Materials

a) Electrical equipment shall be constructed of durable non-hygrosopic materials which are not subject to deterioration in the atmosphere to which it is likely to be exposed.

b) Electrical equipment shall be constructed of at least flame retardant materials.

Guidance note:
Even in "dry" locations, up to 96% relative humidity with a salt content of 1 mg salt per 1 m³ of air may occur; in machinery spaces also mist and droplets of fuel- and lubricating oil may also occur.
Tests for flame retardant properties are described in IEC 60092-101. Flammability test in accordance with UL94 5VA, 5VB, V0 and V1 can also be accepted.
For minor equipment or non-metallic parts of electrical components a glow wire test in accordance with IEC 60695-2-11 may be accepted. Parts of insulation material necessary to retain current-carrying parts should conform to a test temperature of 960 ºC.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

4.1.4 Material deterioration due to cargo vapours

Where the cargo gases or vapours are liable to damage the materials used in the construction of electrical apparatus, careful consideration shall be given to the characteristics of the materials selected for conductors, insulation, metal parts, etc. As far as is practicable, components of copper and aluminium, shall be encapsulated to prevent contact with gases or vapours.

Guidance note:
Attention is drawn to the possibility of gases and vapours being transferred from one point to another through cables or cable ducting unless appropriate precautions are taken, for example, adequate end sealing.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

4.2 Cooling and anti-condensation

4.2.1 General

a) Where electrical equipment depends on additional cooling, the following shall be complied with:

— an alarm shall be initiated when auxiliary cooling or ventilation motors stop running. Alternatively a flow monitoring alarm shall be initiated
— for essential services the windings in the cooled equipment shall be equipped with temperature detectors for indication and alarm of winding temperature
— for important services the windings in the cooled equipment shall be equipped with temperature detectors for alarm at high winding temperature.

b) Where the cooling of electrical equipment depends upon general room ventilation only, temperature detectors in the equipment are not required.
4.2.2 Water cooled heat exchangers

a) Where cooling of equipment is arranged through air-water heat exchangers, these shall be arranged to prevent entry of water into the equipment, whether by leakage or condensation. Leakage alarm shall be provided.

b) Heat exchangers in high voltage equipment shall be of double tube type and shall be fitted with leakage alarm.

c) The construction and certification of air-water heat exchangers shall comply with the requirements for pressure equipment, see Ch.7.

d) For direct water cooling of semi-conductor equipment, see Sec.7.

Guidance note:
Leakage detection is not required for jacket water cooled rotating machines due to the low probability for water leak into the machine.

---end---of---guidance---note---

4.2.3 Anti-condensation

a) For equipment where condensation is likely, e.g. due to long idle periods, heating arrangements may be required.

b) All high voltage converters, transformers and rotating equipment not located in heated and ventilated spaces, shall be provided with heating elements in order to prevent condensation and accumulation of moisture. The heating shall be automatically switched on at stand still.

c) All equipment equipped with air/water heat exchangers shall be provided with heating elements in order to prevent condensation and accumulation of moisture. The heating shall be automatically switched on at stand still.

4.3 Termination and cable entrances

4.3.1 Termination

a) All equipment shall be provided with suitable, fixed terminals in an accessible position with sufficient space for dismantling and connection of external incoming cables. Twist-on or clamp-on connections inside connection boxes for lighting and small power consumers are accepted inside dry accommodation.

b) All connections for current-carrying parts and earthing connections shall be fixed so that they cannot loosen by vibration. This also applies to fixing of mechanical parts when found necessary.

c) Terminals for circuits with different system voltages shall be separated, and clearly marked with the system voltage.

d) High voltage terminals, above 1000 V, shall not be located in the same box, or part of enclosure, as low voltage terminals.

e) Electrical equipment that needs to be connected to protective earth according to [4.4] shall be provided with suitable fixed terminal for connecting a protective earth conductor. The terminal shall be identified by a symbol or legend for protective earthing (PE).

4.3.2 Cable entrance

a) Cable entrance shall be so arranged that the enclosure keeps its intended IP rating after installation and in operation.

b) Cable entrances shall be fit for the outer diameter of the cable in question.

Guidance note:
Cable entries from the top on equipment installed on open deck should be avoided unless other alternatives prove impracticable.

---end---of---guidance---note---
4.4 Equipment protective earthing

4.4.1 General

a) Exposed parts of electrical installations, which are liable, under fault conditions to become live, shall be earthed. Requirements to rating of earth conductors are given in Sec.2 [10.4] additionally to what is required in this paragraph.

b) Fixing devices between a high voltage enclosure and steel hull parts shall not be relied upon as the sole earthing connection of the enclosure. An enclosure in this context implies switchgear and controlgear assemblies, transformers, rotating machines and other high voltage equipment.

c) Switchgear and controlgear assemblies shall be fitted with earth connection(s) to ensure earthing of all metallic non-current carrying parts. In main and emergency switchboards a continuous earth-bar is required for this purpose.

d) For the interconnections within an enclosure, for example between the frame, covers, partitions or other structural parts of an assembly, the fastening, such as bolting or welding is acceptable, provided that a satisfactory conductive connection is obtained.

e) Compartment doors with components such as switches, instruments, signal lamps, etc. with voltage exceeding 50 V AC or DC shall be connected to the switchboard or enclosure by a separate, flexible copper earth conductor. In high voltage equipment, this conductor shall have at least 4 mm² cross-section. A compartment door can be earthed through its metallic hinges when it carries any electric components. In high voltage equipment, this conductor shall have at least 4 mm² cross-section.

f) Each high voltage switchgear and/or controlgear assembly shall be provided with a main earthing conductor of cross-section at least 30 mm² copper, with at least 2 adequate terminals for connection to the steel hull. Each unit enclosure and other metallic parts intended to be earthed shall be connected to this main earthing conductor or bar.

g) Earthed metallic parts of withdrawable components in high voltage equipment shall remain earthed, by means of a special earth device, until they have been fully withdrawn. The earthing shall be effective also when in test position with auxiliary circuits live.

h) The secondary winding of any current or voltage transformer installed in a high voltage system shall be earthed by a copper conductor of at least 4 mm² cross-section. Alternatively, unearthed secondary winding with overvoltage protection is accepted.

Exception:
Exception from this requirement is given for machines or equipment:
— supplied at a voltage not exceeding 50 V DC or AC between conductors
— supplied at a voltage not exceeding 250 V by safety isolating transformers supplying only one consuming device. Auto-transformers may not be used for the purpose of achieving this voltage
— constructed in accordance with the principle of double insulation.
(Interpretation of SOLAS Ch. II-1/45.1.1)

4.5 Enclosures ingress protection

4.5.1 General

a) All equipment shall be constructed to prevent accidental touching of live parts, and shall have enclosures with a minimum degree of protection dependent upon the installation area, according to the installation requirements in Sec.10 Table 1, unless a higher degree is required by these rules.

b) For equipment supplied at nominal voltages above 500 V up to and including 1000 V, and which is accessible to unauthorised personnel, it is in addition required that the degree of protection against touching live parts shall be at least IP 4X.

c) High voltage switchgear and controlgear assemblies shall have enclosure type of at least IP 32 when installed in spaces accessible to authorised persons only, and IP 44 in spaces accessible to unauthorized personnel. High voltage switchgear and controlgear without valid type test demonstrating that it will
withstand the effects of an internal arc may be installed in separate rooms with interlock so that access is only possible when the equipment is isolated and earthed.

d) High voltage transformers shall have enclosure type of at least IP 23, when located in spaces accessible only to authorised personnel, and at least IP 54 in other locations. Alternatively, where a transformer is not contained in an enclosure, a separate transformer room may provide the enclosure of the transformer. The door of the room shall then be interlocked with the supply switchgear.

e) High voltage rotating electrical machines shall have a degree of protection by enclosure of at least IP 23, unless a higher degree is required by location.

f) Connection boxes of rotating machines shall in all cases have a degree of protection of at least IP 44.

Guidance note:
Equipment located in machinery spaces may be considered as being accessible to authorised personnel only. The same applies to equipment located in other compartments that normally are kept locked, under the responsibility of the ship's officers.

4.6 Clearance and creepage distances

4.6.1 General

a) The distance between live parts of different potential and between live parts and the cases of other earthed metal, whether across surfaces or in air, shall be adequate for the working voltage, having regard to the nature of the insulating material and the conditions of service.

b) Clearance and creepage distances shall be as required in relevant product standards. When product standards do not give such requirements (e.g. for generators, motors and transformers) the values given in Sec.4 shall be complied with.

c) Electric insulation, e.g. clearance and creepage distances, shall generally be designed for operation in pollution degree 3 and overvoltage category III as defined in IEC 60664. Lower pollution degree may be accepted case by case.

Guidance note:
Requirements to clearance and creepage distances for high and low voltage switchgear and controlgear is given in Sec.4. For semiconductor converters in Sec.7.

5 Marking and Signboards

5.1 General

5.1.1 General

a) All equipment shall be externally marked to enable identification in accordance with the documentation of the power distribution system, and be marked with the manufacturer's name. In addition the system voltage shall be indicated on switchgear and assemblies.

b) All equipment shall if necessary be marked to ensure correct use.

c) See Sec.11 for the requirements for the marking of hazardous area equipment.

d) All marking shall be permanently fixed.

e) Labels bearing clear and indelible indications shall be so placed that all components and all equipment can be easily identified.
5.1.2 Rating plate
All equipment shall be fitted with a rating plate giving information on make, type, current, voltage and power rating and other necessary data for the application.

Guidance note:
More detailed requirements for information noted on rating plates may be found in other applicable sections regarding each equipment type contained in this chapter (Sec.4 to Sec.9).

5.1.3 Labels for switchgear, terminals, cables
a) Internal components in equipment and assemblies such as switchgear, controlgear, fuse gear, socket outlets, lighting equipment and heating equipment shall be marked with make, type, current, voltage and power rating and other necessary data for the application (i.e. to which standard the equipment is produced).
b) The switchgear and fuse gear for each circuit shall be marked with circuit designation, cable cross-section and rating of fuses or necessary data for easy recognition of components and circuits according to relevant drawings.
c) If the switchboard contains two or more distribution systems with different voltages, the different parts shall be marked with the respective voltages at the partitions.
d) Terminals for circuits with different system voltages shall be clearly separated, and clearly marked with the voltage.
e) All terminals for connection of external instrumentation and control cables shall be marked.
f) External instrumentation and control cables shall be marked for identification inside the cabinet. Each core in a cable shall be marked in accordance with the applicable IEC technical standard for cable construction. See Sec.9 [1.1.3]. The identification marking used shall be reflected in the wiring diagram or schematics.

Guidance note:
It is expected that the owner and the builder agree a mutually acceptable method of providing permanent identification marking.

5.1.4 Signboards and warnings
a) Each switchgear and controlgear fed from more than one individually protected circuit shall be marked with a warning sign stating that these circuits shall be isolated when the main circuit is isolated for maintenance purpose. A warning sign is not required if all live circuits within the enclosure are disconnected together with the main power circuit.
b) When, for fuses above 500 V, the fuse holders permit the insertion of fuses for lower nominal voltage, special warning labels shall be placed, for example “Caution, 660 V fuses only”.
c) Special “high voltage” warning signboards are required on all high voltage machines, transformers, cables, switchgear and controlgear assemblies.

6 Insulation

6.1 Insulation materials

6.1.1 General
a) General purpose insulating materials for supporting conductors shall withstand the temperatures to which they are likely to be exposed. This is normally ambient temperature plus the heat from the conductor itself during full load.
b) A thermal classification in accordance with IEC 60085 shall be assigned to the insulation system when used in machines. The normally used classes are shown in Table 2, with the maximum exposure temperatures (including ambient) shown in the right column.
c) Insulating materials shall be at least flame retardant. For cables see requirements in Sec.9.
d) Insulating materials shall be tracking resistant in accordance with IEC 60112. A tracking index of at least 175 V will be required for low voltage equipment. For high voltage equipment the tracking index shall be minimum 300 V. See Sec.13 regarding tracking index.

Table 2 General insulation classes

<table>
<thead>
<tr>
<th>Insulation class (thermal class)</th>
<th>Maximum temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>105</td>
</tr>
<tr>
<td>B</td>
<td>130</td>
</tr>
<tr>
<td>E</td>
<td>75</td>
</tr>
<tr>
<td>F</td>
<td>155</td>
</tr>
<tr>
<td>H</td>
<td>180</td>
</tr>
<tr>
<td>220</td>
<td>220</td>
</tr>
</tbody>
</table>

7 Inspection and testing

7.1 General

7.1.1 General

a) Requirements to inspection and testing of electric equipment are given in the applicable sections in these rules.
b) For equipment that shall be type approved, type tests as listed in Table 3 - Table 5 shall be performed as applicable.

Table 3 Environmental type tests

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Location</th>
<th>Minimum equipment specification</th>
<th>Test reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>Inside vessel</td>
<td>Ambient temperatures: +0°C to +45°C, see also [2.3.1] c)</td>
<td>IEC 60068-2-2 (Dry heat test)</td>
</tr>
<tr>
<td></td>
<td>Outside vessel</td>
<td>Ambient temperatures: -25°C to +45°C</td>
<td>IEC 60068-2-2 (Dry heat test) IEC 60068-2-1 (Cold test)</td>
</tr>
<tr>
<td>Humidity</td>
<td>All locations</td>
<td>Relative humidity up to 95% at all relevant temperatures.</td>
<td>IEC 60068-2-30 test Db</td>
</tr>
<tr>
<td>Vibration</td>
<td>All locations</td>
<td>Frequency range: 5-50 Hz, Velocity: 20 mm/s (amplitude)</td>
<td>IEC 60068-2-6 test Fc or IEC 60068-2-64 test Fh (max 10 times amplification)</td>
</tr>
</tbody>
</table>
### Table 4 Electrical EMC type tests

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Location as defined in IEC 60533</th>
<th>Minimum equipment specification</th>
<th>Test reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation</td>
<td>All location</td>
<td>Insulation Resistance Sec.10 Table 5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All location</td>
<td>1 minute High Voltage Test [4.6]¹</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All location</td>
<td>Impulse Voltage Test IEC 61439-1 or IEC 62271-200¹</td>
<td></td>
</tr>
<tr>
<td>EMC</td>
<td>All locations</td>
<td>Immunity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conducted Low Frequency</td>
<td>IEC 60533</td>
<td>IEC 61000-4-16, Performance criterion A</td>
</tr>
<tr>
<td></td>
<td>Electrical Fast Transient/Burst</td>
<td>IEC 61000-6-2 ¹ or IEC 60533</td>
<td>IEC 61000-4-4, Performance criterion B</td>
</tr>
<tr>
<td></td>
<td>Conducted Radio Frequency</td>
<td>IEC 61000-6-2 ¹ or IEC 60533</td>
<td>IEC 61000-4-6, Performance criterion A</td>
</tr>
<tr>
<td></td>
<td>Radiated Electromagnetic Field</td>
<td>IEC 61000-6-2 ¹ or IEC 60533</td>
<td>IEC 61000-4-3, Performance criterion A</td>
</tr>
<tr>
<td></td>
<td>Electrostatic Discharge</td>
<td>IEC 61000-6-2 ¹ or IEC 60533</td>
<td>IEC 61000-4-2, Performance criterion B</td>
</tr>
<tr>
<td></td>
<td>Electrical Slow Transient Surge</td>
<td>IEC 61000-6-2 ¹</td>
<td>IEC61000-4-5, Performance criterion B</td>
</tr>
<tr>
<td>General power</td>
<td>Emission</td>
<td>Radiated</td>
<td>CISPR 16</td>
</tr>
<tr>
<td>distribution zone</td>
<td></td>
<td>IEC 61000-6-4 ¹ or IEC 60533 class A</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conducted</td>
<td>IEC 61000-6-4 ¹ or IEC 60533 class A</td>
<td>CISPR 16</td>
</tr>
<tr>
<td>Bridge and Open</td>
<td>Emission</td>
<td>Radiated</td>
<td>CISPR 16</td>
</tr>
<tr>
<td>Deck zone</td>
<td></td>
<td>IEC 60533 class B or IEC 60945</td>
<td>CISPR 16</td>
</tr>
<tr>
<td></td>
<td>Conducted</td>
<td>IEC 60533 class B or IEC 60945</td>
<td>CISPR 16</td>
</tr>
</tbody>
</table>

¹ If the equipment is covered by an IEC product standard, the product standard shall be used.

### Table 5 Type tests for enclosures

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Location</th>
<th>Minimum equipment specification</th>
<th>Test reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingress protection</td>
<td>All location</td>
<td>According to Sec.10 Table 1</td>
<td>IEC 60529</td>
</tr>
<tr>
<td>Fire integrity</td>
<td>All location</td>
<td>Flame Retardant (Ref. [4.1.3] b)</td>
<td>IEC 6092-101</td>
</tr>
<tr>
<td>Surface Temperature</td>
<td>All location</td>
<td>Max 95°C, see limitation in [3.2]</td>
<td></td>
</tr>
<tr>
<td>Corrosion resistance</td>
<td>Outside</td>
<td>IACS UR E10 (item 12)</td>
<td>IEC 60068-2-52, salt mist, test Kb, severity 1.</td>
</tr>
<tr>
<td>UV radiation resistance</td>
<td>Outside</td>
<td>IEC 60068-2-5</td>
<td>IEC 60068-2-5, test C for 80 hours</td>
</tr>
</tbody>
</table>
SECTION 4 SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

1 Construction

1.1 General

1.1.1 Applicable standards
a) Switchgear and controlgear assemblies shall generally comply with IEC 61439-1 and IEC 60092-302 for low voltage equipment, and IEC 62271-200 for high voltage equipment.
b) Electronic equipment used in switchgear and controlgear shall comply with environmental requirements given in Ch.9 Sec.5.
c) Components and accessories used in switchgear and controlgear assemblies shall in general comply with relevant IEC product standards.

1.1.2 General
a) All switchboard and controlgear assemblies shall be safe against accidental touching of live conductors during normal operation of the switchboard or assemblies. (Interpretation of SOLAS Ch. II-1/45.2)
b) A low voltage switchboard or controlgear assembly shall be designed to withstand the short circuit forces for minimum 1 s, created by the short circuit current and magnitude at the particular point of the system without endangering the integrity of the outer switchboard enclosure. For high voltage switchboard and controlgear assemblies, see [2.2.1].
c) For switchgear constructed and type tested in accordance with IEC 61439-1 sections can be designed to withstand the short-circuit stress occurring on the load side of the respective short-circuit protective device as stated in IEC 61439-1. However, this reduced short-circuit level shall not be less than 60% of the short circuit rating of the main busbars.

1.1.3 Accessibility
a) Instruments, handles, push buttons or other devices that should be accessible for normal operation shall be located on the front of switchboard and controlgear assemblies.
b) All other parts that might require operation shall be accessible. If placed behind doors, the interior front shall comply with enclosure type IP 20. When located in spaces accessible to unauthorised personnel, fuses with accessible current-carrying parts may be permitted, if the door is lockable. Operation in this context means for example reset of protective devices and replacement of control circuit fuses inside the assembly.
c) Doors, behind which equipment requiring operation is placed, shall be hinged.
d) Hinged doors, which shall be opened for operation of equipment, shall be provided with easily operated handles or similar. There are also to be arrangements for keeping the doors in open position.
e) All sections of switchboards and controlgear assemblies that require maintenance shall be accessible for maintenance work.

Guidance note:
If the construction does not allow periodical maintenance, the assembly may be designed for maintenance free operation during a 20-year service life.

1.1.4 Materials
Framework, panels and doors are normally to be of steel or aluminium alloy, and shall be of rigid construction.

Guidance note:
Switchgear and assemblies constructed of other materials may be accepted provided requirements in Sec.3 are complied with.
1.1.5 Circuit separation

a) There shall be arranged a separate cubicle for each generator, with flame retardant partitions between the different generator cubicles and between these and other cubicles. The partitions shall withstand the effect of an internal arc, and prohibit this from spreading to other cubicles.

b) If a low-voltage main switchboard is supplied from a high voltage system, the feeder panels of the low-voltage switchboard shall be partitioned with arc-resistant segregations as required for generator cubicles in a).

c) Controlgear for essential or important consumers shall be separated from each other, and from other current carrying parts, by flame retardant partitions providing protection of the cubicle in case of an arcing fault occurring in the neighbouring cubicle. Alternatively, an arrangement without flame retardant partitions may be accepted, provided the busbar is divided with a circuit breaker with short circuit protection, located in a separate cubicle. The arrangement shall be so that maintenance work can be carried out in each unit without danger when isolated.

d) Controlgear for non-important consumers may be installed in a common cubicle provided this cubicle could be effectively isolated.

e) Consumer controlgear installed in main switchboards shall be placed in cubicles separated from all other parts of the switchboard by partitions of flame retardant material.

f) Equipment for different distribution systems shall be placed in separate switchboards (panels), or shall be separated from each other by partitions clearly marked with the actual voltages and system identifications.

g) Switchgear and controlgear assemblies supplied by different supply systems shall not be placed in the same enclosure.

h) For separation due to system redundancy, see Sec.2.

i) Equipment with voltage above 1 kV shall not be installed in the same enclosure as low voltage equipment, unless segregation or other suitable measures are taken to ensure that access to low voltage equipment is obtained without danger.

(IACS UR E11.2)

j) Each outgoing circuit from a switchboard shall be provided with multi-poleswitchgear for isolating purposes in accordance with [2.1.5]. If remote from the consumer, the switchgear shall be lockable in the “off” position. For isolating purposes, a group of non-important consumers may be fed from one common switchgear.

k) On a distribution board the multi-pole switchgear may be omitted when maximum 63 A fuses are used.

Guidance note:
Switching off by an auxiliary circuit will be accepted provided that the off–control switch is placed in front of the relevant compartment and a manual off-switching means is provided when front door is opened.

1.1.6 Handrails

Main and emergency switchboards and other switchgear and controlgear assemblies requiring operation shall have handrails with an insulating surface.

Guidance note:
For small assemblies with simple operation handrails may be omitted.

1.1.7 Nameplates and marking

a) Switchgear and controlgear assemblies shall be marked in accordance with general requirements given in Sec.3 [5].

b) Protection devices shall be permanently marked with voltage, current and breaking capabilities.

c) Protection devices with adjustable settings shall have means that readily identify the actual setting of the protective device.

d) Circuit designation for outgoing circuits and incoming feeders shall be marked for identification.
e) The appropriate setting of overload protective device for each circuit shall be permanently indicated at the location of the protective device. (Interpretation of SOLAS Reg. II-1/45.6.2)

Guidance note:
A document placed inside that assembly with the data required in d) and e) will be accepted.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

### 1.1.8 Clearance and creepage distances for low voltage equipment

a) The minimum clearance and creepage distances for bare busbars in low voltage equipment are given in Table 1, and shall be complied with when insulating materials with tracking index 175 V are used.

b) Clearance or creepage distances lower than what is given in Table 1 may be accepted for switchgear of standard design as long as the following conditions are met:
- minimum clearance distance shall be 8 mm, minimum creepage distance shall be 16 mm
- the assembly has DNV GL Type Approval and has been tested with impulse voltage test in accordance with IEC 61439-1
- maximum operating temperature of busbars shall be documented to be acceptable with respect to fixing materials and internal temperature by a full current type test
- maximum temperature rise at termination points for external cables shall be 60°C.

### Table 1 Low voltage busbar clearances or creepage between phases (including neutral) and between phases and earth

<table>
<thead>
<tr>
<th>Rated insulation voltage, AC root mean square or DC (V)</th>
<th>Minimum clearances (mm)</th>
<th>Minimum creepage distances (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 250 V</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>From 250 to 690 V</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Above 690 V (Maximum 1000 V)</td>
<td>25</td>
<td>35</td>
</tr>
</tbody>
</table>

### 1.1.9 Clearance and creepage distances for high voltage equipment

a) The minimum clearance distance in high voltage equipment shall be suitable for the rated voltage considering the nature of the insulating material and the transient over voltages developed by switching and fault conditions. This requirement may be fulfilled by subjecting each assembly type to an impulse voltage type test according to Table 3. Alternatively, maintaining the minimum distances given in Table 2.

b) Minimum creepage distances for main switchboards and generators are given in Table 4, and for other equipment in Table 5.

c) All insulating materials for fixing and carrying live parts shall have tracking index of at least 300 V according to IEC 60112.

d) Within the busbar section compartment of a switchgear assembly the minimum creepage distance shall be at least 25 mm/kV for non-standardised parts. Behind current limiting devices the creepage distance shall be at least 16 mm/kV. (IACS UR E11 2.3.2)

### Table 2 Clearances for high voltage equipment between phases (including neutral) and between phases and earth

<table>
<thead>
<tr>
<th>Rated voltage [kV]</th>
<th>Highest voltage for equipment, (kV) ¹</th>
<th>Minimum clearance distance for (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>3.6</td>
<td>55</td>
</tr>
<tr>
<td>3.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table 3 Alternative impulse voltage type test

<table>
<thead>
<tr>
<th>Rated voltage [kV]</th>
<th>Highest voltage for equipment [kV]</th>
<th>Rated lightning impulse withstand voltage [kV]</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0</td>
<td>3.6</td>
<td>40</td>
</tr>
<tr>
<td>3.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.0</td>
<td>7.2</td>
<td>60</td>
</tr>
<tr>
<td>6.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.0</td>
<td>12.0</td>
<td>75</td>
</tr>
<tr>
<td>11.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.0</td>
<td>17.5</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1) Intermediate values with corresponding distances are accepted.

### Table 4 Minimum creepage distances for high voltage main switchboards and generators

<table>
<thead>
<tr>
<th>Nominal voltage of the system, (V)</th>
<th>Minimum creepage distance (for tracking index 300) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 V</td>
</tr>
<tr>
<td>1000 to 1100</td>
<td>26 2)</td>
</tr>
<tr>
<td>3000 to 3300</td>
<td>63</td>
</tr>
<tr>
<td>6000 to 6600</td>
<td>113</td>
</tr>
<tr>
<td>10 000 to 11 000</td>
<td>183</td>
</tr>
</tbody>
</table>

1) Intermediate values with corresponding distances are accepted.
2) Minimum 35 mm is required for busbars and other bare conductors in main switchboards.

### Table 5 Minimum creepage distances for other high voltage equipment

<table>
<thead>
<tr>
<th>Nominal voltage of the system, (V)</th>
<th>Minimum creepage distance (for tracking index 300) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>300 V</td>
</tr>
<tr>
<td>1000 to 1100</td>
<td>18</td>
</tr>
<tr>
<td>3000 to 3300</td>
<td>42</td>
</tr>
<tr>
<td>6000 to 6600</td>
<td>83</td>
</tr>
<tr>
<td>10 000 to 11 000</td>
<td>146</td>
</tr>
</tbody>
</table>
1) Intermediate values with corresponding distances are accepted.

2 Power Circuits

2.1 Power components in assemblies

2.1.1 Main busbar sectioning
See Sec.2 for requirements regarding main busbar division arrangement.

2.1.2 Busbar materials
a) Busbars and other conductors shall normally be made of copper or copper covered aluminium.
b) Copper coated aluminium or pure aluminium busbar shall be adequately protected against corrosion by either installing in an air conditioned environment, by special coating sealing the aluminium or by the aluminium itself being seawater resistant.

2.1.3 Rating of busbars
a) The shape, configuration and cross-section shall be such that the temperature rise will not exceed 45°C at rated load.
b) Busbars and other conductors with their supports shall be so mechanically or thermally dimensioned and fixed that they can withstand for 1 s without detrimental effect the forces occurring by the maximum short circuit current which can occur.
c) The cross-section of busbars for neutral connection on an AC three-phase, four-wire system, and for equaliser connection on a DC system, shall be at least 50% of the cross-section for the corresponding phases (poles).
d) For maximum temperatures of busbars in type tested and partially type tested assemblies the requirement in [1.1.8] applies.
e) The maximum permissible load for copper busbars with ambient temperature 45°C is given in Table 6. Other ratings may be accepted based on type test reports.
f) Rating of aluminium busbar to be documented by type test report.

2.1.4 Fuses
Fuses shall normally comply with one of the following standards:
— IEC 60269 for low voltage fuses
— IEC 60282-1 for high voltage fuses.

2.1.5 Circuit breakers, on-load switches, disconnectors, and contactors
a) Switchgear and controlgear shall be rated as required by Sec.2 [7.2.2], and comply with:
   — IEC 60947 for low voltage equipment
   — IEC 60470, IEC 62271-100, IEC 62271-102, IEC 62271-106 for high voltage equipment
   — Low voltage circuit breakers for IT systems shall comply with IEC 60947-2 Annex H.
b) All fault switching and protecting components such as circuit breakers and fuses shall have a fault current withstand and interruption capacity of not less than the maximum short circuit current at the relevant point of their installation.
c) All load switches and contactors shall have a rating not less than the maximum load current at their point of installation. Particularly, contactors shall be protected against the possibility of the contactor breaking current exceeding their load break capacity in fault situations.
d) Fuse switches using the fuse element as making and breaking contacts are not accepted in place of isolating switches, where such are required. Switch-disconnectors and fuse-combination units shall comply with IEC 60947-3.

e) The construction shall be such that accidental making or breaking, caused by the vessel's inclination, movements, vibrations and shocks, cannot occur.

f) Under-voltage and closing coils, including contactor coils, shall allow closing of the switchgear and controlgear when the voltage and frequency are 85 to 110% of nominal value. The under-voltage protection shall release if the voltage is below 70% or absolutely below 35% of nominal voltage.

g) Each circuit-breaker rated more than 16 A shall be of trip-free type, i.e. the breaking action initiated by short-circuit and overcurrent relays, or by under-voltage coil, when fitted, shall be fulfilled independently of the position or operation of manual handle or of other closing devices.

