

BRITISH STANDARD

Code of practice for installation of electrical and electronic equipment in ships

ICS 47.020.60



NO COPYING WITHOUT BSI PERMISSION EXCEPT AS PERMITTED BY COPYRIGHT LAW

Documents
Document Sharing Hub

Publishing and copyright information

Published jointly by British Standards Institution and The Institution of Engineering and Technology, UK.

The BSI/ Institution of Engineering and Technology copyright notice displayed in this document indicates when the document was last issued.

© BSI/ Institution of Engineering and Technology 2006

ISBN 0 580 48280 4

The following BSI references relate to the work on this standard:

Committee reference JPEL/18

Draft for comment 05/30138424 CD

Other publications available from the Institution of Engineering and Technology:

The Institution of Engineering and Technology produces other publications which may be of interest. Please contact the Institution for further details:

Michael Faraday House, Six Hills Way, Stevenage SG1 2AY, United Kingdom.
Tel: + 44 (0) 1438 767328, Fax: + 44 (0) 1438 767375, Email: sales@theiet.org,
Web: www.theiet.org.

Publication history

First published, July 2006

Amendments issued since publication

Amd. no.	Date	Text affected
-----------------	-------------	----------------------

Contents

Foreword *ii*

1	Scope	<i>1</i>
2	Normative references	<i>1</i>
3	Terms and definitions	<i>5</i>
4	General requirements	<i>7</i>
5	Earthing and bonding	<i>10</i>
6	Application of diversity factors	<i>13</i>
7	Distribution	<i>15</i>
8	Generating plant and motors	<i>18</i>
9	Construction of cables	<i>22</i>
10	Selection and installation of cables	<i>24</i>
11	Tables of cable current ratings	<i>27</i>
12	Motor control gear	<i>28</i>
13	Batteries	<i>30</i>
14	Heating and cooking appliances	<i>33</i>
15	Semiconductor converters for power purposes	<i>34</i>
16	Transformers	<i>35</i>
17	Accessories	<i>36</i>
18	Communication and navigation aids	<i>37</i>
19	Control and instrumentation	<i>38</i>
20	Lightning protection	<i>40</i>
21	Systems operating at above 1 kV a.c.	<i>40</i>
22	Dynamic positioning (DP)	<i>41</i>

Annexes

Annex A (informative) Guidance on the selection and use of socket-outlets and welding equipment *43*

Annex B (informative) Guidance on the treatment of the neutral point *46*

Annex C (informative) Guidance on electromagnetic compatibility *56*

Bibliography *58*

List of figures

Figure 1 – Assessment curves *14*

List of tables

Table 1 – Supply conditions for which supplementary bonding is not required *12*

Table 2 – Creepage and clearance distances *41*

Table B.1 – Summary of principal features of the neutral earthing methods *46*

Summary of pages

This document comprises a front cover, an inside front cover, pages i and iv, pages 1 to 61, an inside back cover and a back cover.

Foreword

Publishing and supersession information

This British Standard was published by BSI and came into effect on 26 July 2006. It was prepared by Technical Committee JPEL/18, *Electrical installations of ships*. It supersedes all editions of the “*Regulations for the Electrical and Electronic Equipment of Ships*” (the IEE “Blue Book”), which are withdrawn.

Copyright is held jointly between BSI and Institution of Engineering and Technology.

JPEL/18 wishes to acknowledge the participation of the following organizations in the drafting of this code of practice.

British Electrotechnical and Allied Manufacturers’ Association (BEAMA)

British Cables Association (BCA)

British Marine Equipment Association (BMEA)

British Rig Owners Association (BROA)

British Waterways Board

Electrical Contractors Association (ECA)

Engineering Equipment and Materials Users’ Association (EEMUA)

Association for the Instrumentation, Control and Automation Industry in the UK (GAMBICA)

Health and Safety Executive (HSE)

Institute of Marine Engineering, Science and Technology (IMar EST)

Institution of Engineering and Technology (IET)

Institution of Engineers and Shipbuilders in Scotland

Institution of Incorporated Engineers (IIE)

International Marine Contractors Association (IMCA)

Lloyd’s Register

Maritime and Coastguard Agency (MCGA)

MOD — UK Defence Standardization

SELECT

UK Offshore Operators Association (UKOOA)

The production of this British Standard has required careful comparison of the text of the “Blue Book” with the relevant IEC standards.