### Table 6 Rating of copper busbars

<table>
<thead>
<tr>
<th>With x thickness (mm)</th>
<th>Painted (matt-black)</th>
<th>Bare</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Numbers of bars</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>15 x 3</td>
<td>230</td>
<td>390</td>
</tr>
<tr>
<td>20 x 3</td>
<td>290</td>
<td>485</td>
</tr>
<tr>
<td>20 x 5</td>
<td>395</td>
<td>690</td>
</tr>
<tr>
<td>20 x 10</td>
<td>615</td>
<td>1145</td>
</tr>
<tr>
<td>25 x 3</td>
<td>355</td>
<td>580</td>
</tr>
<tr>
<td>25 x 5</td>
<td>475</td>
<td>820</td>
</tr>
<tr>
<td>30 x 3</td>
<td>415</td>
<td>670</td>
</tr>
<tr>
<td>30 x 5</td>
<td>555</td>
<td>940</td>
</tr>
<tr>
<td>30 x 10</td>
<td>835</td>
<td>1485</td>
</tr>
<tr>
<td>40 x 5</td>
<td>710</td>
<td>1180</td>
</tr>
<tr>
<td>40 x 10</td>
<td>1050</td>
<td>1820</td>
</tr>
<tr>
<td>50 x 5</td>
<td>860</td>
<td>1410</td>
</tr>
<tr>
<td>50 x 10</td>
<td>1260</td>
<td>2130</td>
</tr>
<tr>
<td>60 x 5</td>
<td>1020</td>
<td>1645</td>
</tr>
<tr>
<td>60 x 10</td>
<td>1460</td>
<td>2430</td>
</tr>
<tr>
<td>80 x 5</td>
<td>1320</td>
<td>2080</td>
</tr>
<tr>
<td>80 x 10</td>
<td>1860</td>
<td>2985</td>
</tr>
<tr>
<td>100 x 10</td>
<td>2240</td>
<td>3530</td>
</tr>
<tr>
<td>120 x 10</td>
<td>2615</td>
<td>4060</td>
</tr>
<tr>
<td>160 x 10</td>
<td>3348</td>
<td>5121</td>
</tr>
</tbody>
</table>
2.1.6 Internal wiring

a) Connections to/from busbars to the short circuit protection shall be installed short-circuit proof, as defined in Sec.13. This requirement also applies to branching off for control power and measuring signals from busbars and generator terminals.

b) Interconnection between busbars shall be short circuit protected according to Sec.2 [7.2.1], if the length of the cable/wire/flexible busbar exceeds 3 m.

c) Switchboard wires shall as a minimum be insulated single core wires unless used in a short circuit proof installation requiring double insulating wires or conductors.

d) The maximum permissible load for wires inside switchgear and controlgear assemblies is given in Table 7.

Guidance note:
In distributions boards where the connections mentioned in a) are sufficiently protected by upstream short circuit protection devices, the required short circuit proof installation may be exempted.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

Table 7 Rating of internal wiring

<table>
<thead>
<tr>
<th>Nominal cross-section of conductor</th>
<th>Bunched, exposed or in conduits</th>
<th>Wires run singly, at least one conductor diameter apart</th>
<th>Circuits of all kinds</th>
<th>Current [A]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cross-section in the case of conductors connected in parallel [mm²]</td>
<td>Several power circuits together Current [A]</td>
<td>One power circuit together with its associated measuring and control wires Current [A]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>12</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>12</td>
<td>15</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>16</td>
<td>20</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>20</td>
<td>27</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>26</td>
<td>35</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>36</td>
<td>48</td>
<td>58</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>48</td>
<td>65</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>66</td>
<td>86</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>82</td>
<td>107</td>
<td>125</td>
<td></td>
</tr>
<tr>
<td>50</td>
<td>104</td>
<td>133</td>
<td>157</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td>130</td>
<td>164</td>
<td>194</td>
<td></td>
</tr>
<tr>
<td>95</td>
<td>157</td>
<td>198</td>
<td>231</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>186</td>
<td>231</td>
<td>272</td>
<td></td>
</tr>
</tbody>
</table>

Note

The current ratings shown apply to conductors with a maximum permissible operating temperature \(T\) on the conductor of 70 °C and an ambient temperature of 45 °C. For conductors with a maximum permissible operating temperature \(T\) deviating from 70 °C, the current rating is to be determined by applying the correction factor \(F\).

<table>
<thead>
<tr>
<th>T</th>
<th>60 °C</th>
<th>65 °C</th>
<th>70 °C</th>
<th>75 °C</th>
<th>80 °C</th>
<th>85 °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>0.77</td>
<td>0.89</td>
<td>1.00</td>
<td>1.10</td>
<td>1.18</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Note: The current rating is based on 45°C ambient air temperature. Sufficient ventilation must be ensured, or the loading values shall be reduced.
2.1.7 Screening of horizontally installed busbars
Horizontally installed busbars and bare conductors or connections shall be protected by screens, if they are placed such that there could be a risk of anything falling down on them.

2.1.8 Clearance and creepage distances
See [1.1.8] for clearance and creepage distances in switchgear and assemblies.

2.2 Additional requirements for high voltage assemblies

2.2.1 General design and construction
a) High voltage switchgear and controlgear assemblies shall be metal-enclosed in accordance with IEC 62271-200, or of a construction giving equivalent safety with respect to personnel safety and system integrity. High voltage switchgear and controlgear assemblies supplying more than one consumer shall therefore at least meet the requirements to Loss of Service Continuity Category LSC 2.

b) The high voltage switchgear and controlgear shall be able to withstand an internal short circuit arcing failure with the maximum duration and magnitude, which can occur on the particular point of the installation without harmful effect to operators. High voltage switchgear and controlgear shall be type tested to demonstrate that it will withstand the effects of an internal arc failure (e.g. with classification IAC and testing in accordance with Appendix A of IEC 62271-200). When installed in spaces accessible to authorised persons only, the switchgear and controlgear shall have accessibility type A. When installed in spaces accessible to unauthorized personnel, the switchgear and controlgear shall have accessibility type B. The arcing time shall be 1 s unless discrimination makes a shorter test possible. Then arcing time as low as 0.1 s is accepted.

c) There shall be separate compartments with IP rating to at least IP 20 towards other compartments in the cubicle for at least the following components:
   — control and auxiliary devices
   — each main switching device
   — components connected to one side of the main switching device (the outgoing circuit)
   — components connected to the other side of the main switching device (the busbars).

   Normally, partitions between the compartments shall be made of metal. Alternatively, a partition of other materials not intended to be earthed is accepted, provided it is verified that the safety is of at least the same standard.

d) As required by a), b) and c), there shall be separate busbar compartments for each switchboard cubicle. However, a continuous busbar compartment is permissible if the main high-voltage switchgear is subdivided into two independent and autonomous installations with metal partition between and one of the following solutions is used:
   — a protection system (arc monitor, busbar differential protection) is installed which detects internal faults and isolates the affected part of the installation within 100 ms
   — accidental arcing is reliably prevented by design measures (e.g. solid insulated busbar systems).

e) Means shall be provided for the disconnection and isolation of all circuit breakers and fused circuit breakers, either by using withdrawable components or by installation of separate disconnectors (isolators).

Exception 1
For final feeder circuits where energising of the main switching device from the load side is not possible, the cable terminals and accessories (e.g. voltage and current transformers) may be placed in the same compartment as the main switching device.

Exception 2
For high voltage switchgear and controlgear assemblies installed in accordance with Sec.3 [4.5.1] c) Internal Arc Classification may not be required.
2.2.2 Mechanical interlocks

a) The arrangement in high voltage enclosures shall be such that all operation and functional testing is safeguarded against accidental touching of live parts. For withdrawable switchgear units, it shall be possible to perform functional testing and maintenance in safety, even when the busbar is live.

b) Doors that can be opened for operation or testing of high voltage parts (e.g. for replacement of fuses, or for functional testing of a circuit breaker) shall be interlocked so that they cannot be opened before the components inside have been isolated and made safe.

c) It shall be possible to operate the mechanical off of the circuit breaker having the doors closed.

d) If the conditions for the closing operation are not fulfilled (e.g. release not energized), switching-on, also when actuating the mechanical on button, shall not cause the contact pieces to come into contact.

e) Circuit breakers shall be interlocked with the associated earthing switch.

f) Earthing switches shall have making capacity.

g) Isolating switches shall be interlocked so that they can only be switched under no load. The use of load-switch-disconnectors is recommended.

h) The openings between the contacts of a withdrawable high voltage component and the fixed contacts, to which it is connected in service, shall be provided with automatic shutters.

i) Withdrawable switchgear units shall be fitted with mechanical interlocking devices effective in the operating and disconnected position. A key interlock is permitted for maintenance purposes.

j) Withdrawable switchgear units shall be locked in place in the operating position.

2.2.3 Control wiring

a) The wiring of auxiliary circuits shall, with the exception of short lengths of wire at terminals of instrument transformers, tripping coils, auxiliary contacts etc., be either segregated from the main circuit by earthed metallic partitions (e.g. metallic tubes) or separated by partitions (e.g. tubes or sheathed cables) made of flame retardant insulating material.

b) Fuses of auxiliary circuits, terminals and other auxiliary apparatus requiring access while the equipment is in service, shall be accessible without exposing high voltage parts.

c) An alarm shall be arranged for voltage loss after the last fuses in each auxiliary power system, where a voltage failure is not self-detecting.

d) A possibility for manual operation of each circuit breaker shall be arranged. However, manual closing of the circuit breakers shall not be possible if the arrangement of the auxiliary circuits is such that the protection devices are put out of action and the circuit breakers are still closed after a power failure to the auxiliary circuits.

2.2.4 Safety earthing of high voltage circuits

Each circuit shall be fitted with an integral means of earthing and short circuiting for maintenance purposes, or alternatively an adequate number of portable earthing and short circuiting devices, suitable for use on the equipment in question, shall be kept on board.
**2.2.5 Contactors and motor starters**

If the safety of the crew and the selective protection of the ships grid is ensured by connected upstream devices high voltage motor starters may be dimensioned according to “damage classification Type a” as described in IEC 62271-106.

**Guidance note:**

IEC 62271-106 sub clause 4.107.3 describes “damage classification Type a: as follows: Any kind of damage is allowed (with the exclusion of external damage to the enclosure, if any) so as to make necessary the replacement of the device as a whole or the replacement of fundamental parts in addition to the main contacts and/or the arc chambers of the starter.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

**2.2.6 Monitoring and alarms**

Gas insulated switchboards and busbar systems shall have monitoring of the internal gas pressure. Each gas volume shall be monitored. A pressure drop shall be alarmed. Measures according to manufacturer’s instruction shall be initiated.

### 3 Control and Protection Circuits

#### 3.1 Control and instrumentation

**3.1.1 General**

a) Requirements for power supply and distribution of control circuits are given in Sec.2 [8.2].

b) For short circuit proof installation of control cables, see [2.1.8].

**3.1.2 Control of duplicated consumers**

a) Control circuits for duplicated essential and important equipment shall be kept separated from each other, and not located in the same enclosure.

b) Controlgear for duplicated essential or important equipment shall be mutually independent and shall be divided between two motor control centres or distribution boards having separate supplies from different sides of the main switchboard and/or the emergency switchboard.

c) Where switchboards are fitted with bus ties or bus links, the duplicated circuits shall be fed from different sides of the bus tie.

d) Duplicated equipment for essential or important services shall not be dependent on any common circuits such as e.g. contactors for emergency stop.

**3.1.3 Signal lamps**

Incandescent signal lamps shall be arranged so that a lamp short circuit cannot jeopardise the control system.

**3.1.4 Protection and synchronising devices**

a) Protection and synchronising devices used in switchgear and controlgear assemblies shall in general comply with relevant IEC product standards.

b) Current transformers used for protective or control devices shall be suitable for the overcurrent range expected.

**3.1.5 Panel-instruments in general**

a) Instruments, including current transformers, in switchgear and controlgear shall have a nominal accuracy of 2.5% or better.

b) The upper limit of the scale of ampere-meters and kilowatt-meters shall be at least 130% of the rated full load of the circuit. For generators arranged for parallel operation, the scale shall be arranged for reading of reverse current or power corresponding to at least 15% of the rated full load of the circuit. The upper limit of the scale of each voltmeter shall be at least 120% of the nominal voltage.
c) Ampere-meters, kilowatt-meters and voltmeters shall be provided with means to indicate rated current or power and rated voltage, respectively. Instruments shall have effective screening (e.g. by metal enclosures) in order to diminish faulty readings caused by induction from adjacent current-carrying parts.

d) Frequency meters shall be able to indicate values with a range of at least 8% below and above the nominal frequency.

3.1.6 Generator instrumentation and control

a) Each generator cubicle shall as far as possible function independently as required in Sec.2 [8.2]. The wiring of each generator circuit breaker’s control and release circuits (e.g. under-voltage circuit) is generally to be kept within its cubicle. Exemption: shunt-operated circuits for closing/opening of the circuit-breaker may be carried out e.g. to a common control panel.

b) Each AC generator shall be provided with instrumentation as listed in Sec.2 [8.2]

Instrumentation for current, voltage and frequency shall be arranged for simultaneous and continuous reading.

c) When generators are arranged for parallel operation, they shall in addition be provided with synchronising devices as required by Sec.2 [8.2].

d) Simultaneous functional reading of current and active power shall be provided at operating station for manual operation and synchronisation.

Alternatives for d.

— Single voltmeters and ampere-meters with switches for the alternative readings may be accepted.

— Two separate frequency meters for several generators may be used, one with a change-over switch for connection to all generators, the other connected to the busbars. A “double frequency meter” may be used for this purpose.

3.1.7 Instrumentation for distribution systems including in and outgoing circuits of switchboards

a) Each secondary distribution system shall be equipped with a voltmeter.

b) Incoming feeders in low voltage main switchboards fed from a high voltage system shall be equipped with voltmeters and ampere-meters. It shall be possible to display the currents and voltages of all three phases.

c) Incoming feeders in low voltage main switchboards fed from a high voltage system shall be equipped with signal lights for indication of the operation modes On, Off, Tripped and Ready.

3.1.8 Instrumentation for shore connections

The shore connection circuit shall be equipped with:

— a phase sequence indicator

— a voltmeter or signal lamp.

4 Inspection and Testing

4.1 General

4.1.1 Factory testing

a) Switchgear and controlgear assemblies shall be tested at the manufacturer’s works as described in [4.1.2] to [4.1.6].

b) The manufacturer shall submit test results together with the final documentation for the equipment. The documentation shall give information on make, type, serial no., and all technical data necessary for the application of the switchboard or assembly, as well as the results of the required tests.

c) The following tests are required:
— function test: all basic functions, including auxiliary functions, shall be tested
— insulation resistance test
— high voltage test.

4.1.2 Visual inspection
Switchboards and assemblies are subject to a visual inspection for verification of general workmanship, creepage and clearance distances, IP rating, ventilation and quality of materials and components.

4.1.3 Function testing
a) All circuits shall be verified installed as shown in the as-built documentation.

Guidance note:
Factory testing of switchgear or controlgear assemblies at full power is normally not required.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

b) It shall be verified that supply transformers for control circuits without secondary side short circuit protection are sufficiently protected by the primary side protection. Such verification may be done by application of a short circuit on the secondary side.

c) Control and protection shall be tested for correct functioning.

Guidance note:
Electronic equipment should be disconnected, short circuited and or isolated during high voltage test and insulation resistance measuring.
The secondary winding of current transformers shall be short circuited and disconnected from earth during the test. The secondary winding of voltage transformers shall be disconnected during the test.
The high voltage test needs not to be made for auxiliary circuits protected by a short-circuit protective device rated not higher than 16 A, or if an electric function test has been made previously at the rated operating voltage.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

b) Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Sec.5 Table 4. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level. The insulation level shall be at least 1 MOhm.

Guidance note:
Electronic equipment should be disconnected, short circuited and or isolated during high voltage test and insulation resistance measuring.
The secondary winding of current transformers shall be short circuited and disconnected from earth during the test. The secondary winding of voltage transformers shall be disconnected during the test.
The high voltage test needs not to be made for auxiliary circuits protected by a short-circuit protective device rated not higher than 16 A, or if an electric function test has been made previously at the rated operating voltage.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

Table 8 Power-frequency withstand voltage for main circuits

<table>
<thead>
<tr>
<th>Rated insulation voltage (line to line a.c. or d.c.) V</th>
<th>Dielectric test voltage a.c. r.m.s. V</th>
<th>Dielectric test voltage d.c. V</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 60</td>
<td>1000</td>
<td>1415</td>
</tr>
<tr>
<td>60 – 300</td>
<td>1500</td>
<td>2120</td>
</tr>
<tr>
<td>300 – 690</td>
<td>1890</td>
<td>2670</td>
</tr>
<tr>
<td>690 – 800</td>
<td>2000</td>
<td>2830</td>
</tr>
<tr>
<td>800 – 1000</td>
<td>2200</td>
<td>3110</td>
</tr>
<tr>
<td>1000 – 1500 1)</td>
<td>N/A</td>
<td>3820</td>
</tr>
</tbody>
</table>
Table 9 Power-frequency withstand voltage for auxiliary and control circuits

<table>
<thead>
<tr>
<th>Rated insulation voltage (line to line) V</th>
<th>Dielectric test voltage a.c. r.m.s. V</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;12</td>
<td>250</td>
</tr>
<tr>
<td>12 – 60</td>
<td>500</td>
</tr>
<tr>
<td>60 &lt;</td>
<td>See Table 7.</td>
</tr>
</tbody>
</table>

4.1.5 Verification of creepage and clearance distances
Clearance and creepage distances shall be verified to be at least as given in Table 1 to Table 5.

4.1.6 Power frequency test for high voltage assemblies

a) Each high voltage assembly shall be subjected to a 1 minute power frequency voltage test.
b) The tests are to be performed with all switching devices in the closed position, and with all withdrawable parts in the operating position.
c) Replicas reproducing the field configuration of the high voltage connections may replace voltage transformers or power transformers. Overvoltage protective devices may be disconnected or removed.
d) Test voltages are given in Table 10. The test voltage may be applied at higher than the rated frequency in order to avoid the disconnection of voltage transformers.
e) Insulation resistance shall be measured prior to and on completion of the voltage test. Insulation resistance test voltages and acceptance values are given in Sec. 5 Table 4. It shall be verified that the voltage testing does not cause any reduction in switchgear insulation level.
f) All auxiliary circuits shall be subjected to a 1 minute voltage test between the circuits and the enclosure according to [4.1.4]. The high voltage test needs not to be made for auxiliary circuits protected by a short-circuit protective device rated not higher than 16 A, or if an electric function test has been made previously at the rated operating voltage.

Guidance note:
The environmental conditions during voltage tests are normally to be as specified in IEC 60060-1, "High-voltage test techniques, Part 1, General definitions and test requirements", that is temperature 20°C, pressure 1013 mbar and humidity 11 g water per m³ (corresponding to about 60% relative humidity). Correction factors for test voltages at other environmental conditions are given in IEC 60060-1.
### Table 10 Test voltages for high voltage assemblies

<table>
<thead>
<tr>
<th>Nominal voltage of the system (kV)</th>
<th>Highest system voltage ($U_{m}$) or rated equipment voltage (kV)(^1)</th>
<th>1 minute power frequency test voltage, (kV) (root mean square value) To earth and between phases(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 - 3.3</td>
<td>3.6</td>
<td>10</td>
</tr>
<tr>
<td>6 - 6.6</td>
<td>7.2</td>
<td>20</td>
</tr>
<tr>
<td>10 - 11</td>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>15</td>
<td>17.5</td>
<td>38</td>
</tr>
</tbody>
</table>

Note 1): The rated voltage for switchgear and controlgear is equal to the maximum system voltage for which the equipment is designed.

Note 2): Intermediate values for test voltages may be accepted, other than these standard test voltages.

#### 4.1.7 Onboard testing

Switchgear or controlgear assemblies shall be subject to complete function tests after installation onboard. See Sec.10 [4].
SECTION 5 ROTATING MACHINES

1 General

1.1 References

1.1.1 General

The design and function of rotating machines shall generally comply with the requirements of IEC 60092-301. For basic machine design, the relevant parts of IEC 60034 apply.

1.2 Requirements common to generators and motors

1.2.1 Rating

a) Electrical machines, including any excitation system, shall be designed for continuous duty unless otherwise clearly stated in the rules for specific application.
b) Generally, maximum environmental temperatures for rotating machines shall be as given in Sec.3 Table 1.

1.2.2 Insulation

a) All windings for machines shall be treated to resist moisture, sea air, and oil vapours.
b) For general requirements for insulation materials and terminations, see Sec.3 [4].
c) The winding insulation for converter-fed motors shall be designed for such application.

1.2.3 Temperature rise in windings (insulation)

The maximum permissible temperature rise in windings is given in Table 1, with the following provisions:

a) If the temperature of the cooling medium will be permanently lower than the values given in Sec.3 [2.3], then the permissible temperature rise may be increased with the difference between the actual temperature and the temperature given in Sec.3 [2.3]. Maximum acceptable increase is 20°C.
b) If the ambient temperatures clearly exceed the maximum upper limits, then the temperature rises shall be decreased accordingly.
c) In Table 1 allowance has been made for the temperature in certain parts of the machine being higher than measured. The temperatures at such “hot spots” are assumed not to exceed the values given in Sec.3 Table 2.
d) For vessels with class notation restricting the service to non-tropical waters the design limits for temperature rises given in Table 1 may be increased by 10°C. Alternatively, the upper ambient air temperature limits according to Table 1 may be reduced by 10°C.
e) Where water cooled heat exchangers are used in the machine cooling circuit, the temperature rise shall be measured with respect to the temperature of the cooling water at the inlet to the heat exchanger. Temperature rises given in Table 1 may be increased by 13°C provided the inlet water does not exceed 32°C.
f) If inlet water temperature is above 32°C, permissible temperature rise in Table 1 may be increased by 13°C and then reduced by the amount by which the maximum cooling water temperature exceeds 32°C.
g) If the inlet cooling water temperature is permanently less than 32°C, the permissible temperature rise in Table 1 may be increased by 13°C and may be further increased by an amount not exceeding the amount by which the cooling temperature is less than 32°C.
h) For machines with insulating class 220 the temperature rise will be evaluated in each case.
i) The additional temperature rise caused by the harmonics of currents and voltages shall be taken into consideration in the design of motors and generators by the maker.
### Table 1 Limits of temperature rise of machines for vessels for unrestricted service based on ambient temperature of 45°C

<table>
<thead>
<tr>
<th>Part of machine 1)</th>
<th>Method of measurement of temperature 2)</th>
<th>Maximum temperature rise in for air-cooled machines (°C)</th>
<th>Insulation class</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>A</td>
<td>E</td>
</tr>
<tr>
<td>1.</td>
<td>a) AC winding of machine having output of 5000 kVA or more</td>
<td>ETD</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>b) AC winding of machine having output of less than 5000 kVA</td>
<td>ETD</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>55</td>
</tr>
<tr>
<td>2.</td>
<td>Winding of armature with commutators</td>
<td>R</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T</td>
<td>45</td>
</tr>
<tr>
<td>3.</td>
<td>Field winding of AC and DC machine with excitation other than those in item 4.</td>
<td>R</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T</td>
<td>45</td>
</tr>
<tr>
<td>a) Field windings of synchronous machines with cylindrical rotors having DC excitation</td>
<td>R</td>
<td>85</td>
<td>105</td>
</tr>
<tr>
<td>b) Stationary field windings of DC machines having more than one layer</td>
<td>ETD</td>
<td>55</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>T</td>
<td>45</td>
</tr>
<tr>
<td>4.</td>
<td>c) Low resistance field windings of AC and DC machines and compensating windings of DC machines having more than one layer</td>
<td>R, T</td>
<td>55</td>
</tr>
<tr>
<td>d) Single-layer windings of AC and DC machines with exposed bare surfaces or varnished metal surfaces and single compensating windings of DC machines</td>
<td>R, T</td>
<td>60</td>
<td>75</td>
</tr>
</tbody>
</table>

1) Temperature rise of any part of a machine shall in no case reach such a value that there is a risk of injury to any insulating or other material in adjacent parts.

2) R indicates temperature measurement by the resistance method, T the thermometer method and ETD the embedded temperature detector method. In general for measuring the temperature of the windings of a machine the resistance method shall be applied. (See IEC 60034-1). For stator windings of machines having a rated output of 5000 kW (or kVA) the ETD method shall be used. Determination by ETD method requires not less than six detectors suitably distributed throughout the winding. Highest reading shall be used to determine the temperature for the winding.

3) For high voltage machines having rated output of 5000 kVA or more, or having a core length of 1 m or more, the maximum temperature rise for class E insulation shall be decreased by 5°C.

### 1.2.4 Machine short time overloads

a) General purpose rotating machines shall be designed to withstand the following excess torque:

   — AC induction motors and DC motors: 60% in excess of the torque that corresponds to the rating, for 15 s, without stalling or abrupt change in speed (under gradual increase of torque), the voltage and frequency being maintained at their rated value
— AC synchronous motors with salient poles: 50% in excess of the torque that corresponds to the rating, for 15 s, without falling out of synchronism, the voltage, frequency and excitation current being maintained at their rated values
— AC synchronous motors with wound (induction) or cylindrical rotors: 35% in excess of the torque that corresponds to the rating, for 15 s, without losing synchronism, the voltage and frequency being maintained at their rated value.

b) Induction motors for specific applications the excess torque may be subject to special agreement. See IEC 60034-1 clause 9.3.

c) General purpose rotating machines shall be designed to withstand the following excess current:
   — AC generators: 50% in excess of the rated current for not less than 30 s, the voltage and frequency being maintained as near to the rated values as possible
   — AC motors: 50% in excess of the rated current for not less than 120 s, the voltage and frequency being maintained as near to the rated values as possible
   — commutator machines: 50% in excess of the rated current for not less than 60 s, operating at highest full-field speed.

1.2.5 Balance
Machines shall be so constructed that, when running at any working speed, all revolving parts are well balanced.

1.2.6 Lubrication
a) Bearing Lubrication of rotating machines shall be effective under all operating conditions including towing.
b) Each self-lubricated sleeve bearing shall be fitted with an inspection lid and means for visual indication of oil level or use of an oil gauge. Similar requirement applies to self-contained oil lubricated roller bearings.
c) Provision shall be made for preventing the lubricant from gaining access to windings or other insulated or bare current-carrying parts.
d) For electrical propulsion see Sec.12 [1.6.3] e)

1.2.7 Shafts and shaft currents
a) Shafts shall comply with the requirements in Ch.4 both with regard to strength, bearings and balancing.
b) Means shall be provided to prevent damaging levels of circulating currents between shaft, bearings and connected machinery.
c) When all bearings on a machine are insulated, the shaft shall be electrically connected to the machine’s earth terminal.

1.2.8 Shaft locking device
Propulsion shafts shall be provided with shaft locking devices as required by Sec.12 [1.6.3] and Ch.4 Sec.2 [2.9.3].

1.2.9 Machine overspeed
a) Rotating machines shall be capable of withstanding 1.2 times the rated maximum speed for a period of 2 minutes.
b) for rotating machines coupled to the main propulsion system and not arranged in the main shafting, at 1.25 times the rated speed
c) for rotating machines arranged in the main shafting and whose construction makes testing impracticable, proof by computation of mechanical strength is required
1.2.10 Nameplate
Each machine shall be provided with nameplate of durable material, giving the following information:
— make, type, serial no.
— performance standard
— IP rating
— rated values for: output apparent power, voltage(s), frequency, current(s), power factor, speed
— for AC machines: the winding connection
— thermal classification of insulation
— duty type, if other than S1
— maximum permissible cooling medium temperature
— technical data necessary for the application of the machine
— total mass.

1.3 Instrumentation of machines

1.3.1 Temperature detectors embedded in stator winding

a) Low voltage machines having a rated output above 5000 kW (or kVA), all high voltage machines, and all propulsion motors shall be provided with temperature detectors in their stator windings, for monitoring and alarm.

b) For machines depending on additional cooling, see Sec.3 [4.2.1].

Guidance note:
For the requirements in regard to temperature detectors, reference is made to IEC 60034-11.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2 Additional Requirements for Generators

2.1 General

2.1.1 General
Exciter and voltage regulation equipment is considered as part of the generator.

Guidance note:
See Ch.3 regarding the prime movers’ speed governor characteristics and Ch.9 regarding instrumentation equipment.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.2 Automatic voltage regulator (AVR)
The AVR shall be capable of keeping the voltage within the values specified for stationary and dynamic variations.

2.1.3 Available neutral point
Generators with rating exceeding 1500 kVA, and all high voltage generators, shall be prepared for installation of equipment for short circuit protection of the generator windings.

2.1.4 De-excitation
Generators with rating exceeding 1500 kVA, and all high voltage generators, shall be prepared for external signal for initiation of de-excitation of the generator. Other suitable means to achieve the same objective may be evaluated and accepted.
2.1.5 Voltage waveform
For AC generators, the voltage shall be approximately sinusoidal, with a maximum deviation from the sinusoidal curve of 5% of the peak value.

2.2 Voltage and frequency regulation

2.2.1 Voltage build-up
a) The construction shall normally be such that the generator, when started up, takes up the voltage without the aid of an external electric power source.
b) External power sources may be used to take up the voltage on main generators provided that redundancy for this external source is arranged as required for starting arrangement.

2.2.2 Stationary voltage regulation
a) The voltage regulation shall be automatic, suitable for shipboard condition, and such that the voltage is kept within 97.5% to 102.5% of the rated voltage under all steady load conditions. This is between no-load and full-load current and at all power factors which can occur in normal use, but in any case with power factor from 0.7 to 0.9 lagging, also taking into consideration the effect of the prime mover’s speed characteristic.
b) There shall be provision at the voltage regulator to adjust the generator no load voltage.
c) The limits in a) may be increased to ±3.5% for emergency sets.

2.2.3 Transient voltage regulation
a) Maximum values (current and power factor) of sudden loads to be switched on and off shall be specified. In case of the absence of precise information concerning the maximum values of the sudden loads, 60% of the rated current with a power factor of between 0.4 lagging and zero shall be used for Type Testing.
b) The voltage variations under transient conditions shall comply with the following:
   — when the generator is running at no load, at nominal voltage, and the specified sudden load is switched on, the instantaneous voltage drop at the generator terminals shall not be more than 15% of the generators nominal voltage. The generator voltage shall be restored to within ±3% of the rated voltage within 1.5 s.
   — when the specified sudden load is switched off, the instantaneous voltage rise shall not be more than 20% of the rated voltage. The generator voltage shall be restored to within ±3% of the rated voltage within 1.5 s.
c) For non-paralleling emergency generating sets the regulation limits and time in b) might be increased to ±4% within 5 s.
d) On installations where two or more generators are normally run in parallel, the maximum load that can be switched on may be divided between the generators in relation to their rating and expected maximum duty as individual generator.
e) See Ch.2 and Ch.3 for requirements for the governor of a generator prime mover.

Guidance note:
Special consideration should be given to the overvoltage that may occur when switching off the generators at full load or overload. This overvoltage should not reach a level that may damage power supplies for AVRs, under-voltage coils, instruments etc. connected on the generator side of the generator circuit breaker.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
2.3 Generator short circuit capabilities

2.3.1 Short circuit withstand and contribution capabilities
AC synchronous generators, with their excitation systems, shall, under steady short circuit condition be capable of maintaining, without sustaining any damage, its short circuit current, which shall be at least 3 times the rated full load current, for a duration of at least 2 s. (IEC 60092-301 modified clause 4.2.3) Lower short circuit current and short time duration might be acceptable provided that the selectivity and generator protection requirements Sec.2 [7.1.4] and Sec.2 [7.3.1]) are fulfilled analogously.

2.4 Parallel operation

2.4.1 Load sharing
a) Generators for parallel running shall be such that the sharing of active and reactive power is stable under all load conditions. Oscillations smaller than ±20% of each generator's rated current can be accepted.

b) In the range 20 to 100% of the rated reactive load of each generator, its actual reactive load (mean value, if oscillations occur) shall not differ from its proportionate share of the total reactive load by more than 10% of the rated reactive load of the largest generator in parallel, or not more than 25% of the smallest generator’s rated reactive load, if this is less than the former.

c) Requirement for sharing of active power is given in Ch.3.

Guidance note:
The sharing of power is mainly determined by the prime movers' governor characteristics, to which further requirements are given in Ch.3. Power oscillations, however, are determined both by the prime movers' and generators' characteristics.

2.4.2 Parallel operation on nets with earthed neutral
When generators are run in parallel on nets with earthed neutral, it shall be ensured that the equalising current resulting from harmonics does not exceed 20% of the rated current of each generator.

3 Inspection and Testing

3.1 General

3.1.1 Factory testing
a) Electrical machines shall be tested at the manufacturer's works with the tests specified in this part of the rules. Type tests shall be carried out on a prototype of a machine or the first of a batch of machines. Routine tests shall be carried out on each machine.

b) The type tests (TT) and routine tests (RT) that the machines shall undergo are listed in Table 2. Alternative test methods and calculations may be used as stated in the guidance notes. Alternative test methods and calculations may be used when described in suitable procedures. Such procedures shall be approved.

c) The tests in Table 2 shall be documented. The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the machine, as well as the results of the required tests.

d) The result of type tests, and the serial number of the type tested machine, shall be specified in the documentation of test results for routine tests.

e) Routine tests for squirrel cage motors need not to be performed at rated frequency, as long as the same frequency also was used at the type test. The type testing should then be performed with both rated frequency and the alternative frequency.
### Table 2 Testing and inspection of electrical machines

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Required test for generators</th>
<th>Required test for motors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Examination of technical documentation. Visual inspection. Verification of data on name plate.</td>
<td>TT, RT</td>
<td>TT, RT</td>
</tr>
<tr>
<td>2</td>
<td>Measurement of insulation resistance.</td>
<td>TT, RT</td>
<td>TT, RT</td>
</tr>
<tr>
<td>3</td>
<td>Measurement of winding resistance.</td>
<td>TT, RT</td>
<td>TT, RT</td>
</tr>
<tr>
<td>4</td>
<td>Verification of the voltage regulation system.</td>
<td>TT, RT&lt;sup&gt;1)&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Temperature-rise test at full load.</td>
<td>TT</td>
<td>TT</td>
</tr>
<tr>
<td>6</td>
<td>Overload or overcurrent test&lt;sup&gt;2)&lt;/sup&gt; (IEC 60034-1/9.3 and 9.4).</td>
<td>TT</td>
<td>TT</td>
</tr>
<tr>
<td>7</td>
<td>AC Synchronous generator: Verification of steady short circuit condition.&lt;sup&gt;3)&lt;/sup&gt;</td>
<td>TT</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Overspeed test: 20% in excess of the rated r.p.m. for 2 minutes..&lt;sup&gt;4)&lt;/sup&gt;</td>
<td>TT, RT</td>
<td>TT, RT&lt;sup&gt;5)&lt;/sup&gt;, RT&lt;sup&gt;3)&lt;/sup&gt;</td>
</tr>
<tr>
<td>9</td>
<td>Dielectric strength test</td>
<td>TT, RT</td>
<td>TT, RT</td>
</tr>
<tr>
<td>10</td>
<td>No-load test</td>
<td>TT, RT</td>
<td>TT, RT</td>
</tr>
<tr>
<td>11</td>
<td>Verification of degree of enclosure protection (IP).</td>
<td>TT</td>
<td>TT</td>
</tr>
<tr>
<td>12</td>
<td>Verification of bearings</td>
<td>TT, RT</td>
<td>TT, RT</td>
</tr>
<tr>
<td>13</td>
<td>For high voltage machines a steep fronted impulse test, or equivalent, of the coil interturn insulation shall be carried out according to IEC 60034-15. Tests on each separate fully processed coil after inserting in the slots are preferred. Due to various technologies involved, alternative proposals to verify withstand level of interturn insulation may be considered, e.g. type tests with fully produced sample coils.</td>
<td>RT</td>
<td>RT</td>
</tr>
</tbody>
</table>

<sup>1)</sup> Only functional test of voltage regulator system during Routine test (RT), I.E. verification of [2.2.1] and [2.2.2]. For Type Testing, verification of [2.2.3] shall be performed.

<sup>2)</sup> Overload test for generators. Test of momentary excess torque for motors. The overload/overcurrent test for shaft generators, which are arranged in the main shafting and - due to their construction - could not be tested in the manufacturer’s works, shall be performed at site with 1,1 times the rated current for 10 minutes.

<sup>3)</sup> For shaft generator systems, verification of steady short-circuit current shall be demonstrated together with the associated converter-unit see also [2.3.1].

<sup>4)</sup> Shaft generators arranged in the main shafting and whose construction makes testing impracticable, proof by computation of mechanical strength is required.

<sup>5)</sup> Not applicable for squirrel cage motors.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

**Guidance note 1:**

**Overspeed test (8)**

Dielectric test to be performed on rotors after overspeed test IEC 60034-1-9.7.

**Guidance note 2:**

**Verification of the voltage regulating system (4)**

It is to be verified that the generator, together with its voltage regulation system, complies with the functional requirements given in [2.2].
Guidance note 3:
High voltage tests/Dielectric strength test (9)

a) A 1 minute high voltage test should be applied to a new and completed machine with all its parts in place under conditions equivalent to normal working conditions. The test should be in accordance with IEC 60034-1-9.2 “Withstand voltage test”, and should be carried out at the maker’s works at the conclusion of the temperature-rise test.

b) For voltage levels to be used, see IEC 60034-1 Table 16, normally (for ac windings of machines between 1 kW and 10 000 kW) the test voltage is 1000 V + twice the rated voltage with a minimum of 1500 V.

c) After rewinding or other extensive repair of a machine, it should be subjected to a high voltage test with a test voltage of at least 75% of that specified in IEC 60034-1-9.2.

d) On carrying out high-voltage test, it may be necessary to short circuit semi-conductors in order to avoid damage of such parts.

Guidance note 4:
Temperature rise measurement and testing (5)

a) The temperature rise of a machine should be measured at the rated output, voltage and frequency, and the temperature test should be carried out at the duty for which the machine is rated and marked, in accordance with the testing methods specified in IEC Publication No. 60034-1. See also Guidance note 5.

b) For machines with maximum continuous rating (duty type S1), the temperature rise test should be continued until thermal equilibrium has been reached, that is when the temperature rises of the parts of the machine do not vary by more than a gradient of 2 K per hour.

c) For acceptable methods of winding temperature measurement and corresponding maximum temperatures, see Table 1. See Guidance note 4 e. to i. regarding the variety of temperature measurement methods.

d) The measurement of final winding temperature at end of the test should be performed within the time limits given in Table 3.

e) If the initial resistance reading is obtained within the time interval specified in Table 3, that reading shall be accepted for the temperature measurement.

If a resistance reading cannot be made in the time interval specified in Table 3, it shall be made as soon as possible but not after more than twice the time limits given in Table 3. The temperature shall be measured as a function of time after shutdown, and correct temperature being determined by extrapolation back to the appropriate time interval of Table 3. (See IEC 60034-1 8.6.2 for extended guidance on this subject).

<table>
<thead>
<tr>
<th>Rated output, $P$ $(kW)$ $(kVA)$</th>
<th>Time delay after switching off power (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P \leq 50$</td>
<td>30</td>
</tr>
<tr>
<td>$50 &lt; P \leq 200$</td>
<td>90</td>
</tr>
<tr>
<td>$200 &lt; P \leq 5000$</td>
<td>120</td>
</tr>
<tr>
<td>$5000 &lt; P$</td>
<td>N/A (see note 2 to Table A1)</td>
</tr>
</tbody>
</table>

f) When the resistance method is used, the temperature for copper windings, $\Theta_2$, may be obtained from the ratio of the resistances by the formula:

$$\frac{\Theta_2 + 235}{\Theta_1 + 235} = \frac{R_2}{R_1}$$

$$\Theta_2 = \text{winding temperature at the end of the test}$$
The resistance of a machine winding should be measured and recorded using an appropriate bridge method or voltage and current method.

g) When the embedded temperature detector (ETD) method is used, there should be at least six detectors suitably distributed throughout the machine windings. They should be located at the various points at which the highest temperatures are likely to occur, and in such a manner that they are effectively protected from contact with the coolant. The highest reading of an ETD element should be used to determine compliance with requirements for temperature limits.

h) When there are two or more coil-sides per slot, the ETD elements should be placed between the insulated coil sides. If there is only one coil-side per slot, the ETD method is not a recognised method for determination of temperature rise or temperature limits in order to verify the compliance of the rating.

i) The thermometer method is recognised in the cases in which neither the ETD method nor the resistance method is applicable. See IEC 60034-1 for guidance. The measured temperature rises should not exceed the following values:

- 65 K for class A insulation
- 80 K for class E insulation
- 90 K for class B insulation
- 115 K for class F insulation
- 140 K for class H insulation.

Guidance note 5:

Alternative methods for temperature rise calculations

Temperature tests at full load may be difficult to realise for large machines, due to insufficient test power being available. One of the following simulated tests, or equivalent, will be subject for approval for synchronous generators and induction motors:

- synchronous feedback, or back to back method, according to IEEE Std. 115-1983, 6.2.2
- zero power factor method, according to IEEE Std. 115-1983, 6.2.3
- open-circuit and short circuit loading method, according to IEEE Std. 115-1983, 6.2.4
- "Equivalent loading and super-position techniques - Indirect testing to determine temperature rice", according to 60034-29.

Guidance note 6:

Insulation resistance test (2)

a) The insulation resistance of a new, clean dry machine, should be measured immediately after the temperature test has been carried out and after high voltage test has been carried out using a direct current insulation tester between:

- all current carrying parts connected together and earth
- all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

The minimum values of test voltage and insulation are given in Table 4. The temperature at which the resistance is measured should be near the operating temperature, or an appropriate method of calculation may be used.

b) On carrying out insulation resistance test, it may be necessary to short circuit semi-conductors in order to avoid damage to such parts.

Table 4 Minimum insulation resistance values

<table>
<thead>
<tr>
<th>Rated voltage $U_n$ (V)</th>
<th>Minimum test voltage (V)</th>
<th>Minimum insulation resistance (MΩ)</th>
</tr>
</thead>
</table>

---end---of---guide---note---

---end---of---guide---note---
Guidance note 7:
Overload testing (6)
Overload test is to be carried out as a type test for generators as a proof of overload capability of generators and excitation system, for motors as a proof of momentary excess torque as required in IEC Publication 60034-1. The over current test shall be the proof of current capability of windings, wires, connections etc. of each machine. The overcurrent test can be done at reduced speed (motors) or at short circuit (generators).
Overloads as stated in [1.2.4] are difficult to test on large machines. In case overloads cannot be tested, documentation or calculations based on manufacturers proven methods and experience will be accepted.

Guidance note 8:
Alternative methods for measuring excitation current at rated voltage, current and power factor (15)
Temperature tests at full load may be difficult to realise for large machines, due to insufficient test power being available. One of the following simulated tests, or equivalent, will be subject for approval for synchronous generators and induction motors:
— load excitation, according to IEEE Std. 115-1983, 6.2.2.

Guidance note 9:
Bearing inspection
Upon completion of the tests, machines which have sleeve bearings are to be opened upon request, to establish that the shaft is correctly seated in the bearing shells.

3.1.2 Onboard testing
All machines shall be tested onboard, after installation, so that acceptable starting and running performance are verified with full capacity of driven equipment, alternatively full generator load. See Sec.10.
SECTION 6 POWER TRANSFORMERS

1 General

1.1 General

1.1.1 Reference
The design of transformers shall in general comply with the requirements of IEC 60092-303 and relevant parts of IEC 60076.

1.2 Design requirements for power transformers

1.2.1 General
a) Transformers shall be double wound. Starting transformers and transformers feeding single consumers, as long as the secondary consumer has the same insulation level as the primary side, may be of autotransformer type.
b) Normally, transformers shall be of the dry air-cooled type. Where forced cooling is used, it shall be possible to operate at reduced power if the forced cooling fails. Power transformers with forced cooling shall be equipped with monitoring and alarm as required by Sec.3 [4.2.1].
c) High voltage distribution transformers and propulsion transformers shall be equipped with temperature monitors according to Sec.2 [7.4.1].
d) All windings for air-cooled transformers shall be treated to resist moisture, sea air, and oil vapours.
e) For the general requirements for insulation materials and terminations, see Sec.3 [4].
f) For requirements for busbar material see Sec.4 [2.1].
g) The effects of the harmonics of currents and voltages shall be taken into consideration in the design of transformers with predominate semi-conductor loads.
h) High voltage propulsion transformers shall be equipped with an earthed shield winding

1.2.2 Liquid immersed transformers
a) Liquid immersed transformers, filled with liquid with flashpoint above 60°C, may be accepted in engine rooms or similar spaces if provisions have been made, when installed, for containing or safe draining of a total liquid leakage.
b) Normally, liquid immersed transformers shall be of the sealed type. However, conservator type may be accepted if the construction is such that liquid is not spilled, when the transformer is inclined at 22.5°.
c) Liquid immersed conservator type transformers shall have a breathing device capable of stopping (trapping) moisture from entering into the insulating liquid.
d) Arrangement for containment of accidental leakage shall be arranged.
e) A liquid gauge indicating the normal liquid level range shall be fitted.
f) Liquid immersed transformers shall be provided with monitoring and alarms as required in Table 1 (Ref. IACS UR E11).

Table 1 Monitoring of liquid immersed transformers

<table>
<thead>
<tr>
<th>Item</th>
<th>Alarm</th>
<th>Load reduction or trip</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid level, low 1)</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid level, low 1)</td>
<td></td>
<td>X</td>
<td>Trip</td>
</tr>
<tr>
<td>Liquid temperature, high</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Electrical installations

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid temperature, high high</td>
<td>X</td>
<td>Trip</td>
</tr>
<tr>
<td>Gas pressure, high</td>
<td>X</td>
<td>Trip</td>
</tr>
<tr>
<td>Interturn short circuit</td>
<td>X</td>
<td>Trip</td>
</tr>
</tbody>
</table>

1) There shall be two individual liquid level sensors

1.2.3 Temperature rise
Temperature rise for transformers, above ambient, according to Sec.3 [2.3], shall not exceed the following values (measured by the resistance method):

a) Dry type transformer windings:
   - insulation class A: 55°C
   - insulation class E: 70°C
   - insulation class B: 75°C
   - insulation class F: 95°C
   - insulation class H: 120°C
   - insulation class 220: 145°C

b) Liquid immersed transformers:
   - temperature rise for windings: 55°C
   - temperature rise for liquid when the liquid is in contact with air: 45°C
   - temperature rise for liquid when the liquid not is in contact with air: 50°C.

1.2.4 Parallel operation
Transformers for parallel operation shall have compatible coupling groups and voltage regulation, so that the actual current of each transformer will not differ from its proportionate share of the total load by more than 10% of its full load current.

1.2.5 Voltage regulation
Transformers supplying secondary distribution systems for general use shall normally have a maximum 2.5% voltage drop from no load to full load at resistive load.

1.2.6 Short circuit withstand strength
Transformers shall be constructed to withstand a primary or secondary terminal short circuit with a duration of minimum 1 s, with rated primary voltage and frequency, without damage to internal parts or enclosure.

1.2.7 Nameplate
Each power transformer shall be provided with nameplate of durable material, giving the following information:
   - make, type, serial no.
   - performance standard
   - rated values for: output apparent power, voltage(s), frequency, current(s)
   - duty type, if other than S1
   - thermal classification of insulation
   - IP code of enclosure and termination box
   - vector group of windings
   - maximum permissible cooling medium temperature
   - short circuit impedance value
   - liquid type (if applicable)
   - total mass.
2 Inspection and Testing

2.1 General

2.1.1 Factory testing

a) Transformers shall be tested at the manufacturer’s works with the tests specified in this part. Tests noted as type tests (TT) shall be carried out on a prototype or the first of a batch of identical transformers. Tests noted as routine tests (RT) shall be carried out on each transformer.

b) The tests shall be documented. The documentation shall give information on make, type, serial no., insulation class, all technical data necessary for the application of the transformer, as well as the results of the required tests.

c) The result of type tests, and the serial number of the type tested transformer, shall be specified in the documentation of test results for a routine test.

d) Required inspection and tests for distribution transformers are given in Table 2.

Table 2 Testing and inspection of transformers

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Type of test</th>
<th>IEC reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inspection of enclosure, terminations, instrumentation or protection</td>
<td>RT</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Measuring of insulation resistance</td>
<td>RT</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Measuring of voltage ratio at no load and check of phase displacement</td>
<td>RT</td>
<td>IEC 60076-11.16</td>
</tr>
<tr>
<td>4</td>
<td>Measuring of winding resistance</td>
<td>RT</td>
<td>IEC 60076-11.15</td>
</tr>
<tr>
<td>5</td>
<td>Short circuit impedance and load losses</td>
<td>RT</td>
<td>IEC 60076-11.17</td>
</tr>
<tr>
<td>6</td>
<td>Measuring of no-load loss and current</td>
<td>RT</td>
<td>IEC 60076-11.18</td>
</tr>
<tr>
<td>7</td>
<td>Separate-source AC withstand voltage test</td>
<td>RT</td>
<td>IEC 60076-11.19</td>
</tr>
<tr>
<td>8</td>
<td>Inducted AC withstand voltage test</td>
<td>RT</td>
<td>IEC 60076-11.20</td>
</tr>
<tr>
<td>9</td>
<td>Temperature rise test</td>
<td>TT</td>
<td>IEC 60076-11.23</td>
</tr>
<tr>
<td>10</td>
<td>Partial discharge measurement on transformer windings with Um ≥ 3.6 kV. Maximum level of partial discharge shall be 10 pC. (Not applicable to liquid immersed transformers.)</td>
<td>RT</td>
<td>IEC 60076-11.22</td>
</tr>
</tbody>
</table>

2.1.2 Temperature rise test

Temperature test at full load may be difficult to realise on large transformers, due to insufficient test power being available. One of these simulated tests, or equivalent may be accepted:

— back to back method, according to IEC 60076-11 23.2.2
— simulated load method, according to IEC 60076-11 23.2.1.

2.1.3 Separate-source AC withstand voltage test/ high voltage test

a) A high voltage test shall be applied to a new and completed transformers.

b) The test shall be carried out immediately after the temperature rise test, when such is required.

c) The test shall be applied between each winding and the other windings, frame and enclosure all connected together. The full test voltage shall be maintained for 1 minute. For test levels, see Table 3.

d) Single phase transformers for use in a polyphase group shall be tested in accordance with the requirements for the transformers as connected together in the system.
e) After rewinding or other extensive repair the transformer shall be subjected to a high voltage test with a test voltage of at least 75% of that specified in c) above.

2.1.4 Temperature rise test
The insulation resistance of a new, clean dry transformer shall be measured immediately after the temperature raise test, when such is required, and the high voltage test has been carried out. Test voltage and minimum insulation resistance is given in Table 4. The test shall be carried out between:
— all current carrying parts, connected together, and earth
— all current carrying parts of different polarity or phase, where both ends of each polarity or phase are individually accessible.

Table 3 Test voltages

<table>
<thead>
<tr>
<th>Highest voltage for equipment $U_{m}$ (kV r.m.s.)</th>
<th>Rated short duration power frequency withstand voltage $U_{s}$ (kV r.m.s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leq 1$</td>
<td>3</td>
</tr>
<tr>
<td>3.6</td>
<td>10</td>
</tr>
<tr>
<td>7.2</td>
<td>20</td>
</tr>
<tr>
<td>12</td>
<td>28</td>
</tr>
<tr>
<td>17.5</td>
<td>38</td>
</tr>
</tbody>
</table>

Table 4 Test voltages and minimum insulation resistance

<table>
<thead>
<tr>
<th>Rated voltage $U_{n}$ (V)</th>
<th>Minimum test voltage (V)</th>
<th>Minimum insulation resistance (M$\Omega$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_{n} \leq 250$</td>
<td>$2 \times U_{n}$</td>
<td>1</td>
</tr>
<tr>
<td>$250 &lt; U_{n} \leq 1000$</td>
<td>$500$</td>
<td>1</td>
</tr>
<tr>
<td>$1000 &lt; U_{n} \leq 7200$</td>
<td>$1000$</td>
<td>$(U_{n} /1000) + 1$</td>
</tr>
<tr>
<td>$7200 &lt; U_{n} \leq 15\ 000$</td>
<td>$5000$</td>
<td>$(U_{n} /1000) + 1$</td>
</tr>
</tbody>
</table>

2.1.5 Onboard testing
All transformers shall be subject to function tests with intended loading, after installation onboard.
SECTION 7 SEMI-CONDUCTOR ASSEMBLIES

1 General Requirements

1.1 General

1.1.1 References

a) The design and construction of semi-conductor assemblies shall comply with relevant requirements of Sec.3 and Sec.4. For control and monitoring equipment the requirements are given in Ch.9.
b) Voltage and frequency characteristics of supply networks are given in Sec.2 [1.2].
c) The design of semi-conductor assemblies shall comply with the requirements of IEC 60146-1-1 with applicable requirements modified to suit marine installations like e.g. environmental requirements stated in Sec.3.
d) The design of semi-conductor assemblies for power supply shall in addition to a), b) and c) comply with the requirements of IEC 62040 series.
e) The design of semi-conductor assemblies for motor drives shall in addition to a) b) and c) comply with the requirements of IEC 61800 series.

Guidance note:
Semi-conductor converters for power supply covers systems with converters with and without means for energy storage. UPS, battery chargers, clean power units etc.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.1.2 Technical integration
Unless otherwise stated, it is the responsibility of the Builder to ensure technical integration of transformers, assemblies, motors and generators with respect to:
— rating and cooling (with respect to increased losses)
— torque/speed characteristics
— acceleration/breaking
— bearing currents
— harmonic filters
— operating philosophies
— installation instructions.

1.1.3 Functionality
An assembly shall be described in a functional description. This description shall at least cover the following items:
— intended use and operational modes
— control system
— integration versus higher level control system
— redundancy for cooling
— manual operation
— protection functions, trips and shut downs
— redundancy
— alarms
— specific functional requirements given in applicable rules, e.g. Sec.12 for electric propulsion.
1.2 Design and construction requirements

1.2.1 Electrical rating and duty

a) The specified capacity shall at least include a 100% continuous load, and a specified overload capacity given by a current of maximum duration of time.

b) Converters for motor drives (including soft starters), shall as a minimum withstand two consecutive start attempts immediately followed after stopping, or starting up from cold without being overheated.

c) For battery chargers and UPS, requirements for charger capacity are given in Sec.2 [4.1.2].

1.2.2 Creepage and clearance distances

Creepage and clearance distances shall be in accordance with relevant product standard, The clearance and creepage distances given in the relevant IEC standards are reproduced in Table 1 to Table 3. The impulse voltage test voltages are reproduced in Table 6.

For semi-conductor converters for power supply the requirements are given in IEC 60950-1. For semi-conductor converters for motor drives the requirements are given in IEC 61800-5-1

Table 1 Minimum clearance distances for low voltage semi-conductor converters ¹)

<table>
<thead>
<tr>
<th>Nominal voltage of the system, (line voltage); (V) ²)</th>
<th>Minimum clearance distance, (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>0.80</td>
</tr>
<tr>
<td>220, 230, 240</td>
<td>1.5</td>
</tr>
<tr>
<td>380, 400, 415, 440, 480</td>
<td>3.0</td>
</tr>
<tr>
<td>600, 630, 660, 690</td>
<td>5.5</td>
</tr>
</tbody>
</table>

¹) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2. Applicable for three phase systems. If single phase supply, the distance shall be increased one step.

²) Interpolation is not permitted.

Table 2 Minimum clearance distances for high voltage semi-conductor converters ¹)

<table>
<thead>
<tr>
<th>Nominal voltage of the system (maximum line voltage); (V) ²)</th>
<th>Minimum clearance distance, (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1732</td>
<td>8.0</td>
</tr>
<tr>
<td>6235</td>
<td>25</td>
</tr>
<tr>
<td>12470</td>
<td>60</td>
</tr>
<tr>
<td>20785</td>
<td>90</td>
</tr>
</tbody>
</table>

¹) Extract from IEC 61800-5-1, Table 7, 8 and 9, and IEC 60950-1, Annex G, Table G.2.

²) Interpolation is permitted.

Table 3 Minimum creepage distances, semi-conductor converters ¹)

<table>
<thead>
<tr>
<th>Working voltage (V) ²) ³) (rms)</th>
<th>Minimum creepage distance ⁴), (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>2.2</td>
</tr>
<tr>
<td>160</td>
<td>2.5</td>
</tr>
</tbody>
</table>
### Table 1

<table>
<thead>
<tr>
<th>Voltage (V)</th>
<th>Current (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>3.2</td>
</tr>
<tr>
<td>250</td>
<td>4.0</td>
</tr>
<tr>
<td>320</td>
<td>5.0</td>
</tr>
<tr>
<td>400</td>
<td>6.3</td>
</tr>
<tr>
<td>500</td>
<td>8.0</td>
</tr>
<tr>
<td>630</td>
<td>10.0</td>
</tr>
<tr>
<td>800</td>
<td>12.5</td>
</tr>
<tr>
<td>1000</td>
<td>16.0</td>
</tr>
<tr>
<td>1250</td>
<td>20.0</td>
</tr>
<tr>
<td>1600</td>
<td>25.0</td>
</tr>
<tr>
<td>2000</td>
<td>32.0</td>
</tr>
<tr>
<td>2500</td>
<td>40.0</td>
</tr>
<tr>
<td>3200</td>
<td>50.0</td>
</tr>
<tr>
<td>4000</td>
<td>63.0</td>
</tr>
<tr>
<td>5000</td>
<td>80.0</td>
</tr>
<tr>
<td>6300</td>
<td>100.0</td>
</tr>
<tr>
<td>8000</td>
<td>125.0</td>
</tr>
<tr>
<td>10000</td>
<td>160.0</td>
</tr>
</tbody>
</table>

1) Extract from IEC 61800-5-1, Table 10, and IEC 60950-1, Table 2N.
2) The highest voltage to which the insulation under consideration is, or can be, subjected when the equipment is operating at its rated voltage under conditions of normal use.
3) Interpolation is permitted.
4) Based on insulating material group IIIa/b. If the material group is not known, group IIIa/b shall be assumed.

### 1.2.3 Capacitor discharge

Capacitors within a converter shall be discharged to less than 60 Volt in less than 5 s (or a residual charge of less than 50 μC) after removal of the power. If this requirement is not achievable, warning signboards shall be fitted.

### 1.2.4 Access conditions for high voltage converters

High voltage sections of converters shall have enclosures as required for high voltage switchgear in Sec.4. Doors shall be automatically locked unless the main circuit breaker is open and the circuit is earthed.

### 1.2.5 Cooling

a) Where forced cooling is provided, the apparatus is, unless otherwise particularly required, to be so arranged that the converter cannot remain loaded unless effective cooling is provided, or other effective means of protection against over temperature is provided. See also Sec.3 [4.2.1].

b) Piping shall be arranged to prevent harmful effects due to leakage or condensation, and be installed preferably in the lower part of the assembly.

c) Requirements for cooling of converters used for propulsion are given in Sec.12.
1.2.6 Output voltage and frequency
The output voltage and frequency of the power supply units shall comply with the requirements for power supply systems given in Sec.2 [1].

1.2.7 Short circuit current capabilities
Converters serving as power supplies shall be able to supply a short circuit current sufficient for selective tripping of downstream protective devices without suffering internal damage. Such selective tripping may be achieved by the utilisation of an automatic bypass. Current limiting power supplies, or power supplies limited by internal temperature may be used for single consumers.

1.2.8 By-pass arrangement
For converters serving as AC power supply units used as emergency or transitional source of power, or as power supply to essential or important consumers, a manual electrically independent bypass arrangement shall be provided unless redundant supply to the consumers is otherwise ensured.

1.2.9 Location of batteries
Requirements for location of batteries are given in Sec.2 [9.4].

1.2.10 Protection and monitoring
a) Alarm shall be given for power supply failure and trip of unit
b) For IT distribution systems (insulated neutral point), alarm shall be given for secondary side earth fault (except in dedicated supply system for single consumers).
c) For liquid cooled converters where the cooling liquid is in direct contact with live parts, the conductivity shall be monitored, and high conductivity shall give alarm.
d) When harmonic filters are integrated in a converter, protection and monitoring as required in Sec.2 [7.7.1] is required.
e) Additional requirements for monitoring of converters used in electrical propulsion systems are given in Sec.12.
f) For power supply units with batteries included, the following additional alarms shall be provided:
   — when the charging of a battery fails, alternatively if the battery is being discharged
   — when the automatic bypass is in operation for on-line UPS units.
   — operation of battery protective device.
g) UPS units used as transitional power supply as defined in SOLAS Ch.II-1 Reg. 42, 4 or 43, 4 or as an independent power supply to services as defined in SOLAS Ch.II-1 Reg. 42, 2.3 or 43, 2.4. shall in addition have power supply failure (voltage and frequency) to the connected load,
h) Alarms shall be given to a manned control station.
i) Requirements for protection of batteries and distribution circuits are given in Sec.2 [7].

1.2.11 Emergency stop, shutdown
a) In drives used for applications where emergency stop is required, the emergency stop circuit shall comply with Sec.2 [8.6.1]. I.e. the emergency stop signal shall be directly connected to trip the main power supply to the drive unit, either directly or through the control power circuit for the circuit breaker. Alternative arrangements independent of the software based control system may be accepted (e.g. pulse blocking, disconnection of control voltage to pulse amplifiers.)
b) Requirements for limited shutdown functions for steering and propulsion are given in Sec.12 and Ch.10.

1.2.12 Restart
It shall be possible to restart the converter in a normal manner after a blackout. Local resetting/restarting of the unit shall not be necessary.
2 Inspection and Testing

2.1 General

2.1.1 Factory testing

a) Converters shall be tested at the manufacturer's works. Type tests (TT) shall be carried out on a prototype of a converter or the first of a batch of identical converters. Routine tests (RT) shall be carried out on each converter.

b) The tests shall be documented. The documentation shall give information on make, type, serial no., all technical data necessary for the application of the converter, as well as the results of the required tests.

c) The result of type tests, and the serial number of the type tested converter, shall be specified in the documentation of test results for routine tests.

d) The type tests and routine tests that semi-conductor converters shall undergo are listed in Table 4.

Table 4 Testing and inspection of semi-conductor converters for power supply / UPS

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Required test converter for power supply/UPS</th>
<th>IEC test reference</th>
<th>DNV GL Rule requirement reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual inspection$^1$</td>
<td>TT, RT</td>
<td></td>
<td>Sec.3/Sec.4/</td>
</tr>
<tr>
<td>2</td>
<td>Function test (UPS switch test)$^2$</td>
<td>TT, RT</td>
<td>62040-3 pt. 6.2.2.x</td>
<td>[1.1.3]</td>
</tr>
<tr>
<td>3</td>
<td>Input voltage and frequency tolerance test</td>
<td>TT</td>
<td>62040-3 pt. 6.4.1.x</td>
<td>Sec.2 [1.2]</td>
</tr>
<tr>
<td>4</td>
<td>Stored energy and restored energy tests</td>
<td>TT</td>
<td>62040-3 pt. 6.4.4</td>
<td>Sec.2 [4.1.2]</td>
</tr>
<tr>
<td>5</td>
<td>Insulation tests (High voltage test)</td>
<td>TT, RT</td>
<td>61800-5-1 pt. 5.2.3.2</td>
<td>[2.1.2]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60146-1-1 pt 7.2.3.1</td>
<td>Sec.10 [4.3.3]</td>
</tr>
<tr>
<td>6</td>
<td>Insulation resistance test$^3$</td>
<td>TT, RT</td>
<td>60146-1-1 pt 7.2.3.1</td>
<td>Sec.10 [4.3.3]</td>
</tr>
<tr>
<td>7</td>
<td>Rated current test/Full load test$^4$</td>
<td>TT</td>
<td>62040-3 pt 6.4.3.x</td>
<td>[1.2]</td>
</tr>
<tr>
<td>8</td>
<td>Temperature rise test</td>
<td>TT</td>
<td>60146-1-1 pt 7.4.2</td>
<td>Sec.3 [2.3]</td>
</tr>
<tr>
<td>9</td>
<td>Control and monitoring system (ref also function test)</td>
<td>TT, RT</td>
<td>62040-3 pt. 6.2.2.3.x</td>
<td>[1.2.10]</td>
</tr>
<tr>
<td>10</td>
<td>Short circuit test</td>
<td>TT</td>
<td>62040-3 pt 6.4.2.10.x</td>
<td>[1.2.7]</td>
</tr>
<tr>
<td>11</td>
<td>Cooling failure tests</td>
<td>TT, RT</td>
<td>61800-5-1 pt 5.2.4.5</td>
<td>[1.2.6] and [1.2.10]</td>
</tr>
<tr>
<td>12</td>
<td>Capacitor discharge</td>
<td>TT</td>
<td></td>
<td>[1.2.3]</td>
</tr>
<tr>
<td>13</td>
<td>Pressure test of coolant piping/hoses.</td>
<td>RT</td>
<td></td>
<td>Ch.6 Sec.10 [4]</td>
</tr>
</tbody>
</table>
1) Verification of separation, labelling, IP-rating, creepage and clearance distances.
2) Including check of auxiliary devices, properties of control equipment and protective devices. (IEC 60146-1-1 pt 7.5.1-3) In accordance with functional description and test program. The light load and function test may be performed with power modules identically to the ones that shall be installed onboard. The correct power modules may be tested separately.
3) Insulation resistance test shall be done in accordance with Sec.10 Table 5.
4) Full load current and overcurrent test according to rating as required in [1.2.7]

Table 5 Testing and inspection of semi-conductor converters for motor drives

<table>
<thead>
<tr>
<th>No.</th>
<th>Task</th>
<th>Required test converter for motor drives</th>
<th>IEC test reference</th>
<th>DNV GL Rule requirement reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Visual inspection</td>
<td>TT, RT</td>
<td>61800-5-1 pt. 5.2.1</td>
<td>Sec.3/Sec.4/</td>
</tr>
<tr>
<td>2</td>
<td>Input voltage and frequency tolerance test</td>
<td>TT</td>
<td>62040-3 pt. 6.3.2</td>
<td>Sec.2 [1.2]</td>
</tr>
<tr>
<td>3</td>
<td>Light load and function test</td>
<td>TT, RT</td>
<td>60146-1-1 pt 7.3.1 and 7.5</td>
<td>[1.1.3]</td>
</tr>
<tr>
<td>4</td>
<td>Impulse voltage test</td>
<td>TT</td>
<td>61800-5-1 pt. 5.2.3.1</td>
<td>61800-5-1 pt. 5.2.3.1</td>
</tr>
<tr>
<td>5</td>
<td>Insulation tests (High voltage test)</td>
<td>TT, RT</td>
<td>61800-5-1 pt. 5.2.3.2</td>
<td>61800-5-1 pt. 5.2.3.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60146-1-1 pt 7.2</td>
<td>[2.1.2]</td>
</tr>
<tr>
<td>6</td>
<td>Insulation resistance test</td>
<td>TT, RT</td>
<td>60146-1-1 pt 7.2.3.1</td>
<td>Sec.10 [4.3.3]</td>
</tr>
<tr>
<td>7</td>
<td>Rated current test/Full load test</td>
<td>TT</td>
<td>60146-1-1 pt 7.3.2</td>
<td>[1.2]</td>
</tr>
<tr>
<td>8</td>
<td>Temperature rise test</td>
<td>TT</td>
<td>61800-5-1 pt. 5.2.3.9</td>
<td>Sec.3 [2.3]</td>
</tr>
<tr>
<td>9</td>
<td>Control and monitoring system (ref also function test)</td>
<td>TT, RT</td>
<td>61800-5-1 pt. 5.2.3.9</td>
<td>61800-5-1 pt. 5.2.3.9</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>60146-1-1 pt 7.4.2</td>
<td>[1.2.10]</td>
</tr>
<tr>
<td>10</td>
<td>Cooling failure tests</td>
<td>TT, RT</td>
<td>61800-5-1 pt. 5.2.4.5</td>
<td>[1.2.6] and [1.2.10]</td>
</tr>
<tr>
<td>11</td>
<td>Capacitor discharge</td>
<td>TT</td>
<td>61800-5-1 pt. 5.2.3.7</td>
<td>[1.2.3]</td>
</tr>
<tr>
<td>12</td>
<td>Pressure test of coolant piping/hoses</td>
<td>RT</td>
<td></td>
<td>Ch.6 Sec.10 [4]</td>
</tr>
<tr>
<td>13</td>
<td>Breakdown of components test 6)</td>
<td>TT</td>
<td>61800-5-1 pt. 5.2.3.6.4</td>
<td>Sec.2 [1.1.1] a), Sec.4 [1.1.2] b)</td>
</tr>
</tbody>
</table>
1) Verification of separation, labelling, IP-rating, creepage and clearance distances.
2) Including check of auxiliary devices, properties of control equipment and protective devices. (IEC 60146-1-1) In
d accordance with functional description and test program. The light load and function test may be performed with
power modules identically to the ones that shall be installed onboard. The correct power modules may be tested
separately.
3) To be performed if clearance and /or creepage distances are less than specified in Table 1, Table 2 and Table 3
4) Insulation resistance test shall be done in accordance with Sec.10 Table 5.
5) Full load current and over current test according to rating as required in [1.2.1] a)
6) Only applicable for variable speed drives larger than 1 MW.

### 2.1.2 High-voltage testing

High-voltage testing shall be carried out with test voltages as given in relevant product standard. These
voltages given in IEC 60146-1-1 are reproduced in Table 6.

The test voltage shall be applied for 1 minute for “Type Tests”, and minimum 1 s for Routine Tests. If the
circuit contains capacitors the test may be performed with a DC voltage.

#### Table 6 High voltage test

<table>
<thead>
<tr>
<th>Nominal voltage of the system</th>
<th>Power frequency withstand voltage (V)</th>
<th>Impulse voltage level (kV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ac</td>
<td>DC</td>
<td></td>
</tr>
<tr>
<td>r.m.s (V)</td>
<td>AC</td>
<td>DC</td>
</tr>
<tr>
<td>&lt;50</td>
<td>1250</td>
<td>1770</td>
</tr>
<tr>
<td>100</td>
<td>1300</td>
<td>1840</td>
</tr>
<tr>
<td>150</td>
<td>1350</td>
<td>1910</td>
</tr>
<tr>
<td>300</td>
<td>1500</td>
<td>2120</td>
</tr>
<tr>
<td>600</td>
<td>1800</td>
<td>2550</td>
</tr>
<tr>
<td>1000</td>
<td>2200</td>
<td>3110</td>
</tr>
<tr>
<td>&gt;1000</td>
<td>3000</td>
<td>4250</td>
</tr>
<tr>
<td>3600</td>
<td>10000</td>
<td>14 150</td>
</tr>
<tr>
<td>7200</td>
<td>20000</td>
<td>28 300</td>
</tr>
<tr>
<td>12 000</td>
<td>28 000</td>
<td>39 600</td>
</tr>
<tr>
<td>17 500</td>
<td>38 000</td>
<td>53 700</td>
</tr>
</tbody>
</table>

Some interpolation is permitted

### 2.1.3 Onboard testing

Semi-conductor converters for power supply and semi-conductor converters for motor drives shall be tested
according to Sec.10 [4] after installation onboard.
SECTION 8 MISCELLANEOUS EQUIPMENT

1 General

1.1 Socket outlets and plugs

1.1.1 General

a) Socket outlets and plugs with a rated current not exceeding 63 A in AC installations and 16 A in DC installations, shall be constructed for making and breaking the rated current by insertion and withdrawal of the plug, unless they are provided with an interlock as described in b).

b) Socket outlets with a rated current above 63 A AC or 16 A DC shall be provided with interlocks so that the plug can only be inserted and withdrawn when the switch is in the “off” position.

c) Socket outlets for portable appliances, which are not hand-held during operation (e.g. welding transformers, refrigerated containers), shall be interlocked with a switch regardless of rating, maximum 1 000 V can be accepted. At each such socket outlet, a warning sign shall be fitted, with text: DANGER (maximum voltage) V AC ONLY FOR CONNECTION OF…. (type of equipment)....

d) Higher voltage socket outlets can only be used for special applications.

e) All socket outlets shall be provided with an earthing contact, except that this may be omitted in the following cases:

   — socket outlets on systems with voltage below 50 V AC or DC
   — socket outlets with double insulated transformers for handheld equipment
   — for distribution systems with insulated neutral; socket outlets in dry accommodation spaces where floor covering, bulkhead and ceiling linings are of insulating material. The resistance of the insulating material shall be at least 50 kOhm. Earth potential shall not be brought into the space, for instance through earth conductors, piping etc.

f) Precautions shall be taken so that a plug for one voltage cannot be inserted in a socket outlet for a different voltage. Alternatively, warning signboards shall be fitted.

1.2 Lighting equipment

1.2.1 General

a) The temperature rise of parts of luminaries that are in contact with the support shall generally not exceed 50°C.

b) The temperature rise limit is 40°C for parts installed in contact with flammable materials, such as for example wood.

c) For temperature rise of terminals, see Sec.3.

d) For other parts, temperatures according to recognised national or international standards, which take due consideration of the ambient temperatures on vessels, will be accepted.

e) Luminaires, floodlights and searchlights shall conform to IEC publications 60598 and 60092-306. Other standards may be recognised.

1.2.2 Starting devices

Starting devices which develop higher voltages than the supply voltage are generally to be placed within the luminaries.

1.2.3 Discharge of capacitors

Each capacitor of 0.5 µF or more shall be provided with an arrangement that reduces the voltage to not more than 50 V within 1 minute after disconnection from the supply.
1.3 Heating equipment

1.3.1 General
Each separate heating element rated more than 16A is considered as a separate consumer, for which a separate circuit from a switchboard is required.

1.3.2 Temperature rise limit for heaters
a) Control elements such as switches knobs and handles shall not attain temperatures, while in operation, no higher than
   — 55°C for metal parts or
   — 65°C for parts made of porcelain, glass, moulded plastics or wood.

   A temperature of 5°C higher is permissible for parts operated by finger tipping only (inching operation).

b) Electrical space heaters shall be so designed that, based on an ambient temperature of 20°C, the temperature of the casing or enclosure and of the air flow from the heater does not exceed 95°C under defined test conditions.

   **Guidance note:**
   It is recommended to provide each heater with an interlocked over temperature thermostat with manual reset, accessible only by use of a tool. National regulations of the flag state might require such an over temperature cut out.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.3 Space heaters
a) Space heaters are generally to be of the convection type, and suitable for installation on bulkheads. Radiation heaters and other space heater types may be accepted after consideration in each case.

1.3.4 Heating batteries for ventilation systems
Heating batteries in centralised ventilation systems shall be equipped with the following safety / control functions:
   — heating elements shall be interlocked with respect to the air flow either directly controlled by the power to the fan or by measuring the airflow locally at the heating element
   — heating elements shall be equipped with over temperature switch that can be reset manually only
   — heating elements shall be equipped with thermostat controlgear.

1.3.5 Space heaters combined with air-condition cabinets
The following additional requirements apply for space heaters integrated in air-conditioning cabinets:
   — the maximum temperature rises specified in [1.3.2] shall be complied with, even when the air supply is completely shut off
   — each cabinet shall be provided with an interlocked over temperature thermostat with manual reset, accessible only by use of tool
   — combined cabinets for ceiling installation are accepted provided the ceiling is constructed of incombustible materials.

1.3.6 Water heaters
a) Water heaters are normally to have insulated heating elements and shall be installed as separate units.

b) The requirements for temperature rises specified in [1.3.2] apply.

c) Each water heater shall be provided with a thermostat, sensing the water temperature and maintaining this at the correct level.

d) Continuous flow water heaters shall have a safety thermostat.

   **Guidance note:**
   Electrode heaters and electrically heated steam boilers may be accepted after assessment of the arrangement in each case.
Part 4 Chapter 8 Section 8

Heating by electric elements in the ship's water tanks may be accepted after design assessment of the arrangement in each case. For pressure vessels, the requirements in Ch.7 apply.

---end---of---guidance---note---

1.3.7 Oil heaters

a) Electric oil heaters are normally to be installed as separate units. Heating by electric heating elements in the ship's oil tanks is generally not allowed, but may be accepted after special design assessment of the arrangement in each case.

b) The requirements for temperature rises specified in [1.3.2] apply. In addition, the surface temperature of the heating elements shall be below the boiling point of the oil, under normal working conditions. Further limitation of the heating elements' temperature may be required.

c) Each oil heater shall be provided with a working thermostat, sensing the oil temperature and maintaining this at correct level under normal working conditions. In addition, each oil heater shall be provided with an interlocked over-temperature thermostat with manual reset, and with the sensing device installed in close proximity to the heating elements, so arranged that it will trip the elements, should they tend to overheat, or become dry. Other arrangements, ensuring equivalent protection, may be accepted after design assessment in each case

Guidance note:
The heating element temperature for lubricating oil should be so low that deterioration of the properties is avoided. The oil manufacturer should be consulted regarding the maximum acceptable element temperature.

---end---of---guidance---note---

1.4 Cooking and other galley equipment

1.4.1 General

a) Cooking equipment is generally to have insulated heating elements. Special equipment, such as for example high frequency ovens or electrode pots, shall be suitable for marine use, and installed in accordance with the manufacturer's instructions.

b) Electrode pots giving earth connection of the system shall be fed from separate isolating transformers.

c) For oil pots, the requirements for oil heaters in [1.3.7] apply

d) The temperature rises in [1.3.2] are accepted.

Table 1 Temperature rises for cooking and other galley equipment

<table>
<thead>
<tr>
<th>Part</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enclosure parts against the bulkhead and decks</td>
<td>50</td>
</tr>
<tr>
<td>Other accessible surface parts, except hot plates with adjacent top plates</td>
<td>50</td>
</tr>
<tr>
<td>Hot plates with adjacent top plates, and heating elements</td>
<td>No limit ¹)</td>
</tr>
</tbody>
</table>

¹) Construction and temperatures shall be such that damage and hazards are avoided, when the equipment is used as intended.
SECTION 9 CABLES

1 Application

1.1 General

1.1.1 General

a) This section of the rules contains requirements for selection, construction and rating of fixed electrical cables for permanent installation. Requirements for flexible cables designed for repeated movement are also covered in this section. Other applicable requirements in other sections shall also be complied with.
b) Requirements for cables for special applications are found in other parts of the rules. For cable selection see Sec.2 and for cable installation see Sec.10.

1.1.2 Duty

a) Unless otherwise clearly stated, the rating of electrical cables for power supply to equipment shall be for continuous full load duty. Maximum environmental temperatures shall be as given in Sec.3 Table 1.
b) Requirements for cable sizing, and the tables for the current rating of different cable sizes, can be found in Sec.2.

Guidance note:
Cables for fixed installation are generally accepted for the minimum environmental temperature given in Sec.3 Table 1 without testing for behaviour at low temperature in excess of what is required in the referenced product standards of the 60092 series with the condition that the cables on open deck are properly fixed and mechanically protected.
Flexible cables shall be suitable for the temperatures in which they operate.

1.1.3 Compliance with IEC

The design of all electrical cables installed shall comply with the requirements of applicable IEC Publications.

Guidance note:
Power cables constructed in accordance with these IEC standards will normally have an insulating outer sheath. Certified cables constructed with outer armour or braid will have sufficient insulating material beneath this outer braid. For cables with an outer metal braid, the outer braid cannot be used as earth conductor (as given in Sec.2 Table 4).
Permanently installed cables for power, control and instrumentation shall normally comply with the specifications of International Electrotechnical Commission's (IEC):

1) Publication No. 60092-350 For general construction and test methods of power, control and instrumentation cables for shipboard and offshore applications"
2) Publication No. 60092-353 For power cables with extruded solid insulation for rated voltage 1 kV and 3 kV for lighting and power cables.
3) Publication No. 60092-354 For rated voltages 6 kV (U_{m} = 7.2 kV) up to 30 kV (U_{m} = 36 kV) for High Voltage cables.
4) Publication No. 60092-376 For control and instrumentation cables 150/250 V (300 V).

2 General Cable Construction

2.1 General

2.1.1 This item 2 of the rules contains general requirements for construction of marine cables for permanent installation. Requirements applicable to specific type of cables are found in the following items 3 to 7, and
may open for solutions outside the requirements in this item 2. Other constructions and materials may be accepted when designed for special purposes.

2.2 Fire properties

2.2.1 General

a) All switchboard wires, electrical cables and wiring external to equipment shall be at least of a flame-retardant type. (This requirement is intended to cover SOLAS Ch. II-1/45.5.2.)
b) A single cable shall be flame retardant according to IEC 60332-1.

2.3 Conductors

2.3.1 Conductors

a) All conductors shall consist of plain or metal-coated annealed copper according to IEC 60092-350 and shall be stranded according to IEC 60228 class 2 or class 5.
b) Class 1 (solid conductors) is accepted for data communication cables (Cat. Cables) where the termination assembly provides sufficient mechanical integrity.
c) Class 6 is accepted for flexible cables.

Guidance note:
The use of other conductor metals may be considered in applications where copper cannot be used for chemical reasons. See Pt.5 Ch.7 Sec.17. See also Sec.10 [2.4.1].

2.3.2 Conductor cross section

a) Conductor cross sections shall be based on the rating of the over current and short circuit protection used. However the minimum cross section shall be:
   — 0.5 mm$^2$ for 250 V for cables and switchboard wires for control and instrumentation
   — 1.0 mm$^2$ for power circuit switchboard wires
   — 1.0 mm$^2$ for 0.6/1 kV power cables with the following exceptions: 0.75 mm$^2$ may be used for flexible cables supplying portable consumers in accommodation spaces, and also for internal wiring of lighting fittings, provided that the full load current is a maximum of 6 A and that the circuit's short circuit protection is rated at a maximum of 10 A
   — 10 mm$^2$ for 1.8/3 and 3.6/6 kV cables
   — 16 mm$^2$ and upwards for 6/10 kV cables. (For higher voltage see Table 6).
b) Minimum cross sections of earth conductors are given in Sec.2. Earth conductors in cables shall be insulated, except for earth conductors as specified in Sec.2 Table 6.

2.4 Insulating materials

2.4.1 General

a) The materials and temperature classes given in Table 1 shall in general be used.
b) Electrical and mechanical characteristics shall comply with the specifications of Table 2, 3 and 4, respectively of IEC 60092-360.
c) For cables intended for dynamic applications (flexible cables) other materials may be accepted.

Guidance note:
As per IEC 60092-360, PVC insulation and ST1 sheath are withdrawn for maritime use after 01-01-2016.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---
### Table 1 Temperature classes for insulating materials

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethylene propylene rubber (EPR)</td>
<td>90</td>
</tr>
<tr>
<td>Hard grade ethylene propylene rubber (HEPR)</td>
<td>90</td>
</tr>
<tr>
<td>Cross linked polyethylene (XLPE)</td>
<td>90</td>
</tr>
<tr>
<td>Halogen free cross linked polyolefin (HF 90)</td>
<td>90</td>
</tr>
<tr>
<td>Silicone rubber, (S 95)</td>
<td>95</td>
</tr>
</tbody>
</table>

1) Silicon rubber only to be used together with a varnished glass braid

### 2.5 Wire braid and armour

#### 2.5.1 General

a) Cable braids shall be made of copper, copper alloy, or galvanised steel wire.
b) Braid and/or armour shall be separated from the core insulation by an inner non-metallic sheath, by tape or fibrous braid or roving.
c) Irrespective of the metal used, the nominal diameter of the braid wire shall be in accordance with Table 2.

### Table 2 Nominal diameter of braided wire

<table>
<thead>
<tr>
<th>Diameter of core assembly under braid 1) (mm)</th>
<th>Minimum diameter of threads in braid 2) (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D ≤ 10</td>
<td>0.2</td>
</tr>
<tr>
<td>10 &lt; D &lt; 30</td>
<td>0.3</td>
</tr>
<tr>
<td>D ≥30</td>
<td>0.4</td>
</tr>
</tbody>
</table>

1) Diameter under braid is fictitious and calculated by the method of IEC 60092-350 Appendix A.
2) The "coverage density" of the braid shall be in accordance with IEC 60092-350.

### 2.6 Protective sheaths

#### 2.6.1 General

a) Mechanical and particular characteristics of sheath materials shall comply with the specifications of Table 5, 6, 7, and 8 in IEC 60092-360.
b) Material thickness of sheaths shall comply with relevant design standards, see [1.1.3].

#### 2.6.2 Temperature classes for protective sheaths

a) The temperature classes for the sheath material shall be at least 85 °C.
b) For cables intended for dynamic applications (flexible cables), other materials may be accepted.
c) Sheath materials shall be used in accordance with Table 3
### Table 3 Type of protective sheaths

<table>
<thead>
<tr>
<th>Material</th>
<th>Material information</th>
<th>Abbreviated designation (IEC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermoplastic</td>
<td>Based on polyvinylchloride or copolymer of vinylchloride and vinylacetate</td>
<td>ST2</td>
</tr>
<tr>
<td></td>
<td>Halogen free</td>
<td>SHF1</td>
</tr>
<tr>
<td>Elastomeric or Thermosetting</td>
<td>Based on polychloroprene rubber</td>
<td>SE1</td>
</tr>
<tr>
<td></td>
<td>Based on chlorosulphonated polyethylene or chlorinated polyethylene rubber</td>
<td>SH</td>
</tr>
<tr>
<td></td>
<td>Halogen free</td>
<td>SHF2</td>
</tr>
</tbody>
</table>

### 3 Low Voltage Power Cables

#### 3.1 Construction of cables rated 0.6/1 kV

**3.1.1 General**

The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-353.

**3.1.2 Minimum thickness of insulating walls**

The minimum average thickness of insulating walls shall be in accordance with Table 4.

### Table 4 Minimum average thickness of insulating walls for power cables with rated voltage 0.6/1.0 kV

<table>
<thead>
<tr>
<th>Nominal cross section of conductor (mm²)</th>
<th>Designation of the insulating compound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EPR</td>
</tr>
<tr>
<td></td>
<td>S 95 (mm)</td>
</tr>
<tr>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>2.5</td>
<td>1.0</td>
</tr>
<tr>
<td>4 to 16</td>
<td>1.0</td>
</tr>
<tr>
<td>25 to 35</td>
<td>1.2</td>
</tr>
<tr>
<td></td>
<td>XLPE</td>
</tr>
<tr>
<td></td>
<td>HEPR (mm)</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>0.9</td>
</tr>
<tr>
<td>50</td>
<td>1.4</td>
</tr>
<tr>
<td>70</td>
<td>1.4</td>
</tr>
<tr>
<td>95</td>
<td>1.6</td>
</tr>
<tr>
<td>120</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>1.1</td>
</tr>
<tr>
<td></td>
<td>1.2</td>
</tr>
</tbody>
</table>
3.2 Switchboard wires

3.2.1 General

a) Insulation material shall be one of the following: EPR, HEPR, XLPE, HF90 or S95.
b) The minimum thickness of insulation walls shall be in accordance with Table 4.

4 High Voltage Cables

4.1 Construction of cables rated 1.8/3 kV

4.1.1 General

The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-353.

4.1.2 Minimum thickness of insulating walls

The minimum average thickness of insulating walls shall be in accordance with Table 5

Table 5 Minimum average thickness of insulating walls for power cables with rated voltage 1.8/3kV

<table>
<thead>
<tr>
<th>Nominal cross section of conductor (mm²)</th>
<th>Designation of the insulating compound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EPR (mm)</td>
</tr>
<tr>
<td></td>
<td>HEPR (mm)</td>
</tr>
<tr>
<td>10 - 70</td>
<td>2.2</td>
</tr>
<tr>
<td>95 - 300</td>
<td>2.4</td>
</tr>
<tr>
<td>400</td>
<td>2.6</td>
</tr>
<tr>
<td>500</td>
<td>2.8</td>
</tr>
<tr>
<td>630</td>
<td>2.8</td>
</tr>
</tbody>
</table>

Table 5 is according to IEC 60092-353 for 1.8/3 kV cables.
4.2 Construction of high voltage cables rated above 1.8/3 kV

4.2.1 General
The construction and testing of cables for permanent installations shall normally comply with the requirements of IEC 60092-354.

4.2.2 Minimum thickness of insulating walls
The minimum average thickness of insulating walls shall be in accordance with Table 6.

Table 6 Minimum average thickness of insulating walls for high voltage cables

<table>
<thead>
<tr>
<th>Nominal cross-sectional area of conductor mm²</th>
<th>Nominal thickness of insulation at rated voltage U₀ / U (Uₘₙ)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.6/6 (7.2) kV mm</td>
</tr>
<tr>
<td>10</td>
<td>2.5</td>
</tr>
<tr>
<td>16</td>
<td>2.5</td>
</tr>
<tr>
<td>25</td>
<td>2.5</td>
</tr>
<tr>
<td>35</td>
<td>2.5</td>
</tr>
<tr>
<td>50 to 185</td>
<td>2.5</td>
</tr>
<tr>
<td>240</td>
<td>2.6</td>
</tr>
<tr>
<td>300</td>
<td>2.8</td>
</tr>
<tr>
<td>400</td>
<td>3.0</td>
</tr>
<tr>
<td>500 to 1000</td>
<td>3.2</td>
</tr>
</tbody>
</table>

5 Control and Instrumentation Cables

5.1 Construction of control and instrumentation cables rated 150/250 V

5.1.1 General
The construction of cables for permanent installations shall normally comply with the requirements of IEC 60092-376.

5.1.2 Minimum thickness of insulating walls
The minimum average thickness of insulating walls shall be used in accordance with Table 7.
Table 7 Minimum average thickness of insulating walls for control and instrumentation cables

<table>
<thead>
<tr>
<th>Nominal cross section of conductor (mm²)</th>
<th>Designation of the insulating compound</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>XLPE</td>
</tr>
<tr>
<td></td>
<td>(mm)</td>
</tr>
<tr>
<td>Rated voltage 0.15/0.25 kV</td>
<td></td>
</tr>
<tr>
<td>0.50</td>
<td>0.4</td>
</tr>
<tr>
<td>0.75</td>
<td>0.5</td>
</tr>
<tr>
<td>1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>1.5</td>
<td>0.6</td>
</tr>
<tr>
<td>2.5</td>
<td>0.6</td>
</tr>
</tbody>
</table>

Table 7 is according to IEC 60092-376

6 Data Communication Cables

6.1 General

6.1.1 General
Data communication cables implies Category cables (Cat), field bus cables, and fibre optic cables.
— Category cables approved in accordance with DNVGL CP 0403.
— Field bus cables shall be constructed in accordance with IEC 61158.
— Fibre optic cables shall be constructed in accordance with IEC 60793 and IEC 60794.
— Fibre optic cables approved in accordance with DNVGL CP 0402.

6.2 Lightweight electrical cables

6.2.1 General
Lightweight electrical cables shall be constructed and tested in accordance with the technical requirements given through DNVGL CP 0400.

7 Flexible electrical cables

7.1 General

7.1.1 Flexible electrical cables shall be constructed and tested in accordance with the technical requirements given through DNVGL CP 0417.
8 Inspection and Testing

8.1 General

8.1.1 Factory

a) Cables are normally required to be covered by a Type Approval Certificate. Testing of the individual cables is then not required, except as given below and in Sec.10.

b) For case by case certification of cables, Routine Tests (RT) and Product Sample Tests (PST) shall be carried out. For manufacturers already having other type approved cables, only routine tests are required.

c) Cables shall be tested at the manufactures works with the test specified in this part of the rules. Tests noted as Routine Test (RT) shall be carried out on all cables. Tests noted as Product Sample tests (PST) shall be performed as random test at suitable intervals in order to ensure that products from subsequent production confirm to result of type tests, ensuring "equal production".

d) The following inspection and tests shall be carried out according to IEC 60092-350 (2014 -08) (the brackets in the listing refers to clauses in the IEC standard):
   — checking of rated voltage and cable construction (4.1.3.2) RT
   — measurement of electrical resistance of conductor (5.2.2) RT
   — voltage test (5.2.3) RT
   — insulation resistance test (6.9 ) RT
   — mechanical/particular characteristics of insulating compounds (8.4 ) PST
   — mechanical/particular characteristics of sheathing compounds (8.5 ) PST
   — hot set test for EPR and XLPE insulation and for SE1 and SHF 2 sheath (6.8). PST
SECTION 10 INSTALLATION

1 General Requirements

1.1 General

1.1.1 General
Reference is made to other sections of this chapter, especially Sec.2 for requirements affecting location, arrangements, and installation of systems in an early project stage, and Sec.3 to Sec.9 for requirements affecting the various equipment.

1.1.2 Hazardous areas
Equipment in hazardous areas shall be selected, located and installed according to Sec.11.

1.1.3 Safety equipment
At least the following safety equipment has to be provided for high voltage facilities:
— a voltage detector suitable for the rated voltage of the equipment
— a sufficient number of earthing cables according to IEC publication 61230, including insulated fitting tools
— an insulating matting (mat for repair / maintenance)
— a sufficient number of warning labels "Do not switch"
— safety instructions for gas insulated switchboards

2 Equipment

2.1 Equipment location and arrangement

2.1.1 General
a) All electrical equipment shall be permanently installed and "electrically safe". This shall prevent injury to personnel, when the equipment is handled or touched in the normal manner. (Interpretation of SOLAS Ch. II-1/45.1.3)

b) All electrical equipment shall be selected and installed so as to avoid electromagnetic (EMC) problems thus preventing disturbing emissions from equipment, or preventing equipment from becoming disturbed and affecting its intended function(s).

c) Electrical equipment shall be placed in accessible locations so that those parts, which require manual operation, are easily accessible.

d) Heat dissipating electrical equipment as for example lighting fittings and heating elements, shall be located and installed so that high temperature equipment parts do not damage associated cables and wiring, or affect surrounding material or equipment, and thus become a fire hazard. (Interpretation of SOLAS Ch. II-1/45.7)

e) Equipment shall be installed in such a manner that the circulation of air to and from the associated equipment or enclosures is not obstructed. The temperature of the cooling inlet air shall not exceed the ambient temperature for which the equipment is specified.

f) All equipment of smaller type (luminaires, socket outlets etc.) shall be protected against mechanical damage either by safe location or by additional protection, if not of a rugged metallic construction.

g) Requirements for installation of switchboards given in Sec.2 [9.2.1] shall also be applied to installation of transformers.

h) Requirements for rotating machinery arrangement are given in Sec.2 [9.3].

i) See Sec.2 [9] for additional requirements for vessel arrangement.
j) In shower rooms and bath rooms the electrical equipment shall be installed in accordance with IEC publication 60364-7-701.

2.1.2 Ventilation of spaces with electrical equipment
The ventilation shall be so arranged that water or condensation from the ventilator outlets does not reach any unprotected electrical equipment. See also Sec.2 [9.1.1].

2.1.3 High voltage switchgear and controlgear assemblies
Access to high voltage switchgear rooms and transformer rooms shall only be possible to authorised and instructed personnel.

Guidance note:
Equipment located in machinery spaces may be considered as being accessible only to instructed personnel. The same applies to equipment located in other compartments that are usually kept locked, under the responsibility of the ship's officers.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.4 Passage in front or behind switchgear
The passageways in front of and behind main and emergency switchboards shall be covered by mats or gratings of oil resistant insulating material, when the deck is made of a conducting material. See also Sec.2 [9.2.3] regarding free passage ways for main and emergency switchboards.

Guidance note:
Mats complying with IEC 61111 or equivalent standard will be accepted.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.5 Transformers
Liquid immersed transformers shall be installed in an area or space with provisions for complete containment and drainage of liquid leakage.

2.1.6 Heating and cooking appliances
a) All combustible materials close to heating and cooking appliances shall be protected by incombustible or insulating materials.
b) Cabling and wiring (feeding) shall be suitable for the possible higher temperature in the termination room of such equipment.
c) Additional protection of Infra Red–type of open heating elements shall be installed, if necessary to guard against fire and accidental touching.
d) Space heaters are normally to be installed on a free bulkhead space, with about 1 m free air above, and so that for example doors cannot touch the heaters. If not constructed with an inclined top plate, a perforated plate of incombustible material inclined about 30° shall be mounted above each heater. Space heaters shall not be built into casings of woodwork or other combustible material.

2.2 Equipment enclosure, ingress protection

2.2.1 Enclosure types in relation to location
Equipment enclosures shall comply with Table 1 in relation to the location of where it is installed and for high voltage equipment, see Sec.3 [4].
**Table 1 Enclosure types in relation to location**

<table>
<thead>
<tr>
<th>Location</th>
<th>Switchgear and transformers</th>
<th>Luminaries</th>
<th>Rotating machines</th>
<th>Heating appliances</th>
<th>Socket outlets</th>
<th>Miscellaneous such as switches and connection boxes</th>
<th>Instrumentation and communication components</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine and boiler rooms 15)</td>
<td>IP 22</td>
<td>IP 22</td>
<td>IP 22</td>
<td>IP 22</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44</td>
</tr>
<tr>
<td>Below the floor</td>
<td>N</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44</td>
<td>N</td>
<td>IP 44</td>
<td>IP 55</td>
</tr>
<tr>
<td>Dry control rooms and switchboard rooms</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
</tr>
<tr>
<td>Navigation bridge, radio room, control stations</td>
<td>IP 21</td>
<td>IP 21</td>
<td>IP 21</td>
<td>IP 21</td>
<td>IP 21</td>
<td>IP 21</td>
<td>IP 21</td>
</tr>
<tr>
<td>Closed compartments for fuel oil and lubrication oil separators</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44</td>
<td>N</td>
<td>IP 44</td>
<td>IP 44</td>
</tr>
<tr>
<td>Fuel oil tanks 2)</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>IP 68</td>
</tr>
<tr>
<td>Ballast and other water tanks, bilge wells 2)</td>
<td>N</td>
<td>N</td>
<td>IP 68</td>
<td>IP 68</td>
<td>N</td>
<td>N</td>
<td>IP 68</td>
</tr>
<tr>
<td>Ventilation ducts 13)</td>
<td>N</td>
<td>N 13)</td>
<td>IP 44 13)</td>
<td>N</td>
<td>N</td>
<td>N 13)</td>
<td></td>
</tr>
<tr>
<td>Deckhouses, forecastle spaces, steering gear compartments and similar spaces</td>
<td>IP 22 3)</td>
<td>IP 22</td>
<td>IP 22 3)</td>
<td>IP 22</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44 3)</td>
</tr>
<tr>
<td>Ballast pump rooms, columns below main deck and pontoons and similar rooms below the load line</td>
<td>IP 44 14)</td>
<td>IP 34</td>
<td>IP 44 14)</td>
<td>IP 44</td>
<td>IP 55 5)</td>
<td>IP 55 5)</td>
<td>IP 55 5)</td>
</tr>
<tr>
<td>Cargo holds, keel ducts, pipe tunnels 4)</td>
<td>IP 55 N</td>
<td>IP 55</td>
<td>IP 55</td>
<td>N</td>
<td>IP 55 5)</td>
<td>IP 55 5)</td>
<td>IP 56 5)</td>
</tr>
<tr>
<td>Open deck, keel ducts</td>
<td>IP 56</td>
<td>IP 55</td>
<td>IP 56 6)</td>
<td>IP 56</td>
<td>IP 56 5)</td>
<td>IP 56 5)</td>
<td>IP 56</td>
</tr>
<tr>
<td>Battery rooms, paint stores, welding gas bottle stores or areas that may be hazardous due to the cargo or processes onboard 7)</td>
<td>EX 12)</td>
<td>EX 12)</td>
<td>EX 12)</td>
<td>EX 12)</td>
<td>EX 12)</td>
<td>EX 12)</td>
<td>EX 12)</td>
</tr>
<tr>
<td>Dry accommodation spaces</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20</td>
<td>IP 20 8)</td>
<td>IP 20</td>
<td></td>
</tr>
<tr>
<td>Galleys, laundries and similar rooms 10)</td>
<td>IP 44</td>
<td>IP 34</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 44</td>
<td>IP 55</td>
</tr>
</tbody>
</table>
1) Switchboards and transformers in engine and boiler rooms above the floor may be accepted with IP21 when the switchgear or transformer has a roof with eaves. If there is a chance of dripping water from piping, condensed water, etc. then a higher IP rating may be necessary. If there is no chance of dripping water, and the room is equipped with air conditioning system, the IP rating for control desks may be as required for dry accommodation spaces.

2) For cable pipes and ducts through fuel oil and water tanks, see [3.7].

3) Such equipment shall be provided with heating elements for keeping it dry when not in use, regardless of IP rating. The heating elements shall normally be automatically switched on when the equipment is switched off. Continuously connected heating elements may be accepted provided the maximum allowed temperatures are maintained when the equipment is in operation.

4) For enclosures in cargo holds, placed so that they are liable to come into contact with the cargo or cargo handling gear, see Sec.3 [4.1]. For truck battery charging arrangements, see Sec.2 [9]. For electrical installations in cargo holds for dangerous goods, see Pt.6 Ch.5 Sec.10. For closed vehicle spaces, closed ro-ro spaces and special category spaces see SOLAS Reg. II-2/20.3.2.

5) IP 44 may be accepted, when placed in a box giving additional protection against ingress of water. Equipment for control and indication of watertight doors and hatches shall have watertightness based on the water pressure that may occur at the location of the component, if intrusion of water can affect the control or indication system. For passenger vessels, requirements to IP rating for watertight doors are given in SOLAS II-1 Regulation 15.

6) Motors on open deck shall have ingress protection IP 56, and either:
   — be naturally cooled, i.e. without external cooling fan
   — be vertically mounted and equipped with an additional steel hat preventing ingress of water or snow into any external ventilator
   — or be equipped with a signboard requiring that the motor shall only be used in port, and be provided with additional covers (e.g. tarpaulins) at sea.

7) For arrangement and connection of batteries, see Sec.2. For installations in paint stores, welding gas bottle stores or areas that may be hazardous due to the cargo or processes onboard, the requirements in Sec.11 shall be complied with. Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes.

8) Connection boxes may be accepted installed behind panels in dry accommodation spaces provided that they are accessible through a hinged panel or similar arrangement.

9) Socket outlets shall be so placed that they are not exposed to splash, e.g. from showers. Circuits for socket outlets in bathrooms shall either be fed from a double insulated transformer, or be equipped with residual current device (RCD) with a maximum release current of 30 mA.

10) Stoves, ovens and similar equipment may be accepted with IP 22 when additionally protected against water splash by hose or washing of the floor.

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

12) Type of ingress protection shall be in accordance with the minimum requirements in Sec.11 or minimum requirements in this table, whichever is the strictest. Minimum explosion group and temperature class shall be one of those specified in Sec.11 (some national regulations may limit the choice of type of protection).

13) Luminaries and instrumentation components may be accepted after special consideration. It shall be observed that a ventilation duct may be a hazardous area, depending upon the area classification at the ends of the duct. Equipment in ventilation ducts to open deck shall have IP 55.

14) Electric motors, switchgear and starting transformers for thrusters shall be equipped with heating elements for standstill heating. Provided the space will not be used as pump room for ballast, fuel oil etc., the thrusters motor may be accepted with IP22 enclosure type.
Electrical and electronic equipment and components located in areas or in the vicinity of areas protected by Fixed Water-Based Local Application Fire-Fighting Systems as required by SOLAS Ch. II-2/10 5.6 using fresh water shall be to a degree of protection not less than IP22.

When salt water is used, electrical and electronic equipment and components located in areas, or in the vicinity of areas, protected shall be to a degree of protection not less than IP44, unless the manufacturer of the electrical and electronic equipment or components submits evidence of suitability using a lower degree of protection (e.g. IP23, IP22, etc.) restricted to:

- For the natural air cooled static power equipment (e.g. starter, distribution panel, transformer, lighting etc.) at least IP23 is required.
- For the natural air cooled electronic equipment mounted or located on the protected system (e.g. sensors, actuators, etc.), at least IP44 is required.
- For the rotating machinery and mechanically air cooled type equipment (e.g., rotating machinery, air cooled SCR panel, etc.) which needs the forced cooling air from outside the equipment, a lower degree than IP44 may be accepted if measures are taken, in addition to ingress, to prevent the ingest of water. The terminal boxes shall be of at least IP44.

Generators with a lower degree of protection as IP44 may be used if they are separated to each other in a way that the water used for the FWBLAFFS (e.g. water mist, water drops) will harm only the set concerned.

### 2.3 Batteries

#### 2.3.1 Enclosure types in relation to location

Battery installations shall comply with the requirements in Sec.2 [9] (Lead Acid or NiCd technology) or Pt.6 Ch.2 Sec.1 (other battery technologies) regarding requirements for their location, compartments etc.

#### 2.3.2 Arrangements and materials

The following requirements apply to all stationary accumulator batteries:

- a) Battery stands, boxes and lockers shall be fixed to the vessel's structure. The batteries shall be fixed or supported on the shelves. Shelves and fixings shall be constructed to withstand the forces imparted from the batteries, during heavy sea.
- b) All materials used for the construction, including ventilation ducts and fans, shall be corrosion resistant or shall be protected against corrosion by suitable painting, with consideration given to the type of electrolyte actually used.
- c) The materials shall be at least flame retardant, except that impregnated wood can be used for the support of battery cells, and for battery boxes on deck.
- d) Except when corrosion resistant materials are used, the shelves in battery rooms and lockers and the bottom of battery boxes shall be covered with a lining of corrosion resistant material, having a minimum thickness of 1.5 mm and being carried up not less than 75 mm on all sides (e.g. lead sheath for lead and acid batteries, steel for alkaline batteries). If the shelves in battery rooms and lockers are of corrosion resistant materials and the floor is not, either the shelves or the floor shall be covered with such lining.

#### 2.3.3 Marking and signboards

See [2.5.2] for the requirements for marking and signboards, with respect to battery installations.

### 2.4 Protective earthing and bonding of equipment

#### 2.4.1 General

- a) Earth conductors shall normally be of copper. However, other suitable materials may be accepted if, for example the atmosphere is corrosive to copper.
- b) The earth conductor's cross section shall be equivalent to that of copper with regard to conductivity. Applicable arrangements and cross sections are given in Sec.2 Table 6.
c) The connection to the hull of earth conductors or equipment enclosure parts, which shall be earthed, shall be made by corrosion resistant screws or clamps, with cross section corresponding to the required cross section of earth given in Sec.2 [10.4.1].

d) Earthing screws and clamps shall not be used for other purposes. Suitable star washers and conductor terminals shall be used, so that a reliable contact is ensured.

e) Metal enclosures or other exposed conductive parts being a part of electrical equipment shall be earthed by fixing the metal enclosure or exposed parts in firm (conductive) contact to the hull (main earth potential) or by a separate earth conductor.

f) Portable equipment shall always be earthed by an earth conductor contained in the flexible supply cable.

g) All parts supporting electrical equipment and cable support systems, that is ladders, pipes and ducts for electrical cables, are considered to be in firm electrical contact with the hull as long as elements are welded or mechanically attached (metal to metal without paint or coating) with a star washer, thereby ensuring a firm conductive contact. If firm electrical contact is not achieved, the parts shall be bonded by a separate copper conductor between supporting parts and the hull.

h) Additional precautions shall be applied regarding earthing of portable electrical equipment for use in confined or exceptionally damp spaces where particular risks due to exposure and conductivity may exist.

i) High voltage metal enclosures and the steel hull shall be connected by a separate earth conductor. The enclosures fixing device shall not be the sole earthing connection of the enclosure.

j) If a separate earthing conductor is chosen for equipment, then the connection of the separate earth conductor to the hull, (safe earth potential) shall be made in an accessible position. The conductor shall be terminated by a pressure type cable lug onto a corrosion protected bolt, which shall be secured against loosening. Other suitable terminating systems for direct receipt of the conductor may be considered.

Guidance note:
Additional precautions in h) might be: The equipment having extra safe low voltage, or for ordinary 230 V equipment, by using a safety transformer system or by having an earth fault switch of maximum 30 mA in front of the circuit.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

2.4.2 Exceptions to the earthing or bonding requirements

a) If one of the following bullet points is fulfilled, the requirements in [2.4.1] may be omitted:

— equipment supplied at a voltage not exceeding 50 V DC or AC between conductors. Auto-transformers shall not be used for the purpose of achieving this voltage
— equipment supplied at a voltage not exceeding 250 V by safety isolating transformer and the transformer is supplying only one consumer device
— equipment constructed in accordance with the principle of double insulation.

b) Parts fixed to non-conductive materials, and separated from current carrying parts and from earthed parts in such a way that they cannot become live under normal or electrical fault conditions.

c) Bearing housings which are insulated in order to prevent circulating currents.

d) Cable clips do not need protective earthing.

2.4.3 Dimension of protective earth and bonding conductors
For dimension of protective earth and bonding conductors, see Sec.2 [10.4].

2.5 Equipment termination, disconnection, marking

2.5.1 General
All equipment shall be installed and terminated in accordance with manufacturer’s instructions to ensure that correct functions and safe properties are contained.
2.5.2 Signboards for equipment

a) Labels (nameplates) of durable material, bearing clear and indelible indications, shall be so placed that all equipment necessary for the operation can be easily identified. All labels shall be permanently fixed.

b) All equipment shall, if necessary, be marked so as to ensure correct use. Signboards giving guidance for safe use, or conditions for use, shall be fitted, if necessary, in order to avoid inadvertent or dangerous operation of equipment and or systems.

c) "High voltage" warning signboards are required on all high voltage equipment.

d) High voltage cables shall be suitably marked with “high voltage” warning signboards, at least every 20 m, so that a signboard is always visible, unless colour coding of cables has been used.

e) For rotating machines, on deck, which are not naturally cooled, i.e. with external cooling fan, a signboard shall be fitted on the machines requiring that the machines shall only be used in port and be provided with additional covers (e.g. tarpaulins) when at sea. See Table 1, note 6.

f) For socket outlets for portable appliances where 1000 V is accepted, (e.g. welding transformers, refrigerated containers etc., which are not hand-held during operation) an additional warning sign shall be fitted, with the text: DANGER (maximum voltage) V AC ONLY FOR CONNECTION OF...(type of equipment)....

g) Signboards shall be fitted on doors to rooms and lockers and covers of boxes containing batteries, warning against smoking and the use of naked lights due to the possible presence of explosive gas.

h) All batteries shall be provided with labels (nameplates) of durable material, giving information on the application for which the battery is intended, make, type, voltage and capacity. Instructions shall be fitted either at the battery or at the charging device, giving information on maintenance and charging.

i) Battery systems above 50 V shall be marked with special visible warning signboard, i.e. “Warning xxx voltage”.

j) Emergency lighting fixtures shall be marked for easy identification.

2.6 Neon lighting

2.6.1 General

a) Neon tubes for voltage above 1000 V, shall be installed at least 2.5 m above the floor.

b) Each circuit shall have circuit protection rated at maximum 16 A.

c) The on and off switch shall be clearly marked. The switch is not accepted on the secondary side of the transformer.

d) Cables and wires shall have braiding, armour or be fitted in an earthed pipe.

2.7 Lighting fixtures

2.7.1 General

For installation of lighting fixtures, the conductor insulation material of the installation cable shall be suitable for the fixture being installed. Preferably, the lighting fixture shall provide a shielding between the lighting tubes and the termination part for the external cable. If there is no shielding between the lighting tube and the termination part for the installation cable, the installation cable shall have an insulating material of its conductors that is UV resistant.
3 Cables

3.1 General

3.1.1 General
a) Cable sizing with respect to current carrying capacity and short circuit withstand capabilities shall comply with the requirements in Sec.2.
b) For requirements for cable construction and materials, see Sec.9.
c) For installation of lighting fixtures, see [2.7.1].

Guidance note:
Use of cables with low emission of smoke in case of a fire, should be considered for all indoor installations. In areas where equipment sensitive to corrosion is installed or kept, use of Halogen free cables should be considered to avoid corrosive smoke in case of a fire, as far as is practicable.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.2 Painting of cables
Electrical cables may be coated or painted, but this shall not adversely affect the mechanical, chemical or fire resistant characteristics of the sheath.

Guidance note:
The Society has been notified of cables being damaged by two-component epoxy painting bonding to the sheath material. Unless the Builder has experience with the combination of paint and cable type used, the Builder should consult the manufacturer.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.1.3 Cable braid/armour
Cables with braid or armour without outer sheath for corrosion protection is accepted with the following exceptions:
— when installed in hazardous areas (see Sec.11 [4.2.1])
— when the braiding is used for protective earthing.

3.1.4 Corrosion protection
Braid or armour of lead, bronze or copper shall not be installed in contact with aluminium alloy structures, except in dry accommodation spaces.

3.1.5 Flexible cables
The use of flexible cables shall be limited to applications where flexibility is necessary, and the lengths of such flexible cables shall be kept as short as practicable. Special requirements may be made to the type, installation and protection of flexible cables, depending upon the application.

3.1.6 High voltage cables
High voltage cables shall in general be provided with a continuous metallic sheath which is effectively bonded to earth, and be installed on cable trays. High voltage cables without continuous metallic sheath or braid are to be installed for their entire length in metallic casings effectively bonded to earth.
Installation of high voltage cables in accommodation spaces is not permitted unless required by the application. The necessity for special protection shall be evaluated when high voltage cables are installed in accommodation spaces, for prevention of harmful effects to personnel from cable short circuits, and strong electromagnetic fields.

3.1.7 Fibre optic cables
Tensile stress applied to fibre optic cables for any reason during the installation period or during normal operation shall not exceed the maximum allowed value stated by the manufacturer.
3.2 Routing of cables

3.2.1 General
General requirements for routing of cables are given in Sec.2 [9.5].

3.2.2 Segregation of low and high voltage cables
a) Low voltage power cables shall not be bunched together with, or run through the same pipes as, or be terminated in the same box as, cables for high voltage.
b) High voltage cables are not to be installed on the same cable tray as cables operating at nominal system voltage of 1 kV and less. (according to IACS UR E11)

3.2.3 Special precautions for single core cables
When the use of single core cables or parallel connection of conductors of multi-core cables is necessary for AC circuits with nominal current exceeding 20 A the following applies:
a) Armour or braiding on single core cables shall be of non-magnetic type.
b) For single core cables, metallic sheaths are to be insulated from each other and the ship’s hull over the entire length. If provided, the non-magnetic armour or braiding shall be earthed at one end, only. (See [3.9.4].)  
c) Single core cables belonging to the same circuit shall be contained within the same pipe, conduit or trunk. Clamps that fix them shall include all phases.
d) The phases shall be laid as close as possible and preferably in a triangular formation. If spacing between the cables cannot be avoided, the spacing shall not exceed one cable diameter.
e) Magnetic material shall not be used between single core cables for one consumer. All phases belonging to the same circuit shall be run together in a common bulkhead cable penetration, unless the penetration system is of non-magnetic material. Unless installed in a triangular formation, the distance between the cables and magnetic material shall be minimum 75 mm. For the installation of single core parallel cables between the cable groups these measures are not necessary, if the cable groups are arranged in trefoil formation.
f) Circuits with several single core cables for each phase (forming groups) shall follow the same route and have the same cross sectional area.
g) The cables belonging to the same phase shall as far as practicable alternate with those of the other phases, so that an unequal division of current is avoided.
h) For fixing of single core cables, see [3.5.6].
i) For DC-installations with a high “ripple” content (e.g. thyristor (SCR) units), the requirements above are applicable.

3.2.4 Accessible cable runs
a) Cable runs shall be accessible for later inspection, except cables carried in pipes.
b) When cable runs are carried behind wall lining in accommodation spaces (except when carried in pipes), the panels shall be hinged or fixed for example by screws, so that they can be removed for inspection without damaging the cable or the bulkhead.
c) Exceptions can be made for cables to light fittings, switches, socket outlets etc. in dry accommodation spaces, when the deck and bulkhead constructions are made of incombustible materials.

3.3 Penetrations of bulkhead and decks

3.3.1 General
a) Penetrations shall meet the fire and watertight integrity of the bulkhead or deck.
b) The penetrations shall be carried out either with a separate penetration for each cable, or with boxes or pipes filled with a suitable flame retardant packing or moulded material when those are put between areas or spaces with different fire or water integrities.

c) The installation shall be in accordance with the manufacturers' installation instructions.

d) Fire rated penetrations shall be documented as required by Ch.11.

Guidance note:
Penetrations of watertight bulkheads should be placed as high as practicable.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.2 Watertight internal bulkhead or deck
If cables are passing through watertight bulkheads and/or decks, it should be verified that the penetrations are able to withstand the pressure they may be exposed to. The installation requirements made by manufacturer shall be followed.

Guidance note:
Penetrations of watertight bulkheads should be placed as high as practicable.
No compound or packing is required for boxes or pipes on the bulkhead or deck when cables are passing between areas or spaces within the same water or fire integrity.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.3 Weathertight deckhouse bulkheads and decks
Cable penetrations are to be carried out so that they are capable of preventing water to enter during intermittent submersion under any wind or wave condition up to those specified as critical design conditions.

Guidance note:
Penetration with "bended pipe" (goose neck) is acceptable as long as the pipe is properly filled with compound and providing that the integrity of the water tight bulkheads and deck is not affected.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.3.4 Thermal insulation
Cable runs shall not be laid in or covered with thermal insulation (e.g. through refrigerated cargo holds), but may cross through such insulation.

3.3.5 Hot oil pipes near to penetrations
The distance from cable penetrations to flanges of steam or hot oil pipes shall not be less than 300 mm for steam or hot oil pipes with diameter D ≤ 75 mm, and not less than 450 mm for larger pipes.

3.3.6 Chafing
Penetrations of bulkheads and decks shall be such that the cables are not subject to chafing. (Interpretation of SOLAS Ch. II-1/45.5.5)

3.3.7 Mechanical support of penetrations
The cable shall have mechanical fixing on both sides of a bulkhead penetration.

3.4 Fire protection measures

3.4.1 General
The cable installation shall be protected against fire, fire spreading, thermal, mechanical, corrosive and strain damage. (Interpretation of SOLAS Ch. II-1/45.5.2)

3.4.2 Flammable materials
Cables shall not be installed in contact with flammable materials such as wooden bulkheads, when the conductor temperature exceeds 95°C at full load, at the actual ambient temperature.
3.4.3 Precautions against fire spreading in cable bunches
Cables that are installed in bunches shall have been tested in accordance with a recognised fire test for cables installed in bunches, such as the test specified in IEC 60332-3, or be provided with protection according to [3.4.4].

Guidance note:
A cable bunch in this context is defined as five or more cables laid close together in trunks from machinery spaces and in spaces with a high risk of fire, and more than 10 cables in other areas.

---end of guidance note---

3.4.4 Cable bunches not complying with IEC 60332-3 or other recognised standard fire spread test.

a) Cable bunches, not complying with flame retardant properties according to IEC 60332-3, shall be provided with fire stops having at least class B-0 penetration properties at the following locations:
   — cable entries at the main and emergency switchboards
   — where cables enter engine control rooms
   — cable entries at centralised control panels for propulsion machinery and essential auxiliaries
   — at each end of totally enclosed cable trunks.

Additional fire stops need not be fitted inside totally enclosed cable trunks.

b) In enclosed and semi-enclosed spaces, cable runs not complying with flame retardant properties according to IEC 60332-3, shall be provided with fire stops having at least B-0 penetrations:
   — at every second deck or approximately 6 metres for vertical runs
   — at every 14 metres for horizontal.

Alternatively, to additional fire stops, fire protective coating may be applied to the cable bunch according to the following:
   — to the entire length of vertical runs
   — to at least 1 m in every 14 m for horizontal runs.

Alternatively, type approved fire protective coating or mats installed as described in the type approval certificate can be accepted.

3.4.5 Fire resistance of penetrations
Where "A" or "B" class bulkheads or decks are penetrated for the passage of electrical cables, arrangements shall be made to ensure that the fire resistance of the bulkheads or decks, is not impaired.

Guidance note:
Cable transits in "A", "B" or "F" class divisions should not have more than 40% of the inside cross sectional area of the transit occupied by cables. The installation should be in accordance with the transit manufacturer's instructions.

---end of guidance note---

3.4.6 Fire resistant cables
For requirements for fire resistant cable, see Sec.2 [10.1.2].

3.5 Support and fixing of cables and cable runs

3.5.1 General
Cable ladders, trays and cable pipes shall not be used for carrying water, oil or steam pipes. Hydraulic pipes for valve control are exempted. Other exemptions may be considered in each case.
3.5.2 Cable ladder or tray material and mechanical requirements

a) Cable ladders and trays with their fixing devices shall be made of steel adequately protected against corrosion, aluminium, or type tested non-metallic materials with equal properties.

b) Structure and cable tray made of different metals that can cause galvanic corrosion is only accepted for indoor installations. The fixing method shall ensure protection against galvanic corrosion. The cable tray shall, if fixed by insulating pads or pieces, have metallic connections to the structure for earthing purpose.

c) Cable trays or protective casings made of non-metallic materials shall be supplemented by metallic fixing and straps such that in event of a fire they, and the cable affixed, are prevented from falling and causing an injury to personnel and/or an obstruction to any escape route.

The load on the cable trays or protective casings shall be within the Safe Working Load (SWL). The support spacing shall not be greater than manufacturer’s recommendation nor in excess of spacing at the SWL test. In general the spacing shall not exceed 2 m. (IACS UR E 16).

Guidance note:
The term “cable ladder” includes support brackets. The term “cable tray” means constructions being formed by continuous tray plates or structural steel.
Adequate protection against corrosion may be stainless steel, hot dipped galvanised steel or black steel adequately coated in accordance with a marine coating standard.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.5.3 Mechanical protection of cables and cable runs

a) Cables shall be so installed that they are not likely to suffer mechanical damage. If necessary, they shall be protected by providing the cable runs with covers of plates, profiles or grids, or by carrying the cables in pipes.

b) Below the floor in engine and boiler rooms and similar spaces, cables that may be exposed to mechanical damage during maintenance work in the space, shall be protected in accordance with a).

c) All cables that may be exposed to mechanical damage, shall be protected by covers of steel plates, steel grids or profiles, or by being carried in steel pipes, e.g. on weather decks, in cargo hold areas, and through cargo holds.

Guidance note:
As an alternative the covers can be made of perforated steel plates or grids with mesh opening maximum 25 mm, having at least the same impact strength as a 4 mm steel plate. Exemptions can be accepted when the location of the cable run is such that in all probability cargo or cargo handling gear cannot come into contact with the cable run. When cable runs are fixed to aluminium structures, aluminium may be used instead of steel.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.5.4 Cable bends

a) The internal bending radius for the installation of cables shall be as recommended by the manufacturer according to the type of cables chosen, and shall not be less than values given in Table 2 and Table 3.

Table 2 Cable bending radii for low voltage cables

<table>
<thead>
<tr>
<th>Cable construction</th>
<th>Overall diameter of cable (D)</th>
<th>Minimum internal radius of bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Insulation</td>
<td>Outer covering</td>
<td></td>
</tr>
<tr>
<td>Thermoplastic or thermosetting with circular copper conductors</td>
<td>Unarmoured or unbraided</td>
<td>≤ 25 mm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&gt; 25 mm</td>
</tr>
<tr>
<td></td>
<td>Metal braid screened or armoured</td>
<td>Any</td>
</tr>
</tbody>
</table>
Electrical installations

### Metal wire armoured

<table>
<thead>
<tr>
<th>Composite polyester or metal laminate tape screened units or collective tape screening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any</td>
</tr>
</tbody>
</table>

### Metal tape armoured or metal sheathed

| Any | 8 D |

### Composite polyester or metal laminate tape screened units or collective tape screening

| Any | 8 D |

### Thermoplastic or thermosetting with sector shaped copper conductors

| Any | Any | 8 D |

#### Table 3 Cables bending radii for cables rated at 3,6/6,0(7,2) kV and above

<table>
<thead>
<tr>
<th>Cable construction</th>
<th>Overall diameter of cable (D)</th>
<th>Minimum internal radius of bend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-core cable</td>
<td>Any</td>
<td>12 D</td>
</tr>
<tr>
<td>3-core cables</td>
<td>Any</td>
<td>9 D</td>
</tr>
</tbody>
</table>

NOTE: For cables rated at 3.6/6(7.2) kV and above employing flexible conductor stranding (Class 5) and braid insulation shields indicating a minimum bend radius of 6 D for unarmoured cables and 8 D for armoured cables in concurrence with the approval of the cable manufacturer

#### 3.5.5 Fixing of cables

- **a)** Cables shall be fixed by clips, saddles or bands, except when carried in pipes.
  
  When cables are fixed on a tray by means of clips or straps of non-metallic material, and these cables are not laid on top of horizontal cable trays or supports, metallic cable clips or saddles shall be added at regular distances (e.g. 1 to 2 m) in order to retain the cable during a fire.

- **b)** Flame retardant polymer material may be used for cable fixing if the material is resistant to heat and light radiation, affecting the material during the lifetime of the vessel.

- **c)** The spacing between supports or fixing shall be suitably chosen according to the type of cable and the probability of vessel movement and vibration at the actual point of installation, as given in Table 4.

- **d)** When cables are installed on top of horizontal ladders or trays, the fixing distance may be 3 times larger than given in Table 4. However, when cable runs are subjected to water splashing on weather decks the maximum distance between fixings of cable and its support (cable trays or pipes) shall be 500 mm.

- **e)** When cable runs are installed directly on aluminium structures, fixing devices of aluminium shall be used. For mineral insulated cables with copper sheath, fixing devices in metallic contact with the sheath shall be of copper alloy.

#### Table 4 Spacing of fixing points for cables

<table>
<thead>
<tr>
<th>External diameter of cables</th>
<th>Non-armoured or unbraided cables (mm)</th>
<th>Armoured or braided cables (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exceeding (mm)</td>
<td>Not exceeding (mm)</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>8</td>
<td>200</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
<td>250</td>
</tr>
<tr>
<td>13</td>
<td>20</td>
<td>300</td>
</tr>
<tr>
<td>20</td>
<td>30</td>
<td>350</td>
</tr>
<tr>
<td>30</td>
<td>-</td>
<td>400</td>
</tr>
</tbody>
</table>

#### 3.5.6 Fixing of single core cables

In order to guard against the effects of electro dynamic forces developing on the occurrence of a short circuit or earth fault, single core cables shall be firmly fixed, using supports of strength adequate to withstand the...
dynamic forces corresponding to the prospective fault current at that point of the installation. The fixing clamps of the cables should not damage the cable when the forces affect the cables during a 1 s short circuit period.

Guidance note:
Manufacturer's instructions for installation with respect to prospective fault current should be followed.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.6 Cable expansion

3.6.1 Expansion of cable runs
Cable runs and bulkhead penetrations shall be installed so that they do not take up hull forces caused by the vessel's movements, different load conditions and temperature variations.

3.6.2 Cables across expansion joints
a) The installation of electric cables across expansion joints in any structure shall be avoided. Where this is not practicable, a loop of electric cable of length sufficient to accommodate the expansion of the joint shall be provided. The internal radius of the loop shall be at least 12 times the external diameter of the cable.
b) All cables shall be fastened on each side of an expansion loop, such that all relative movement between structure and cable is taken up at this point, and not in the rest of the cable run.

3.6.3 Cable trays and pipes run in the length of the vessel
a) Cable trays or pipes run in the length of the vessel shall be divided into a number of sections each rigidly fixed to the deck at one point only and sliding supports for the rest of the section.
b) The expansion and compression possibility shall ensure that the cables do not become fully stretched during operation. The expansion and compression possibility shall be at least ±10 mm for every 10 m section length from the fixing point.
c) The cables shall be fixed to the tray as required by [3.5], and at each expansion and compression point, the cable shall have adequate room for bending and stretching.
d) When pulled in pipes, the cable shall be fixed in order to avoid chafing. Each pipe section shall be installed without the possibility for expansion within the section.

Guidance note:
When pipes are joined by the use of expansion joints, the pipe ends will not satisfy the above requirements.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

3.7 Cable pipes

3.7.1 Cable pipes
a) Cables that are carried in the same pipe shall be of such construction that they cannot cause damage to each other.
b) The pipes shall be suitably smooth on the interior and protected against corrosion. The ends shall be shaped or bushed in such a way that the cable covering is not damaged. The pipes shall be fitted with drain holes.
c) When cable pipes are installed vertically due attention shall be paid to the cable's mechanical self-carrying capacity. For longer pipes, suitable installation methods shall be used, e. g. sand filling.
d) Cable pipes shall not include expansion elements required by [3.6].

3.7.2 Cable pipe material
a) Cable pipes shall be made of steel or type tested non-metallic materials.
b) The cable pipe material shall not have less resistance against fire than required from the cable itself.
c) Aluminium cable pipes may be used if fixed to aluminium structures.

### 3.7.3 Corrosion protection of cable pipes

Steel cable pipes on deck, through cargo holds, in keel ducts, pump rooms and similar wet spaces, and in water and fuel oil tanks shall be internally and externally galvanised, or shall have an equivalent effective corrosion protection.

### 3.7.4 Condensation in cable pipes

Cable pipes with connection and draw boxes shall be arranged so that condensed water is drained out of the system.

### 3.7.5 Bending radius of pipes

The bending radius of cable pipes shall be sufficiently large so that “drawing-in” of the cables does not cause damage to the cables, and shall in no case be less than:

- the minimum bending radius of the cables according to [3.5.4]
- twice the internal diameter of the pipe.

### 3.7.6 Filling of cable pipes

3.7.6 The sum of the cables’ total cross section, based on the cables’ external diameter, shall not exceed 40% of the pipe’s internal cross section. This does not apply to a single cable in a pipe.

### 3.7.7 Connection and draw boxes

a) Connection and draw boxes shall have at least the same wall thickness as required for the pipes, and shall be of steel, with exemption for aluminium alloy pipes, where galvanised cast iron or aluminium alloy shall be used.

b) All connection and draw boxes shall be accessible (for boxes behind panels in accommodation spaces, see Table 1, footnote 8).

### 3.8 Splicing of cables

#### 3.8.1 Splicing

a) Splicing of cables by using a kit or system from a recognised manufacturer is accepted.

b) The two cables spliced shall have the same basic construction.

**Guidance note:**

Splicing is meant as the direct continuation of cable lengths and not transfer into a distribution box.

The splicing kit should contain the following as minimum:

- connectors for conductors, of correct size
- replacement insulation
- replacement inner sheet or common covering
- connector for braiding or armour
- replacement outer sheath with minimum fire properties as the original sheath
- splicing instructions.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

#### 3.8.2 Splicing in junction boxes

a) Junction boxes may be used for splicing of cables when the following is complied with:

- the boxes shall be located in accessible places
- cables for main and emergency circuits shall not be spliced in the same box
- cables for different systems and/or voltages shall be clearly marked and separated.

b) Junction boxes used for splicing shall be marked with voltage level(s) and box identification.
c) All conductors shall be connected in permanently fixed terminals.

3.9 Termination of cables

3.9.1 Termination of data communication cables
Data cables shall be installed such that the insulation is fixed as part of the termination. For stranded conductors, all strands shall be fixed by the termination.

3.9.2 Termination of high voltage cables
a) High voltage cable shall have ending or termination kits approved or recommended from the cable manufacturer.
b) The termination kit shall be appropriate for the voltage level in question. As far as is feasible, all connections of a high voltage cable in termination boxes shall be covered with suitable insulating materials. Where the conductors are not insulated, the phases are to be separated from each other and from the hull potential by mechanically robust barriers of suitable insulating material.

3.9.3 Cable entrance
Cable entrances in equipment shall at least have the same IP rating as the equipment itself in order to maintain the integrity of the enclosure.
All termination of conductors and braiding shall be made inside enclosures. Where space does not permit this cable braids/sheaths may be bonded to earth in a protected none corrosive area below the enclosure but braids/sheaths shall still be continued into the enclosure and thereby reduce EMC effect.

Guidance note:
See Sec.11 for requirements for cable glands, with respect to equipment in hazardous areas.
---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.9.4 Earthing of cable metal covering
a) All metal coverings (braiding or armour) of power cables shall be electrically connected to the metal hull (earth) of the vessel at both ends of the cable, except for short circuit proof installation where the braiding shall be insulated with crimp-on sleeve. Single point earthing is permitted for final sub circuits and in those installations (such as for control or instrumentation) where it is required for technical reasons. For cables installed in hazardous areas, see Sec.11 [4.2]. (Interpretation of SOLAS Reg. II-1/45.5.1)
b) The electrical continuity of all metal coverings shall be ensured throughout the length of the cables, at joints, tappings and branching of circuits.
c) When metal coverings (braiding or armour) are earthed at one end only, the floating end shall be properly insulated.
d) Special DC cables with a high ripple content (e.g. for thyristor equipment) and single core cables for AC shall be earthed at one end only.
e) The metal covering or braiding or armour of cables may be earthed by means of glands intended for that purpose. The glands shall be firmly attached to, and in effective metal contact with the earthed enclosure, of equipment.
f) When the cable braid is used as a PE conductor (see Sec.2 [10.4]), the braiding shall be connected directly from the cable to dedicated earth terminal or bar. Special clamp-on connections for making the connection from metal covering or armour or braiding to the earth terminal might be accepted if being of a suitable type intended for the purpose.
g) When the cable braid not is used for protective earthing of the consumer, earthing connection may be carried out by means of clamps or clips of corrosion resistant metal making effective contact with the sheath or armour and earthed metal. Earth connection of metal covering shall not be made by ordinary soldering or other untested solutions.
h) Screens around individual pairs for earthing for EMC purposes in cables for control, electronic, communication and instrumentation equipment, shall normally be earthed at one end only. Cables having
both individual screen and common screen (or braiding) shall have these metal coverings separated from each other at the “floating” end, when earthed at one end only.

**Guidance note:**
The requirement for earthing of the cable metal sheath, armour and braid, in [3.9.4] is not made with respect to earthing of equipment or consumers, but for the earthing of the cable itself.
Armour or braiding might be accepted as a PE-conductor for the equipment itself if cross section is sufficient and the cable type is constructed for that purpose.
For cables without an insulating sheath over the metal sheath or armour or braiding, the earthing of the cable itself may be carried out by fixing the cable to the hull constructions, or to parts that are welded or riveted to the hull constructions (metal to metal without paint or coating), by corrosion resistant clamps or metal clips.
For earthing of instrument and control circuits for guarding against disturbances (EMC) see also Ch.9.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

### 3.9.5 Conductor ends (termination)

a) All conductor ends shall be provided with suitable pressured sockets or ferrules, or cable lugs if appropriate, unless the construction of the terminal arrangement is such that all strands are being kept together and are securely fixed without risk of the strands spreading when entering the terminals.
b) IEC 60228 Class 5 conductors shall be fitted with pressured ferrules as required by a).
c) Termination of high voltage conductors shall be made by using pressure based cable lugs unless the actual equipment has connection facilities for direct connection of the stripped conductor tip.
d) Spare cable conductors shall either be terminated or insulated.

### 3.10 Trace or surface heating installation requirements

#### 3.10.1 General

a) Heating cables, tapes, pads, etc. shall not be installed in contact with woodwork or other combustible material. If installed close to such materials, a separation by means of a non-flammable material may be required.
b) Heat tracing shall be installed following the system documentation from the manufacturer.
c) Serial resistance heat tracing cables shall not be spliced.
d) Heat tracing cables shall be strapped to equipment and pipes using a heat resistant method that does not damage the cable.
e) Space between fixing points should be a maximum of 300 mm.
f) Where practicable and where exposed to weather, the cables shall pass through the thermal insulation from below, via a gland to avoid mechanical damage to the trace cable.
g) The trace cable system with feeder connection boxes, thermostats, etc. shall be mounted to avoid or be protected against mechanical damage.
h) Flexible conduits should be used as mechanical protection for the feeder cable to the trace start junction box installed on the pipe.
i) Heat tracing cables shall be installed in such a way as to allow dismantling of joints and valves, instruments etc. without cutting or damaging the cable. Heat tracing cables shall be installed along the lower semi-circle of the pipes.
j) The outside of traced pipes thermal insulation or protective cladding shall be clearly marked at appropriate intervals to indicate the presence of electric tracing of surface heating equipment.
k) Trace circuits shall be readably marked (or identified) at both the switchboard and the field end, for fault finding purposes.
l) Circuits, which supply trace and surface heating, shall be provided with an earth fault circuit breaker. Normally the trip current shall be 30 mA. Higher trip currents (maximum 300 mA) for the circuit breaker will be accepted if 30 mA is impossible, due to capacitive current leakage in the trace cable circuit.
4 Inspection and Testing

4.1 General

4.1.1 General
Before an installation is put into service or considered ready for operation, it shall be inspected and tested. The aim for this testing shall verify that the physical installation is correct. The installation shall be verified in accordance with relevant documentation. There shall be no hazard to personnel, no inherent fire hazard, and the installation shall function as required for the safe operation of the vessel. This also applies after modifications and alterations.

4.2 Equipment installation

4.2.1 Location and ingress protection
It shall be verified that all equipment is suitably installed with respect to ventilation, ingress protection and accessibility.

4.2.2 Inspection and test of cable installation and cable penetrations
Inspection and testing of cable installation and cable routing shall be performed with regard to:

a) separation of cable routes
b) fire safety
c) the supply to emergency consumers
d) selection and fixing of cables
e) construction and installation of watertight and fireproof bulkhead and deck penetrations

4.3 Wiring and earthing

4.3.1 General
All equipment shall be verified with respect to proper installation with respect to external wiring and protective earthing.

4.3.2 Electrical test of high voltage cable after installation
After installation, with termination kit applied, high voltage cables shall be subject to one of the following alternative high voltage tests, with the voltage applied between the conductors and the screen:

a) When a DC voltage withstand test is carried out, the voltage shall be not less than:
   — $4.0 \cdot U_0$ kV required for the cable (as required by the system voltage and the system earthing)
   The test voltage shall be maintained for a minimum of 15 minutes. ($U_0$ is the rated phase to earth voltage.)

b) Alternatively, for cables with $U_0$ in excess of 3.6 kV:
   — A power frequency test at the normal operating voltage of the system, applied for 24 hours, or.
   — A power frequency test with the phase-to-phase voltage of the system applied between the conductor and the metallic screen or earth for 5 minutes.
   A very low frequency test with 0.1 Hz, sine wave, for 30 minutes with a test voltage of $1.8 \cdot U_0$ required for the cable (as required by the system voltage and the system earthing).
   (IACS UR E11 7.2.6)

Guidance note:
The 5 minutes power frequency test is seldom used at the installation site due to the high reactive power needed for this method.
### 4.3.3 Insulation resistance testing of circuits and equipment

All outgoing power circuits from switchboards (cables and consumers) connected during installation shall undergo insulation resistance testing to verify its insulation level towards earth and between phases where applicable (i.e. switchboards assembled onboard.)

The insulation resistance tests (megger tests) shall be carried out by means of a suitable instrument applying a DC voltage according to Table 5.

No minimum acceptance value for insulation resistance for a distribution system is given. However, expected values are about 0.5 kΩ per Volt (e.g. 220 kΩ for a 440 Volt distribution system).

<table>
<thead>
<tr>
<th>Rated voltage $U_n$ (V)</th>
<th>Minimum test voltage (V)</th>
<th>Minimum insulation resistance for single consumers (MΩ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_n \leq 250$</td>
<td>$2 \times U_n$</td>
<td>1</td>
</tr>
<tr>
<td>$250 &lt; U_n \leq 1000$</td>
<td>500</td>
<td>1</td>
</tr>
<tr>
<td>$1000 &lt; U_n \leq 7200$</td>
<td>1000</td>
<td>$(U_n/1000) + 1$</td>
</tr>
<tr>
<td>$7200 &lt; U_n \leq 15 000$</td>
<td>5000</td>
<td>$(U_n/1000) + 1$</td>
</tr>
</tbody>
</table>

### 4.4 Electric distribution and power generation

#### 4.4.1 Testing of consumers

Tests as specified below shall be carried out:

a) Function and load testing for essential and important equipment.

b) Consumers for essential and important services shall be tested under normal operating conditions to ensure that they are suitable and satisfactory for their purpose.

c) Setting of protective functions shall be verified.

d) Consumers having their protective function (e.g. overload, short circuit and earth fault protection) wired up during installation, shall be tested for correct function. See also guidance note to [4.4.3].

e) Testing of all safety shut down functions for consumers (e.g. emergency stops, process safety stops, etc.)

#### 4.4.2 Testing of electric distribution systems

Tests as specified below shall be carried out:

a) Upon completion, the electric distribution system shall be subject to final tests at a sea trial.

b) The final test at sea assumes that satisfactory tests of main components and associated subsystems have been carried out.

c) The test program shall include tests of the distribution in normal conditions, and in any abnormal condition in which the system is intended to operate.

d) Start-up and stop sequences shall be tested, together with different operating modes. Also when controlled by automatic control systems when relevant.

e) Interlocks, alarms and indicators shall be tested.

f) All control modes shall be tested from all control locations.

g) The approved load balance calculation shall be verified during sea trials, as far as practical.

#### 4.4.3 Testing of generators and main switchboards

Tests as specified below shall be carried out:
a) All generating sets together with their switchboard equipment (switchgear or protection and cabling) shall be run at the rated load until the exhaust temperature and cooling water temperature has stabilised and at least for the time specified in Ch.3 Sec.1 [9]. The following has to be verified:

— electrical characteristics in general and control of the generator itself
— engine room ventilation/air flow.

b) Dynamic tests such as voltage regulation, speed governing and load sharing shall be carried out to verify that voltage and speed regulation under normal and transient conditions is within the limits given in Sec.2 [1], Sec.2 [5], Sec.5 [2] and Ch.2 Sec.5.

c) The following tests shall be carried out:

— testing of overload protection
— reverse power protection
— overcurrent and short circuit protection
— other protection like: earth fault, differential, under-voltage, overvoltage (if applicable)
— synchronising systems.
— Local manual operation of the generator cubicles
— Automatic operation (as installed) of generator circuit breakers and distribution system
— Independency between control modes

Guidance note:
Testing of overcurrent and short circuit protection: Secondary current injection is accepted as a method for verification of correct operation. For off the shelf moulded case circuit breakers and smaller MCBs with integrated protection units routine tested at the breaker manufacturer, testing of the protection functionality is generally not required. For other circuit breakers where testing at the switchboard manufacturer has been witnessed by DNV GL, and the circuit has not been wired up onboard, a verification of protection settings on board may be accepted.

4.4.4 Testing of voltage drop
Tests may be required to verify that the allowable voltage drop is not exceeded.

4.4.5 Testing of current distribution
Current distribution in parallel connected cables shall be verified. See Sec.2 [10.6.1] d).

4.4.6 Testing and inspection of battery installations
Tests as specified below shall be carried out:

a) UPS systems and regular DC battery backed up power supply (transitional, emergency or clean power) systems serving essential or important services shall be function tested. The testing shall include normal power supply being switched off and on.

b) Capacity tests: The battery backed up power supply system shall be run on expected load (in battery feeding mode) for a period determined by the requirements for the actual system and by the relevant rules.

c) Alarms and monitoring functions shall be verified for correct function.

d) Verification of ventilation of battery rooms and boxes, and cross-sections of ventilation ducts

e) Verification of the required caution labels and information plates

f) Verification that a battery schedule is available, enabling future maintenance.

4.4.7 Testing of harmonic distortion
When more than 20% of connected load is by semi-conductor assemblies, in relation to connected generating capacity, tests shall be performed in order to verify that the level of harmonic distortion does not exceed the limits given in Sec.2 [1.2.7].
4.4.8 Testing of independency between main and emergency system
It shall be verified that the main electrical power supply system is independent of the emergency electrical power supply systems. Before testing the main system, the emergency system including emergency switchboard and all battery systems powered from the emergency system shall be disconnected. The tests shall be performed under as realistic conditions as practicable.

The following shall be verified:
— black out start
— normal operation

4.4.9 Testing of dead ship recovery
Dead ship recovery, as required by Sec.2 [2.2.4], shall be verified by testing. The tests shall be performed under as realistic conditions as practicable.

4.4.10 Redundancy tests
If separate emergency source of power is omitted in accordance with Sec.2 [3.1.4] a selection of tests within each system analysed in the FMEA shall be carried out. Specific conclusions of the FMEA for the different systems shall be verified by tests when redundancy or independence is required. The test procedure for redundancy shall be based on the simulation of failures and shall be performed under as realistic conditions as practicable.

4.4.11 Testing of semi-conductor converters
a) Semi-conductor converters for power supply shall be subject to complete function tests with intended loading onboard.
b) Functional tests of semi-conductor converters for motor drives shall be performed with all relevant ship systems simultaneously in operation, and in all characteristic load conditions.

4.4.12 Onboard testing of electric propulsion plants
See Sec.12 [2] for additional requirements to testing of electric propulsion plants.

4.4.13 Onboard verification and testing of electric installation in hazardous areas
a) It shall be verified that electrical installations in hazardous area is verified and tested by the Builder.
b) It shall be verified that the installation is in accordance with approved documentation.
c) Additionally, at least the following shall be tested:
— Verification that purging can be effected
— Purge time shall be documented
— Testing of shut downs and alarms upon loss of overpressure
— Equipment that depends upon correct operation of protective devices (e.g. over current protection of Ex-e motors, purging and shut down for Ex-p)
— Test of interlocking and shutdown arrangements or lighting
SECTION 11  HAZARDOUS AREAS Installations

1 General

1.1 Reference

1.1.1 Reference to international standards, regulations and definitions
a) The requirements in this section are based upon the standards in the IEC 60079 series, IEC 61892 part 7 Mobile and fixed offshore units; Hazardous areas, and IEC 60092 502 Special features-tankers, for equipment selection and installation requirements.
b) For definitions related to installations in hazardous areas, see Sec.13 [1.6].

2 Documentation

2.1 General

2.1.1 General
Electrical installations in hazardous areas shall be documented to comply with these rules.

2.1.2 Compilation of documented data
For electrical installations in hazardous areas, the information in Table 1 shall be compiled in a list or schedule of Ex-equipment (see Sec.1 with respect to any formalities for a classed vessel).

Table 1 Schedule of information on installations in hazardous areas

<table>
<thead>
<tr>
<th>Information element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification</td>
<td>Tag number or other reference used for marking of the specific equipment. This shall be the same in the documentation as on the physical installation</td>
</tr>
<tr>
<td>Equipment type</td>
<td>Descriptive title of equipment, e.g. &quot;cable gland&quot;, &quot;fire detector&quot;</td>
</tr>
<tr>
<td>Location of equipment</td>
<td>The relevant location of the equipment, according to the hazardous area classification drawing</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>Name and nationality of manufacturer</td>
</tr>
<tr>
<td>Type designation</td>
<td>Manufacturers' type designation</td>
</tr>
<tr>
<td>Certification body, certificate number and type of protection</td>
<td>Identification of certifying body, the Ex certificate number and type of Ex protection</td>
</tr>
<tr>
<td>Special conditions</td>
<td>If the certificate number ends with &quot;X&quot; or &quot;U&quot;, compliance with the special conditions given in the certificate shall be stated</td>
</tr>
<tr>
<td>Is-circuit limits and values</td>
<td>Unless a system certificate is available defining the parameters for the complete intrinsically safe circuit, a system document shall be prepared containing barrier data and field instrument data for verification of compatibility between Is barrier and field equipment. Rated voltage and current of the field equipment shall not be exceeded. Maximum permissible inductance, capacitance or L/R ratio and surface temperature shall not be exceeded. The permissible values shall be taken from the associated apparatus documentation or the marking plate.</td>
</tr>
</tbody>
</table>
3 Equipment Selection

3.1 General

3.1.1 General
For the selection of electrical equipment that shall be installed in hazardous areas the following requirements apply:

a) Electrical equipment installed in a hazardous area shall be certified safe as required in [3.2]. (Certified safe is defined in Sec.13 [1.6.2].) The Ex protection type shall be in accordance with any requirements for the area or zone in question, or as found in any applicable additional class notation.

b) Unless described in additional class notations, the hazardous area shall be categorised into hazardous zones in accordance with a relevant IEC standard, and the equipment shall be acceptable in accordance with [3.2] for installation in the hazardous zone category.

c) Electrical equipment and wiring shall not be installed in hazardous areas unless essential for operational purposes and when permitted by the relevant rules.

d) Gas group and temperature class of electrical equipment shall be in accordance with the requirements relevant for the gas or vapour that can be present (IEC 60092-502, 6.2.3, 6.2.4).

3.2 Ex protection according to zones

3.2.1 Zone 0
Equipment for zone 0 installation shall be in accordance with one of the following alternatives:

a) Electrical equipment installed in zone 0 shall normally be certified safe for intrinsic safety Ex-ia.

b) For zone 0 systems, the associated apparatus (e.g. power supply) and safety barriers shall be certified safe for Ex-ia application.

c) Equipment specially certified for use in zone 0.

3.2.2 Zone 1
Equipment for zone 1 installation shall be in accordance with one of the following alternatives:

a) Certified safe for zone 0 application.

b) Certified safe for zone 1 application.

c) Normally, Ex o (oil filled) and Ex q (sand filled) are not accepted. However, small sand filled components as i.e. capacitors for Ex e light fixtures are accepted.

Guidance note:
For electrical equipment installed into zone 1 the following protection methods maybe used:

- Ex i (intrinsic safe) category a or b
- Ex d (flameproof)
- Ex e (increased safety)
- Ex p (pressurised)
Electrical installations

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

3.2.3 Zone 2
Equipment for zone 2 installation shall be in accordance with one of the following alternatives:

a) Certified safe for zone 0 application.
b) Certified safe for zone 1 application.
c) Certified safe for zone 2 application.
d) Have a manufacturer conformity declaration stating that it is made in accordance with an Ex-n standard.
e) Documented by the manufacturer to be suitable for zone 2 installation. This documentation shall state compliance with a minimum enclosure protection as per IEC 60079-15, maximum temperature for internal or external surfaces according to the temperature class for the area and that the equipment contains no ignition sources during normal operation.

3.2.4 Battery rooms, paint stores, welding gas bottle stores, and refrigerating systems
a) Electrical equipment installed in battery rooms, lockers or boxes, paint stores or welding gas bottle stores, and in ventilation ducts serving such spaces shall be suitable for installation in zone 1 with the following requirements for gas group and ignition temperature:
   — battery rooms for NiCd and Lead Acid batteries: minimum gas group II C and temperature class T1
   — battery rooms for other battery technologies are covered by Pt.6 Ch.2 Sec.1
   — paint stores: minimum gas group II B and temperature class T3
   — welding gas bottle stores: minimum gas group II C and temperature class T2.

b) For refrigerating systems containing R717 (Ammonia, NH₃), see Ch.6 Sec.6 [4.1.6].
c) Cables routed through spaces listed in a) and b) shall either be suitable for installation in hazardous area zone 1, or be installed in metallic conduit.
d) Areas on open deck within 1m of inlet and exhaust ventilation openings or within 3 m of exhaust outlets with mechanical ventilation are classified as zone 2.
e) Enclosed spaces giving access to such areas may be considered as non-hazardous, provided that:
   — the door to the space is a gastight door with self-closing devices and without holding back arrangements (a watertight door is considered gastight)
   — the space is provided with an acceptable, independent, natural ventilation system ventilated from a safe area
   — warning notices are fitted adjacent to the entrance to the space stating that the store contains flammable liquids or gas.

f) Battery rooms and lockers or boxes shall be regarded as zone 2 hazardous areas with respect to access doors, lids or removable panels and possible interference with other rooms, i.e., outside of access doors, cabinets and boxes there is no hazardous area.
g) The fan mounted inside ventilation ducts shall be of non-sparking type.
3.3 Additional requirements for equipment and circuit design

3.3.1 Ex-e motors (increased safety)
Motors certified Ex-e shall, when installed in zone 1, have an overload or thermal protection that disconnects the motor before the TE-time is exceeded in a situation with locked rotor or some kind of machine stalling condition.

**Guidance note:**

*Ex-e equipment, TE-time*

The TE-time is the time it takes for the motor, starting from normal operating temperature, to reach the temperature given by the temperature class of the Ex certification if the rotor is locked. The TE-time is stated in the Ex-certificate for the motor.

---end of guidance note---

3.3.2 Frequency converter driven Ex-e and Ex-d motors

a) Ex-e motors driven by a power converter are not accepted to be installed in zone 1 unless the converter and the motor are certified together. The certificate shall state allowed motor-converter combinations.

b) The requirement in a) applies also for Ex-d motors unless the motors are equipped with embedded RTDs in the windings and an over temperature trip device.

c) For Ex-n motors driven by converters, a conformity declaration as described in [3.2.3] is required. This declaration shall include information on accepted type of converter.

3.3.3 Ex-p equipment

a) For zone 1 installation, Ex-p protected equipment shall normally be certified safe as a complete system by an independent test institution (complete system being the equipment, the enclosure, the purging and the control system).

b) For zone 2 installation, Ex-p protected equipment may either be certified safe as for zone 1, or be verified safe by a competent person before taken into service. Such verification shall be documented in a verification report.

c) In zone 1 applications, automatic shutdown and or isolation of equipment inside enclosures will be required upon loss of pressurisation. If automatic shutdown increases the hazard to the vessel, then other protection methods shall be utilised for equipment that has to remain connected. In zone 2 applications, a suitable alarm at a manned control station for indication of loss of overpressure is accepted, instead of the automatic shutdown.
### 3.3.4 Ex-i circuits

a) All intrinsic safe circuits shall have a safety barrier in form of a Zener barrier or galvanic isolation certified safe for the application in front of the circuit part going into hazardous areas.

b) The complete intrinsically safe circuit shall not contain more than the maximum allowed inductance, \( L_{eq} \) and/or capacitance, \( C_{eq} \) the barrier is certified for. The \( L_{eq} \) and \( C_{eq} \) for the circuit shall be the total of the cable to the hazardous area plus the values of connected equipment.

c) Both the safety barrier in the safe area, and the equipment installed in hazardous area shall be certified safe unless it is "simple apparatus".

**Guidance note:**

**Simple apparatus**

a) A simple (non-energy storing) apparatus is an electrical component of simple construction with no, or low energy consumption or storage capacity, and which is not capable of igniting an explosive atmosphere. Normal maximal electrical parameters are 1.5 V, 100 mA and 25 mW. The component should not contain inductance or capacitance. Components such as thermocouples or passive switches are typical examples of simple, non-energy storing, apparatus.

b) Simple (non-energy storing) apparatus, when used in an intrinsically safe circuit, generally does not need to be certified safe, provided that such apparatus is constructed in accordance with IEC 60079-14, Part 14: "Electrical apparatus for explosive gas atmospheres".

---end---of---guidance---note---

### 3.3.5 Ex-d equipment

a) Ex-d enclosures and their flameproof joints shall not be installed closer to a bulkhead or solid object than 10 mm for gas group II A, 30 mm for II B, and 40 mm for II C.

b) Flameproof joints shall be protected against corrosion with suitable non-hardening grease.

c) Gaskets can only be applied if originally fitted in the equipment from the manufacturer, and the equipment has been certified or tested with gaskets.

d) One layer of soft tape around the flameproof joint opening for corrosion protection is allowed for Ex-d enclosures installed in areas with gas groups II A and II B, but not II C areas.

e) Tape into (on the threads of) flameproof joints of threaded type, is not allowed.

f) Flameproof joints might be covered with a thin layer of paint on the outside. However, this is not accepted in II C areas.

### 3.3.6 Circuits supplied from a TN-S distribution system

Circuits from a TN-S distribution system shall be supplied through a circuit breaker with earth fault protection (RCD).

---

### 4 Installation Requirements

**4.1 General**

**4.1.1 General**

For general installation requirements, see Sec.10. The following clauses are requirements especially for hazardous area installations.

**4.1.2 Ingress protection**

Ingress protection of equipment in relation to its location shall in general be as described in Sec.10, with the addition that the minimum IP degree of enclosures for Ex-n protected equipment is IP 44.

**Guidance note:**

A comparison between the IEC based IP-rating and the NEMA types used in the USA is given in Table 2.
### Table 2 Corresponding values for NEMA-Type and IP-rating

<table>
<thead>
<tr>
<th>NEMA-Type</th>
<th>Description of NEMA-Type</th>
<th>IP-rating</th>
<th>Description of IP-rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General purpose, indoor</td>
<td>11</td>
<td>Protection from solid objects larger than 55 mm</td>
</tr>
<tr>
<td>2</td>
<td>Suitable where severe condensation present</td>
<td>32</td>
<td>Protection against dripping water, spillage (not rain)</td>
</tr>
<tr>
<td>3</td>
<td>Weathertight against rain and sleet</td>
<td>54-55</td>
<td>Dustproof and resistant to splashing water (5) and rain (4) (normal outdoor weatherproof)</td>
</tr>
<tr>
<td>3R</td>
<td>Less severe than NEMA 3</td>
<td>14</td>
<td>Protected from water only (rarely used in the IEC system)</td>
</tr>
<tr>
<td>4</td>
<td>Watertight. Resistant to direct water jet spray</td>
<td>56</td>
<td>Dustproof and heavy water jets (like on an open deck)</td>
</tr>
<tr>
<td>4X</td>
<td>Same as NEMA 4 although corrosion resistant, stainless or non-metallic</td>
<td>No equivalent</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Dust tight</td>
<td>52</td>
<td>Dustproof and resistant to dripping water (not rain)</td>
</tr>
<tr>
<td>6</td>
<td>Limited submersion in water</td>
<td>67</td>
<td>Protected against effect of immersion maximum 1 m (depth)</td>
</tr>
<tr>
<td>7</td>
<td>Explosion-proof. (Contains gaseous internal ignition)</td>
<td>no direct equivalent</td>
<td>Flameproof (Ex-d) works by the same principal</td>
</tr>
<tr>
<td>12</td>
<td>Dust tight and drip proof</td>
<td>52</td>
<td>Dustproof and resistant to dripping water (not rain)</td>
</tr>
<tr>
<td>13</td>
<td>Oil tight and dust tight. (Constructed with special gasketing to resist oil and liquid chemical penetration)</td>
<td>54-55</td>
<td>Dustproof and resistant to splashing water and rain. (normal outdoor weather proof)</td>
</tr>
</tbody>
</table>

---end---of---guide---note---

### 4.2 Cable types, cabling and termination

#### 4.2.1 Cable types

a) All cables installed in hazardous areas shall have an outer non-metallic impervious sheath.

b) Power and signal cables shall have a metallic braiding or armour between conductors and the non-metallic impervious sheath in the following zones and areas:
   - zone 0
   - zone 1

For class notation **DG** (dangerous goods) see Pt.6 Ch.5 Sec.10.

Cables forming an integrated part of a certified safe apparatus need not to have a metallic screen or braiding.

c) Multicore cables for Ex-i circuits shall have metallic braiding in all zones, and in addition have individual screened pairs unless all of the following is complied with:
   - the cable shall be installed as fixed installation i.e. mechanically protected
   - the circuit voltage shall be less than 60 V
   - the cable shall be type approved or case by case.
4.2.2 Fixed cable installations

a) In zone 0 only cabling for Ex-ia circuits are allowed.
b) In zone 1 trough runs of cables other than the ones intended for Ex-equipment, shall be avoided.
c) In zone 2, through runs of cables are accepted.
d) All metallic protective coverings of power and lighting cables passing through a hazardous zone, or connected to apparatus in such a zone, shall be earthed at least at their ends. Special DC cables with a high ripple content (e.g. for thyristor equipment) and single core cables for AC shall be earthed at one end only (Sec.10 [3.9.4]).

4.2.3 Flexible cables

a) Flexible cables for non-intrinsically safe circuits shall be avoided in hazardous areas and shall not be used permanently in zone 1, unless necessary for operational purposes.
b) Fixed installation with short flexible cable supported from connection boxes to equipment will be accepted in zone 2.

4.2.4 Penetrations of bulkheads and decks

Cable penetrations through bulkheads and decks shall be gas tight, and shall be of an approved type when used as sealing between zones or between hazardous areas and non-hazardous areas.

4.2.5 Cable entrance into equipment

a) In the case of direct entry into an Ex-d enclosure a certified safe gland shall be applied according to the following instructions:
   — Zone 1: Either barrier or compound filled type of gland shall be used, or a rubber compression type gland might be used provided it is not a II C area, and the Ex-d internal volume is below 2 dm³.
   — Zone 2: Both barrier or compound filled type and compression type gland is accepted.
b) For Ex-e, Ex-n and general non-sparking equipment the cable gland shall maintain the required IP-rating for the enclosure in question.
c) Unused openings for cable glands shall be blanked off by suitable plugs according to the equipment's Ex-protection method. For Ex-e and Ex-n type of protection, the sealing plug shall maintain the required IP-rating for the enclosure in question. For Ex-d equipment, with direct entry, the sealing plug shall be certified safe (Ex-d) for the relevant application.

4.2.6 Termination and wiring inside Ex-e and Ex-d enclosures

a) Only one conductor is allowed to be connected into one Ex-e terminal.
b) In certified empty Ex-e enclosures, only the maximum amount of wiring and equipment stated in the certificate shall be installed within the enclosure.
c) All components inside an Ex-e enclosure shall be certified safe with protection Ex-e, -d, -m or other approved method for zone 1 application.
d) Certified empty Ex-d (flameproof boxes) shall have a final certificate taking into account the equipment installed within the Ex-d enclosure during installation.

4.2.7 Intrinsically safe circuit wiring and termination

a) The braid, armour or collective screen provided in intrinsically safe circuits shall be connected to the local earth at both ends, and might also be earthed at intermediate junction boxes or panels where relevant. Where the bonding of the braiding, armour or screen at the field end is not practical, it may be earthed at the safe end only.
b) The individual screen, when provided, of single pair or multi pair cable, shall be connected to earth in safe area at the barrier end only. In hazardous area, the inner screen shall be properly insulated or terminated. If there is special reason to connect the inner screen to earth at both ends, then this might be accepted based on the explanation in IEC 60079-14 Clause 12.2.2.3.
c) Where the installation has separate earth bars for protective earth, instrument earth and intrinsically safe earth, these bars shall be used accordingly.

d) Terminals for intrinsically safe circuits and terminals for non-intrinsically safe circuits shall be separated by a physical distance of 50 mm or a by an earthed metallic partition. Terminals for intrinsically safe circuits shall be marked as such.

e) Category Ex-ia- circuits intended for zone 0, and category Ex-ib-circuits shall not be run in the same cable.

f) Intrinsically safe circuits and non-intrinsically safe circuits shall not be carried in the same cable.

g) Inside cabinets, screened wiring of non-intrinsically safe circuits can be laid in the same channel or tray as screened intrinsically safe circuits. Unscreened conductors in intrinsically safe and non-intrinsically safe circuits do not need any separating distance provided that the parallel wiring length is below 1m, and that the intrinsically safe and non-intrinsically safe conductors are not laid in the same cable or wiring bundle or wiring channel. For lengths longer than 1 m, the conductors shall be run at least 50 mm apart, or with an earthed metallic partition between the conductors.

4.2.8 Special conditions in EX certificates

Verification and inspection of Ex certified equipment shall include checking that special conditions for safe use given in the certificates are compiled with.
SECTION 12 ELECTRIC PROPULSION

1 General

1.1 General

1.1.1 Application

a) The technical requirements in this section are in addition to those in Sec.2 to Sec.11 and apply to propulsion systems, where the main propulsion is performed by some type of electric motors.

b) A vessel with shaft generator(s) which can be operated in a “power take in” mode (PTI) is not regarded as having electric propulsion, unless this motor provides temporarily solely the entire propulsive power.

c) Prime movers for generators providing electric power for propulsion
   — Instrumentation and monitoring (control, monitoring and alarms) shall be as required for propulsion engines in Ch.3 Sec.1 [5.4]
   — Safety actions (safety system) shall be as required for auxiliary engines Associated speed governing and control shall be arranged as for auxiliary engine.
   — Shipboard testing of the prime movers shall be as for auxiliary engines.

d) Prime movers that drive generators for the supply of power for general service other than propulsion, are defined as auxiliary prime movers, even if they may be connected to the propulsion power system and thus contribute to propulsion power.

e) Local and remote control systems for electric propulsion machinery shall comply with main class rules.

f) For instrumentation and automation, including computer based control and monitoring, the requirements in this chapter are additional to those given in Ch.1 and Ch.9.

1.2 System design

1.2.1 General

a) Electric propulsion systems shall be designed with defined operating modes of the vessel, described in an “electric philosophy” for the installation. All these modes shall comply with the requirements in this section.

b) All operating modes shall be so designed that a single failure in the electrical system or the control system not disables the propulsion permanently. The propulsion system shall be designed with redundancy type R1, see Ch.1 Sec.1 [2] so that power for manoeuvrability is restored preferably within 30 seconds, but in any case not more than 45 seconds after loss of power.

c) Unless otherwise stated, it is the responsibility of the Builder to ensure technical integration of propulsion system with respect to:
   — The settings of the protection devices for the generators, transformers and propulsion motors shall be coordinated with the settings of the power management system and those of the propulsion plant’s converters.
   — The requirements given in Ch.1 Sec.4 [1.4.8] with regard to alarm, slowdown and shutdown shall be complied with.

d) Electrical equipment in propulsion lines, which have been built with redundancy in technical design and physical arrangement, shall not have common mode failures endangering the manoeuvrability of the vessel, except for fire and flooding, which are accepted as common mode failures. The cables of any drive section unit shall, as far as is practicable, be run over their entire length separately from the cables of the other drive section.

e) Vessels having two or more propulsion motors and converters, or two electric motors on one propeller shaft, shall be arranged so that any unit may be taken out of service and electrically disconnected.
without affecting the operation of the others. Motors where the excitation not can be disconnected shall have means to preventing rotation (e.g. water-milling) when other propulsion motors are used (e.g. a shaft locking device or clutch). It is accepted that the propulsion power is reduced after a disconnection. However, power sufficient for manoeuvring shall be maintained.

1.2.2 Ventilation and cooling
The general requirements in Sec.2 will normally imply that loss of ventilation or cooling to spaces or equipment with forced air-cooling, shall not cause loss of propulsion. Sufficient power necessary for manoeuvring shall be available after any single failure. Where the propulsion system is arranged in different lines with the associated equipment for power distribution to these lines arranged in different rooms, failure of ventilation or cooling shall only render one propulsion line out of operation. However, redundancy requirements for main class and relevant additional class notations shall be adhered to.

1.3 System capacity

1.3.1 Torque
a) The torque/thrust available at the propeller shaft shall be adequate for the vessel to be manoeuvred, stopped, or reversed when the vessel is sailing at full speed.
b) Adequate torque margin shall be provided to guard against the motor pulling out of synchronism during rough weather conditions or manoeuvres.
c) Sufficient run-up torque margin shall be provided to ensure a reliable start under all ambient conditions.
d) Required locked rotor torque shall be considered in view of the operation of the vessel.

Guidance note:
For thrusters, a gear oil temperature of 0°C should be considered.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.3.2 Overload capacity
The system shall have sufficient overload capacity to provide the necessary torque, power, and for AC systems reactive power, needed during starting, manoeuvring and crash stop conditions.

1.4 Electric supply system

1.4.1 Electric supply system
The electric distribution system shall comply with the requirements in Sec.2.

Frequency variations shall be kept within the limits given in Sec.2. During crash-stop manoeuvres, it will be accepted that voltage and frequency variations exceed normal limits, if other equipment operating on the same net is not unduly affected.

1.5 System protection and controls

1.5.1 System protection and controls
a) Where a single failure in the generators’ excitation systems may endanger the manoeuvrability of the vessel, provisions shall be made to monitor the proper operation of the excitation system. Upon detection of abnormal conditions, an alarm shall be given on the navigating bridge and in the engine control room and actions to bring the system into a safe operational mode shall be automatically executed.
b) Any protection devices in the voltage regulator shall be deactivated or adjusted so that they respond subsequently.
c) Protection devices shall be set to such values that they do not respond to overload occurring under normal service condition, e.g. while manoeuvring or in heavy seas.
1.5.2 Converter protection and controls
a) The following monitoring and alarms shall be provided for static converter:
   — Power stage failures (Input circuits, DC-Link, Output circuits)
   — System error of the control system (Watchdog-Alarm)
   — Actual speed failure
   — Reference value input failure
   — Control power supply failure
b) Communication failures
   It shall be possible to identify the cause for the shutdown/ tripping of converter even after switching off the main supply.

1.5.3 Motor protection and controls
a) Circuit protection in an excitation circuit shall not cause opening of the circuit, unless the armature circuits are disconnected simultaneously.
b) In the supply of exciter circuits, only short-circuit protection shall be provided. Failure of the excitation system shall be signalled by an alarm.
c) In addition to the motor protection as stipulated in Sec.2 [7.5] the following protection is required:
   — Overspeed protection, if applicable
   — protection device which detects internal faults of the motor for propulsion motors with an output of more than 1500 kW (e.g. current unbalance protection).
   — Earth fault protection
d) For motors with several stator windings, a manual switch-disconnector shall be arranged between the motor terminals and the static converter.
e) For permanently excited machines, the disconnectors shall open automatically and have a corresponding switching capacity.
f) For separately excited motors the disconnectors shall open automatic together with the exciter circuit.
g) For asynchronous motors, it is sufficient to switch off the static converter and, if applicable, to open disconnecting devices for single windings.

Guidance note:
Following an internal fault in the motor or a short circuit in the output, different measures may be necessary, depending on the location of the damage and the motor type. Error indication shall make it possible to identify the damaged parts of the plant. The feeder breakers and the disconnector shall open automatically, insofar as they serve to limit the damage.

1.6 Control systems

1.6.1 Propulsion control
a) The electric propulsion system shall be equipped with means for local control. These means shall be understood as a method of controlling the equipment that constitutes the propulsion system. These means shall be independent of the normal propulsion remote control system.
b) Failure of the remote propulsion control system shall not cause appreciable change of the thrust level or direction and shall not prohibit local control.
c) The normal propulsion remote control system shall include means for limiting the thrust levels when there is not adequate available power. This may be an automatic pitch or speed reduction.

d) In the event of failure of an actual or reference value, it shall be ensured that the propeller speed does not increase unacceptably, that the propulsion is not reversed, or that dangerous operating conditions can arise. The same applies to failure of the power supply for the control and regulating functions.

e) Means for emergency stop of propulsion motors shall be arranged at all control locations. The emergency stops shall be independent of the normal stop, and separate for each propulsion line.

f) In case remote control of a propulsion drive is arranged for selecting other than the normal speed control mode (e.g. torque or power) the propeller thrust shall not change significantly as a consequence of selecting an alternative operating mode.

g) The propulsion power shall be limited or reduced in the event of overcurrent, undervoltage, underfrequency, reverse power and overload

h) A limitation of the running-up of the propulsion system that is caused by generators reaching their maximum output should not be signalled as an alarm.

i) Start blocking shall interlock the start-up process of the propulsion system if existing malfunctions would trigger a shutdown or if the start-up process itself would cause damage to the propulsion system.

Guidance note:
It is accepted that ahead and astern thrust output will be different due to the propeller characteristics.
It is accepted that an emergency stop system has common power supply for several propulsion motors, as long as each motor can be stopped by this system independently of the other motors, and as long as a single failure in this emergency stop system cannot cause loss of manoeuvrability.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.6.2 Power plant control

a) When electric propulsion is utilised, the electric power generation and distribution system shall be equipped with an automatic control system having at least the following functions:

— ensure adequate power for safe manoeuvre is available at all times i.e. load dependent stop of generators during manoeuvring shall be inhibited.
— In manoeuvring mode, each main busbar section shall be supplied by at least one generating set to ensure even load sharing between on-line generators.
— execute load tripping and/or load reduction when the power plant is overloaded.
— ensure that adequate power for safe manoeuvring is available also if one running generator is tripped. If necessary by tripping of non-essential consumers
— no changes in available power shall occur if the automatic control system fails, that is no start or stop of generators shall occur as an effect of a failure
— control the maximum propulsion motor output.

b) The control system shall initiate an alarm, to the operator, when adequate power is no longer available.

c) The control system shall be fail safe, so that a failure in a load sharing line not result in a blackout.

Guidance note:
The control system may have a selector for transit or manoeuvre mode, enabling operation with different levels of reserve power in these two modes of operation.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.6.3 Monitoring and alarms

a) Safety functions installed in equipment and systems for electric propulsion shall not result in automatic shutdown unless the situation implies that the equipment is not capable of further functioning, even for a limited time. Automatic reduction of propulsion power is accepted.

b) Priming control shall not prevent blackout start, if arranged.

c) Shutdowns caused by a safety function shall, as far as possible, be arranged with a pre-warning alarm.
d) Critical alarms for propulsion shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms.

e) Monitoring with alarm shall be arranged for:

- high temperature of cooling medium of machines and semi-conductor converters having forced cooling
- high winding temperature of all propulsion generators, transformers and motors
- loss of flow of primary and secondary coolants of machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself. Auxiliary contacts from motor starters may be used for this purpose
- Bearing-temperature monitoring shall be provided for generators above 1500 kVA and for propulsion motors. A thermometer shall be installed locally for monitoring purposes. If the bearings are inaccessible, the temperature measurement system shall be designed to provide redundancy.
- Bearings with external lubrication shall be monitored for adequate lubrication under all operating conditions. In addition the oil temperature shall be monitored. An inspection lid and means for visual indication of oil level or use of an oil gauge shall be fitted. If the bearings are inaccessible, the lubrication monitoring system shall be designed to provide redundancy.
- Engaged and dis-engaged position of shaft locking device shall be monitored. An alarm shall be triggered if the locking device is in an inadmissible position.
- Leakage of water-air heat exchanger for cooling of machines and semi-conductor converters
- earth fault for main propulsion circuits
- earth fault for excitation circuits. (This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW)
- fuses for filter units, or for other components where fuse failure is not evident
- high and low voltage on main busbars
- high and low frequency on main busbars.

Guidance note:
If the system has an operating mode with open bus tie breaker, each busbar shall have voltage, frequency and low insulation alarms.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

e) A request for manual load reduction shall be issued, visually and acoustically on the bridge, or an automatic load reduction shall be arranged in case of:

- low lubricating oil pressure to propulsion generators and motors
- high winding temperature in propulsion generators, transformers and motors
- failure of cooling in machines and converters.

Guidance note:
High-high, or extreme high, temperatures may, when higher than the high alarm limit, cause shut down of the affected equipment. For redundancy requirements, see [1.2]. Critical alarms for propulsion machinery are alarms causing automatic shutdown or load reduction of parts of the propulsion power.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

1.6.4 Instruments

a) A temperature indicator for directly reading the temperature of the stator windings of generators and propulsion motors shall be located in the control room.

b) The following values shall be displayed in the control room or on the applicable converter:

- stator current in each motor
- field current in each motor (if applicable).

c) For each generator: A power factor meter or kVAR meter.

d) On the bridge and in the control room, instruments shall be provided for indication of consumed power and power available for propulsion.
e) At each propulsion control stand, indications, based on feedback signals, shall be provided for pitch or
direction of rotation, speed, and azimuth, if applicable.

f) Indications as listed for control stands shall be arranged in the engine control room, even if no control
means are provided.

Guidance note:
When the rated power of semi-conductors is a substantial part of the rated power of the generators, it should be ensured that
measurements are displayed in true root mean square values. Temperature indicators may be omitted for winding temperatures that
are displayed on the alarm system display.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2 Verification

2.1 Survey and testing upon completion

2.1.1 Onboard testing/dock trial

a) Failure in load sharing lines shall be tested.
b) Safety functions, alarms and indicators shall be tested.
c) All control modes shall be tested from all control locations.
d) start-up, loading and unloading of the power generation, distribution system and propulsion motors in
accordance with the design of the system.
e) At least the following shall be verified:
— propeller speed regulation and all associated equipment
— protection, monitoring and indicating/alarm equipment including the interlocks
— re-activation of collective alarms
— insulation condition of the main propulsion circuits

Guidance note:
For testing the power generation, distribution system and propulsion motors, a trial with a zero-thrust propeller or comparable
equipment is recommended.

---e-n-d---of---g-u-i-d-a-n-c-e---n-o-t-e---

2.1.2 Sea trial

a) Upon completion, the electric propulsion system shall be subject to final tests at a sea trial.
b) The final test at sea assumes that satisfactory tests of all subsystems have been carried out during dock
trials including generator prime movers test with full load individually. During the sea trial test with full
propulsion power all generators shall have been used during the trial.
c) The test program shall include tests of the propulsion plant in normal and abnormal conditions as well as
crash stop manoeuvres. All operating modes for the vessel, as defined in the operating philosophy, shall
be tested.
d) The reverse power applied during reversing or speed-reducing manoeuvres shall be limited to the
acceptable maximum values.
e) Required level of redundancy shall be verified through tests
f) Characteristic values, such as speed, system currents and voltages, and the load sharing of the
generators, shall be recorded. If necessary, oscillograms shall be made.
g) Upon completion of the sea trial, a visual inspection of the components of the propulsion plant shall be
performed. The insulation resistances of the propulsion transformers, propulsion motors and generators
shall be determined and recorded.
SECTION 13 DEFINITIONS

1 Definitions

1.1 General

1.1.1 Electrical installations
The term electrical installations is an all-inclusive general expression that is not limited to the physical installations. For physical installations, the wording, “installation of...” is used.

1.1.2 Normally
The term "normally", or "normally not", when used in these rules, shall basically be understood as a clear requirement in line with "shall", or "shall not". However, upon request, other designs may be accepted.

1.2 Operational conditions

1.2.1 Normal operational and habitable condition
Normal operational and habitable condition is a condition under which the vessel, as a whole, is in working order and functioning normally. As a minimum, the following functions shall be operational: Propulsion machinery, steering gear, safe navigation, fire and flooding safety, internal and external communications and signals, means of escape, emergency boat winches, anchor winches and lighting necessary to perform normal operation and maintenance of the vessel. Additionally, designed comfortable conditions for habitability, including; cooking, heating, domestic refrigeration, mechanical ventilation, sanitary and fresh water. All utility systems for the listed functions shall be included. Exemptions are made for consumers for which IMO requires emergency power only. Such consumers are considered as emergency consumers, and not as required for normal operational and habitable conditions.

1.2.2 Emergency condition
An emergency condition is a condition under which any services needed for normal operational and habitable conditions are not in working order due to the failure of the main electrical power system.

1.2.3 Dead ship condition
Dead ship is defined in Ch.1 of the Rules for Classification of Ships.

1.2.4 Blackout situation
Blackout situation occurs when there is a sudden loss of electric power in the main distribution system and remains until the main source of power feeds the system. All means of starting by stored energy are available.

1.3 Services

1.3.1 Essential services
a) Essential (primary essential) services are those services that need to be in continuous operation for maintaining the vessel’s manoeuvrability in regard to propulsion and steering (see IACS UI SC134). Additional class notations may extend the term essential services. Such extensions, if any, can be found in the relevant rule chapters.

b) Examples of equipment and or systems for essential services:
— control, monitoring and safety devices or systems for equipment for essential services
— scavenging air blower, fuel oil supply pumps, fuel valve cooling pumps, lubricating oil pumps and freshwater cooling water pumps for main and auxiliary engines
— viscosity control equipment for heavy fuel oil
— ventilation necessary to maintain propulsion
— forced draught fans, feed water pumps, water circulating pumps, condensate pumps, oil burning installations, for steam plants on steam turbine vessels, and also for auxiliary boilers on vessels where steam is used for equipment supplying primary essential services
— steering gears
— azimuth thrusters which are the sole means for propulsion or steering - with lubricating oil pumps, cooling water pumps
— electrical equipment for electric propulsion plant - with lubricating oil pumps and cooling water pumps
— pumps or motors for controllable pitch propulsion or steering propellers, including azimuth control
— hydraulic pumps supplying the above equipment
— electric generators and associated power sources supplying the above equipment.

1.3.2 Important services
Important (secondary essential) services are those services that need not necessarily be in continuous operation for maintaining for the vessel’s manoeuvrability, but which are necessary for maintaining the vessels functions as defined in Pt.1 Ch.1 Sec.1 [1.2], or other relevant parts of the rules (see IACS UI SC134). Important electrical consumers are electrical consumers serving important services. Electrical equipment necessary to fulfil requirements to additional class or service notations are to be considered important equipment.

a) Such extensions, if any, can be found in the relevant rule chapters.

b) Examples of equipment or systems for important services:
   — anchoring system
   — thrusters not part of steering or propulsion
   — fuel oil transfer pumps and fuel oil treatment equipment
   — lubrication oil transfer pumps and lubrication oil treatment equipment
   — pre-heaters for heavy fuel oil
   — seawater pumps
   — starting air and control air compressors
   — bilge, ballast and heeling pumps
   — fire pumps and other fire extinguishing medium appliances
   — ventilating fans for engine and boiler rooms
   — ventilating fans for gas dangerous spaces and for gas safe spaces in the cargo area on tankers
   — inert gas systems
   — fire detection and alarm system
   — main lighting system
   — electrical equipment for watertight closing appliances
   — electric generators and associated power sources supplying the above equipment
   — hydraulic pumps supplying the above equipment
   — control, monitoring and safety systems for cargo containment systems
   — control, monitoring and safety devices or systems for equipment to important services
   — jacking motors
   — water ingress detection and alarm system
   — auxiliary boilers in vessels with Heavy Fuel Oil (HFO) as the main fuel.

1.3.3 Emergency services
a) Emergency services are those services that are essential for safety in an emergency condition.

b) Examples of equipment and systems for emergency services:
   — equipment and systems that need to be in operation in order to maintain, at least, those services that are required to be supplied from the emergency source of electrical power
— equipment and systems that need to be in operation in order to maintain, at least, those services that are required to be supplied from the accumulator battery for the transitional source(s) of emergency electrical power
— equipment and systems for starting and control of emergency generating sets
— equipment and systems for starting and control of prime movers (e.g. diesel engines) for emergency firefighting pumps
— equipment and systems that need to be in operation for the purpose of starting up manually, from a “dead ship” condition, the prime mover of the main source of electrical power (e.g. the emergency compressor)
— equipment and systems that need to be in operation for the purpose of fire fighting in the machinery spaces. This includes emergency firefighting pumps with their prime mover and systems, when required according to Ch.11.
— equipment required to be powered from the emergency source of power as e.g.:
— navigational lights and signals
— navigation equipment
— internal and external safety communication equipment.

c) Further requirements for emergency services are given in Sec.2.

1.3.4 Non-important services
Non-important services are those services not defined as essential or important; or those services that are not defined, according to [1.3.1], [1.3.2] and [1.3.3].

1.4 Installation

1.4.1 Short circuit proof installation
For low voltage installations, short circuit proof installation means one of the following methods:
— bare conductors mounted on isolating supports
— single core cables (i.e., conductors with both insulation and overall jacket) without metallic screen or armour or braid, or with the braid fully insulated by heat shrink sleeves in both ends
— insulated conductors (wires) from different phases kept separated from each other and from earth by supports of insulating materials, or by the use of outer extra sleeves
— double insulated wires or conductors.

1.5 Area definitions

1.5.1 Open deck
Open deck is a deck that is completely exposed to the weather from above or from at least one side.

1.5.2 EMC zone
Deck and bridge zone: area in close proximity to receiving and/or transmitting antennas and the wheelhouse navigation bridge as well as the control rooms, characterized by equipment for intercommunication, signal processing, radio communication and navigation, auxiliary equipment and large openings in the metallic structure.

General power distribution zone: area characterized by normal consumers.
Special power distribution zone: area characterized by propulsion systems, bow thrusters, etc., producing emissions exceeding the limits given for the General power distribution zone.

Guidance note:
These definitions of EMC zones are based on IEC 60533.
1.6 Hazardous area

1.6.1 Area definitions
A hazardous area is an area (zones and spaces) containing a source of hazard and or in which explosive gas and air mixture exists, or may normally be expected to be present in quantities such as to require special precautions for the construction and use of electrical equipment and machinery.

1.6.2 Certified safe equipment
Certified safe equipment is equipment certified by an independent national test institution or competent body to be in accordance with a recognised standard for electrical apparatus in hazardous areas.

1.6.3 Marking of certified safe equipment
Certified safe equipment shall be marked in accordance with a recognised standard for electrical apparatus in hazardous areas. This includes at least:
— Ex-protection type and Ex certificate number
— gas and equipment group, according to Table 1
— temperature class, according to Table 2.

Table 1 Equipment and gas groups

<table>
<thead>
<tr>
<th>Gas groups (IEC surface industry = II)</th>
<th>Representative gas</th>
<th>NEC 500 (US surface industry = class 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>II A</td>
<td>Propane</td>
<td>Group D</td>
</tr>
<tr>
<td>II B</td>
<td>Ethylene</td>
<td>Group C</td>
</tr>
<tr>
<td>II C</td>
<td>Hydrogen</td>
<td>Group B</td>
</tr>
<tr>
<td>II C</td>
<td>Acetylene</td>
<td>Group A</td>
</tr>
</tbody>
</table>

Table 2 Temperature classes

<table>
<thead>
<tr>
<th>Temperature classes (equipment maximum temperature)</th>
<th>Ignition temperature of gas or vapour °C</th>
<th>Corresponding NEC (US) temperature classes</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC and EN norms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T1</td>
<td>Above 450</td>
<td>T 1</td>
</tr>
<tr>
<td>T2</td>
<td>Above 300</td>
<td>T 2 *</td>
</tr>
<tr>
<td>T3</td>
<td>Above 200</td>
<td>T 3 *</td>
</tr>
<tr>
<td>T4</td>
<td>Above 135</td>
<td>T 4 *</td>
</tr>
<tr>
<td>T5</td>
<td>Above 100</td>
<td>T 5</td>
</tr>
<tr>
<td>T6</td>
<td>Above 85</td>
<td>T 6</td>
</tr>
</tbody>
</table>

* Intermediate values of temperature classes by letter marking ABCD exist.

Guidance note:
Comparison between the IEC based zone, NEC based divisions and ATEX equipment categories are given in Table 3.

Table 3 Divisions and zones

<table>
<thead>
<tr>
<th>Continuous hazard</th>
<th>Intermittent hazard</th>
<th>Hazard under abnormal conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
1.7 Sources of power, generating station and distribution

1.7.1 Main source of electrical power
A main source of electrical power is a source intended to supply electrical power to the main switchboard(s) for distribution to all services necessary for maintaining the vessel in normal operational and habitable conditions.

Guidance note:
A generator prime mover and associated equipment is called "generators' primary source of power".

1.7.2 Emergency source of electrical power
An emergency source of electrical power is a source intended to supply the emergency switchboard and/or equipment for emergency services in the event of failure of the supply from the main source of electrical power.

Guidance note:
Emergency source of electrical power may be generator(s) or battery(ies).
A generator prime mover and associated equipment is called "emergency generators' primary source of power".

1.7.3 Main electric power supply system
a) A main electric power supply system consists of the main source of electric power and associated electrical distribution. This includes the main electrical generators, batteries, associated transforming equipment if any, the main switchboards (MSB), distribution boards (DB) and all cables from generators to the final consumer.
b) Control systems and auxiliary systems needed to be in operation for the above mentioned systems or equipment are included in this term.

1.7.4 Emergency electric power supply system
a) An emergency electric power supply system consists of the emergency source of electric power and associated electrical distribution. This includes emergency generators, batteries, associated transforming equipment if any, the transitional source of emergency power, the emergency switchboards (ESB), emergency distribution boards (EDB) and all cables from the emergency generator to the final consumer.
b) A transitional source of power is considered to be part of the emergency electric power supply system.
c) Control systems and auxiliary systems needed to be in operation for the above mentioned systems or equipment are included in this term.

1.7.5 Battery systems
A battery system is an interconnection of electrical batteries wired in series, parallel or as a combination of both connections. Battery management systems, if installed, are considered as a part of the battery system.
1.7.6 Uninterruptible Power System (UPS)
A combination of converter, inverter, switches and energy storage means, for example batteries, constituting a power supply system for maintaining continuity of load power in case of input power failure (IEC publication 62040).

Off-line UPS unit: A UPS unit where under normal operation the output load is powered from the input power supply (via bypass) and only transferred to the inverter if the input power supply fails or goes outside preset limits. This transition will invariably result in a brief break in the load supply.

On-line UPS unit: A UPS unit where under normal operation the output load is powered from the inverter, and will therefore continue to operate without break in the event of the power supply input failing or going outside preset limits.

1.7.7 Main generating station
A main generating station is a space in which the main source of electrical power is situated.

1.7.8 System with high resistance earthed neutral
A system with high resistance earthed neutral is a system where the neutral is earthed through a resistance with numerical value equal to, or somewhat less than, 1/3 of the capacitive reactance between one phase and earth.

1.7.9 System with low resistance earthed neutral
A system with low resistance earthed neutral is a system where the neutral is earthed through a resistance which limits the earth fault current to a value of minimum 20% and maximum 100% of the rated full load current of the largest generator.

1.7.10 Voltage levels
The terminology used in these rules is as follows:
Safety voltage: rated voltage not exceeding 50 V AC or DC
Low voltage: rated voltages of more than 50 V up to and inclusive 1000 V with rated frequencies of 50 Hz or 60 Hz, or direct-current systems where the maximum voltage does not exceed 1500 V
High voltage: rated voltages of more than 1 kV and up to and inclusive 15 kV with rated frequencies of 50 Hz or 60 Hz, or direct-current systems with the maximum voltage under rated operating conditions above 1500 V.

1.7.11 Continuity of service
Condition for protective system and discrimination; after a fault in a circuit has been cleared, the supply to the healthy circuits is re-established.

1.7.12 Continuity of supply
Condition for protective system and discrimination; during and after a fault in a circuit, the supply to the healthy circuits is permanently ensured.
1.8 Switchboard definitions

1.8.1 Main switchboard (MSB)

a) A main switchboard is a switchboard directly supplied by the main source of electrical power or power transformer and intended to distribute electrical energy to the vessel’s services.

b) Switchboards not being directly supplied by the main source of power will be considered as main switchboards when this is found relevant from a system and operational point of view.

c) Technical requirements for functionality and construction of main switchboards, apply also to emergency switchboards.

Guidance note:

Normally, all switchboards between the main source of electrical power and (inclusive) the first level of switchboards for power distribution, to small power consumers, will be considered to be main switchboards (MSBs) (i.e. at least first level of switchboards for each voltage level used).

Cubicles for other system voltages attached to a main switchboard are considered part of the main switchboard.

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.8.2 Emergency switchboard (ESB)

a) An emergency switchboard is a switchboard, which in the event of failure of the main electrical power supply system, is directly supplied by the emergency source of electrical power and/or the transitional source of emergency power and is intended to distribute electrical energy to the emergency power consumers.

b) Switchboards not being directly supplied by the emergency source of power may be considered as emergency switchboards when this is found relevant from a system and operational point of view.

Guidance note:

Normally all switchboards between the emergency source of electrical power and (inclusive) the first level of switchboards, for power distribution to small power consumers, will be considered to be emergency switchboards (ESBs) (i.e. at least one level of switchboards for each voltage level used).

---e-n-d---o-f---g-u-i-d-a-n-c-e---n-o-t-e---

1.8.3 Distribution board (DB) and emergency distribution board (EDB)

A distribution board or an emergency distribution board is any switchboard utilised for distribution to electrical consumers, but which is not considered as a main or emergency switchboard.

1.9 Expressions related to equipment and components

1.9.1 Switchboards, assemblies, switchgear and controlgear

a) For definitions of terms related to switchgear and controlgear, see IEC 60947-1 for low voltage, and IEC 60470 and IEC 60056 for high voltage equipment.

For assemblies, the following definitions are used in the rules (reference to the International Electrotechnical Vocabulary given in brackets):

— Controlgear (IEV ref 441-11-03): a general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for the control of electric energy consuming equipment.

— Switchgear (IEV ref 441-11-02): a general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures, intended in principle for use in connection with generation, transmission, distribution and conversion of electric energy.
— switchgear and controlgear (IEV ref 441-11-01): a general term covering switching devices and their combination with associated control, measuring, protective and regulating equipment, also assemblies of such devices and equipment with associated interconnections, accessories, enclosures and supporting structures.
— switchgear and controlgear (IEV ref 826-16-03): electric equipment intended to be connected to an electric circuit for the purpose of carrying out one or more of the following functions: protection, control, isolation, switching.
— Electrical assembly (assembly of switchgear and controlgear) (IEV ref 441-12-01): a combination of switchgear and/or controlgear completely assembled with all internal electrical and mechanical interconnections.
— Semi-conductor assembly: a combination of semiconductor converters, switchgear and/or controlgear completely assembled with all internal electrical and mechanical interconnections.
— Semi-conductor converter: A device converting incoming electric power to electric power of another frequency. This covers:
  — rectifier, a device converting alternate power to direct power
  — inverter, a device converting direct power to alternate power
  — frequency converter, a device converting alternate power to alternate power of another frequency, where the output frequency may be controllably varied.

b) Tracking index is the numerical value of the proof voltage, in volts, at which a material withstands 50 drops without tracking, in accordance with IEC 60112 (i.e. a voltage value describing the isolating materials surface property to withstand tracking when wet.) Determination of the tracking index shall be done in accordance with the requirements in IEC 60112, and is normally done by type testing of the material by the manufacturer, before the material is available in the market.

1.9.2 Conductor, core, wire, cable
a) A conductor is a part of a construction or circuit designed for transmission of electric current.
b) A core is an assembly consisting of a conductor and its own insulation.
c) A wire is an assembly consisting of one core where the insulation is at least flame retardant.
d) In electrical terms, a cable is an assembly consisting of:
  — one or more cores
  — assembly protection
  — individual covering(s) (if any)
  — common braiding (if any)
  — protective covering(s) (if any)
  — inner and/or outer sheath.

Additional un-insulated conductors may be included in the cable.
e) A cable may be either Class 2 or Class 5 as defined in IEC 60228. In a Class 2 cable the conductor is made up by a minimum number of strands. In a Class 5 cable the conductor is made up by many small strands with a maximum size according to IEC 60288.

1.9.3 Neutral conductor
A neutral conductor is a conductor connected to the neutral point of a system, and capable of contributing to the transmission of electric energy.

1.9.4 Batteries
a) Vented batteries are of the type where individual cells have covers, which are provided with an opening, through which products of electrolysis and evaporation are allowed to escape freely from the cells to atmosphere.
b) Valve-regulated batteries are of the type in which the cells are closed, but have an arrangement (valve) that allows the escape of gas if the internal pressure exceeds a predetermined value.
c) Sealed batteries are of the type in which cells are hermetically sealed. For abuse conditions a safety vent or venting mechanism shall exist. (Lead Acid batteries are not sealed batteries).

1.9.5 Ingress protection of enclosures

Ingress protection of enclosures in regard to intrusion of particles and water, normally called IP rating, is defined as follows:

<table>
<thead>
<tr>
<th>First characteristic numeral</th>
<th>Protection against intrusion of particles and against accidental touching of live parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Non-protected</td>
</tr>
<tr>
<td>1</td>
<td>Protected against solid objects greater than 50 mm</td>
</tr>
<tr>
<td>2</td>
<td>Protected against solid objects greater than 12.5 mm</td>
</tr>
<tr>
<td>3</td>
<td>Protected against solid objects greater than 2.5 mm</td>
</tr>
<tr>
<td>4</td>
<td>Protected against solid objects greater than 1.0 mm</td>
</tr>
<tr>
<td>5</td>
<td>Dust protected</td>
</tr>
<tr>
<td>6</td>
<td>Dust tight</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Second characteristic numeral</th>
<th>Protection against intrusion of water</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Non-protected</td>
</tr>
<tr>
<td>1</td>
<td>Protected against dripping water</td>
</tr>
<tr>
<td>2</td>
<td>Protected against dripping water when tilted up to 15°</td>
</tr>
<tr>
<td>3</td>
<td>Protected against spraying water from above up to 60° from vertical</td>
</tr>
<tr>
<td>4</td>
<td>Protected against splashing water</td>
</tr>
<tr>
<td>5</td>
<td>Protected against water jets</td>
</tr>
<tr>
<td>6</td>
<td>Protected against heavy seas</td>
</tr>
<tr>
<td>7</td>
<td>Protected against the effects of immersion</td>
</tr>
<tr>
<td>8</td>
<td>Protected against submersion (water depth to be given)</td>
</tr>
</tbody>
</table>

Examples of designations:

<table>
<thead>
<tr>
<th>Code letters (Ingress Protection)</th>
<th>Protection against intrusion of particles and against accidental touching of live parts</th>
<th>First characteristic numeral</th>
<th>Protection against solid objects greater than 50 mm</th>
<th>Protected against solid objects greater than 12.5 mm</th>
<th>Protected against solid objects greater than 2.5 mm</th>
<th>Protected against solid objects greater than 1.0 mm</th>
<th>Dust protected</th>
<th>Dust tight</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

For further details see IEC 60529.
APPENDIX A LIST OF ALARMS AND MONITORING PARAMETERS

1 General

1.1 General

1.1.1 The alarms and monitoring requirements in the Rule text are listed in Table 1 which can be used as guidance. Switchboard instrumentation is not listed.

In case of any deviation between Table 1 and the Rule text, the Rule text shall apply.

Table 1 List of alarms and monitoring parameters of miscellaneous electrical equipment

<table>
<thead>
<tr>
<th>System</th>
<th>Item</th>
<th>Indication</th>
<th>Alarm Trip</th>
<th>Location indicated in the rules</th>
<th>Reference</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0 Design principles</td>
<td>Failure in one of the power supplies for consumers with dual supply</td>
<td>A</td>
<td>MAS</td>
<td>Sec.2 [6.1.1]d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Failure in cooling unit in environmentally controlled spaces</td>
<td>A</td>
<td>MAS</td>
<td>Sec.2 [1.1.2] b)</td>
<td>Note 1) IACS URE19</td>
<td></td>
</tr>
<tr>
<td>1.1 Automatic operation of CB and start / stop diesel engines/PMS</td>
<td>Control system power failure</td>
<td>A</td>
<td>MAS</td>
<td>Sec.2 [8.2.1] b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Starting failure of prime mover</td>
<td>A</td>
<td>MAS</td>
<td>Sec.2 [8.2.3] a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Frequency</td>
<td>LA / HA</td>
<td>MAS</td>
<td>Sec.2 [8.2.1] b)</td>
<td>Sec.12 [1.6.3]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Voltage</td>
<td>LA / HA</td>
<td>MAS</td>
<td>Sec.2 [8.2.1] b)</td>
<td>Sec.12 [1.6.3]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Excessive percentage difference in loads</td>
<td>HA</td>
<td>MAS</td>
<td>Sec.2 [8.2.3] a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Generator standby</td>
<td>IR</td>
<td>MAS</td>
<td>Sec.2 [2.2]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2 Emergency generator / ESB</td>
<td>Prime mover for emergency generator not ready for start</td>
<td>IR and A</td>
<td></td>
<td>Sec.2 [3.3.1] c) and Sec.2 [8.3.1] a)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>When used in port: Monitoring and safety requirements of prime mover</td>
<td></td>
<td>MAS</td>
<td>Sec.2 [3.3.4] c)</td>
<td>See Ch.3 Sec.1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When used in port: Fuel oil supply tank level</td>
<td>LA</td>
<td>MAS</td>
<td>Sec.2 [3.3.4] d)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3 Battery / UPS systems</td>
<td>Charging fail (Alternatively: battery being discharged)</td>
<td>A</td>
<td>MCS/MAS</td>
<td>Sec.2 [4.1.3]</td>
<td>Sec.7 [1.2.10] f)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ventilation fail</td>
<td>A</td>
<td>MCS</td>
<td>Sec.2 [4.1.3]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4 Navigation light</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>----------------------</td>
<td>--------</td>
<td>--------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Automatic bypass in operation</td>
<td>A</td>
<td>MCS</td>
<td>Sec.7 [1.2.10] f</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operation of battery protection device</td>
<td>A</td>
<td>MCS</td>
<td>Sec.7 [1.2.10] f</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Failure in power supply</td>
<td>A</td>
<td>NB</td>
<td>Sec.2 [6.2.3] a) Note 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short-circuit</td>
<td>A</td>
<td>NB</td>
<td>Sec.2 [6.2.4] c) Note 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulb failure</td>
<td>A</td>
<td>NB</td>
<td>Sec.2 [6.2.4] c) Note 2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation fault in distribution system</td>
<td>IL</td>
<td></td>
<td>Sec.2 [7.1.2] a) Note 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Insulation fault in high voltage system without automatic disconnection by insulation fault</td>
<td>LA</td>
<td>MAS</td>
<td>Sec.2 [7.1.2] a) and c) Note 3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overload alarm for motors without overcurrent trip</td>
<td>A</td>
<td>MAS</td>
<td>Sec.2 [7.5.1] d</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Activation of circuit protection in filter circuits</td>
<td>A</td>
<td>MCS</td>
<td>Sec.2 [7.7.1] Sec.12 [1.6.3]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.5 Protection</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of control voltage to protective functions</td>
<td>A</td>
<td>MAS</td>
</tr>
<tr>
<td>Failure power supply to essential and important control and monitoring systems</td>
<td>A</td>
<td>MAS</td>
</tr>
<tr>
<td>Loss of voltage in the auxiliary power system in high voltage switchboards</td>
<td>A</td>
<td>MAS</td>
</tr>
<tr>
<td>When a component or system has two or more power supply circuits with automatic change over, an alarm shall be initiated at a manned control station upon loss of any of these power supplies.</td>
<td>A</td>
<td>MAS</td>
</tr>
<tr>
<td>Failure in control power supply when arranged NO</td>
<td>A</td>
<td>MAS</td>
</tr>
<tr>
<td>Computer based system: System failure</td>
<td>A</td>
<td>MAS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2.0 Cooling and anti-condensation</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure in mechanical cooling of electrical systems</td>
<td>A</td>
<td>MAS</td>
</tr>
<tr>
<td>Winding temperature in the cooled equipment for essential services</td>
<td>HA, IR</td>
<td>MAS</td>
</tr>
<tr>
<td>Winding temperature in the cooled equipment for important services</td>
<td>HA</td>
<td>MAS</td>
</tr>
<tr>
<td>Leakage alarm for water cooled heat exchangers</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>4.0 Rotating machines</td>
<td>Temperature detectors embedded in stator winding</td>
<td>HA</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------</td>
<td>----</td>
</tr>
<tr>
<td>5.0 Power transformers</td>
<td>Immersed transformers: Liquid level low and low low</td>
<td>LA, SH</td>
</tr>
<tr>
<td></td>
<td>Immersed transformers: Liquid temperature high and high high</td>
<td>HA, SH</td>
</tr>
<tr>
<td></td>
<td>Immersed transformers: Gas pressure high</td>
<td>SH</td>
</tr>
<tr>
<td></td>
<td>Immersed transformers: Interturn short circuit</td>
<td>SH</td>
</tr>
<tr>
<td>6.0 Semiconductor Converters</td>
<td>Power supply failure and/or trip of unit</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Secondary side earth fault (IT distributions)</td>
<td>AL</td>
</tr>
<tr>
<td></td>
<td>High conductivity of cooling liquid</td>
<td>AH</td>
</tr>
<tr>
<td>7.0 Pressurised spaces and Ex-p</td>
<td>Loss of pressure to Ex-p (zone 2)</td>
<td>A and/or SH</td>
</tr>
<tr>
<td></td>
<td>Failure in generator excitation system</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Static converter power stage failure</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Static converter, system error of control system (watchdog-alarm)</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Static converter, actual speed failure</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Static converter, reference value input failure</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Static converter, control power supply failure</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Failure of propulsion motor excitation system</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Overspeed of propulsion motor</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Protection device which detects internal faults of the motor for propulsion motors with an output of more than 1500 kW (e.g. current unbalance protection).</td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>Earth fault monitoring in propulsion motor and its supply circuit</td>
<td>A</td>
</tr>
<tr>
<td>Condition</td>
<td>Code</td>
<td>Risk Level</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>Insufficient power for propulsion</td>
<td>A</td>
<td>NB</td>
</tr>
<tr>
<td>Pre warning alarms for shut down caused by safety functions (as far as possible)</td>
<td>A</td>
<td>NB</td>
</tr>
<tr>
<td>Cooling medium temperature</td>
<td>HA</td>
<td>NB</td>
</tr>
<tr>
<td>Winding temperature of all propulsion generators and motors</td>
<td>HA</td>
<td>NB</td>
</tr>
<tr>
<td>Loss of flow of primary and secondary coolants</td>
<td>LA/A</td>
<td>NB</td>
</tr>
<tr>
<td>Bearing temperature</td>
<td>HA</td>
<td>NB</td>
</tr>
<tr>
<td>Lubricating monitoring</td>
<td>LA</td>
<td>NB</td>
</tr>
<tr>
<td>Monitoring of shaft locking device</td>
<td>IR</td>
<td>MAS</td>
</tr>
<tr>
<td>Water-air heat exchanger leakage</td>
<td>A</td>
<td>NB</td>
</tr>
<tr>
<td>Earth fault for main propulsion circuits</td>
<td>A</td>
<td>NB</td>
</tr>
<tr>
<td>Earth fault for excitation circuits</td>
<td>A</td>
<td>NB</td>
</tr>
<tr>
<td>Miscellaneous components</td>
<td>A</td>
<td></td>
</tr>
</tbody>
</table>
Notes:
1) Applicable for cooling equipment in environmentally controlled spaces, where equipment with reduced ambient temperature tolerance is installed.
2) Alarms/indication required in WH only
3) Insulated or high resistance earthed systems
4) Applicable if rated output > 5000 kW and all high voltage motors and all propulsion motors
5) Critical alarms shall be relayed to the navigation bridge and displayed with separate warnings separated from group alarms.
6) This may be omitted in circuits of brushless excitation systems and for machines rated less than 500 kW
7) For machines and semi-conductor converters having closed cooling method with a heat exchanger, when this flow is not caused by the propulsion motor itself.
8) Fuses for filter units or for other components where fuse failure is not evident.
CHANGES – HISTORIC

October 2015 edition

General
This is a new document.
The rules enter into force 1 January 2016.
Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16 000 professionals are dedicated to helping our customers make the world safer, smarter and greener.