This British Standard indicates only additional requirements or recommendations for UK industry that (BS) IEC 60092 lacks entirely or, in the opinion of JPEL/18, does not cover adequately, although frequent reference is made to other relevant standards and publications. References to the applicable parts of (BS) IEC 60092 are given at the beginning of each clause.

Use of this document

As a code of practice, this British Standard takes the form of guidance and recommendations. It should not be quoted as if it were a specification, and particular care should be taken to ensure that claims of compliance are not misleading.

Disclaimer

While the publisher and contributors believe that the information and guidance given in this work is correct, all parties must rely on their own skill and judgement when making use of it. Neither the publisher nor any contributor assume any liability to anyone for any loss or damage caused by any error or omission in the work, whether such error or omission is the result of negligence or any other cause. All and any such liability is disclaimed.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a British Standard cannot confer immunity from legal obligations.

In particular, attention is drawn to the statutory regulations listed as items [1] to [22] in the bibliography.

1 Scope

This British Standard gives recommendations for the design, installation and maintenance of electrical equipment for the generation, storage, conversion, distribution and utilization of electrical energy for all purposes in ships of all descriptions, including, where relevant, inland and harbour craft, but excluding ships of war.

NOTE For vessels smaller than 500 grt or with a length less than 50 m, IEC 60092-507 provides a basic standard for small vessel electrical installations, including direct current systems not exceeding 50 V and alternating current systems not exceeding 250 V single phase or 500 V three phase.

These recommendations are intended to provide satisfactory operation and safety, especially from fire and electrical shock, of installed equipment and portable and transportable equipment which is intended to be connected to the ship's electrical distribution system. They relate principally to requirements for the installation, utilization, inspection and testing, but certain recommendations for the construction of electrical and electronic equipment are included.

This British Standard is not applicable to the internal wiring of manufactured apparatus that is not wired on board. It is not intended to provide for every circumstance – those of a special character may require appropriate advice.

2 Normative references

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

BS 21, *Specification for pipe threads for tubes and fittings where pressure-tight joints are made on the threads (metric dimensions).*

BS 196, *Specification for protected-type non-reversible plugs, socket-outlets cable-couplers and appliance-couplers with earthing contacts for single phase a.c. circuits up to 250 volts.*

BS 1363 (all parts), *13 A plugs, socket-outlets and adaptors.*

BS 1387, *Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads.*

BS 1597, *Specification for limits and methods of measurement of electromagnetic interference generated by marine equipment and installations.*

BS 3135, *Specification for gas turbine acceptance test.*

BS 3456 (all parts), *Specification for safety of household and similar electrical appliances.*

BS 3863 (all parts), *Guide for gas turbines procurement.*

BS 4167 (all parts), *Specification for electrically-heated catering equipment.*

BS 4568-1, *Specification for steel conduit and fittings with metric threads of ISO form for electrical installations — Part 1: Steel conduit, bends and couplers.*

BS 4999 (all parts), *General requirements for rotating electrical machines.*

BS 5308-1, *Instrumentation cables — Part 1: Specification for polyethylene insulated cables.*

BS 5308-2, *Instrumentation cables — Part 2: Specification for PVC insulated cables.*

BS 5467, *Electric cables — Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V.*

BS 5514 (all parts), *Reciprocating internal combustion engines: performance.*

BS 6004, *Electric cables — PVC insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring.*

BS 6231, *Specification for PVC-insulated cables for switchgear and controlgear wiring.*

BS 6290-4, *Lead-acid stationary cells and batteries — Part 4: Specification for classifying valve regulated types.*

BS 6346, *Electric cables — PVC insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V.*

BS 6351-1, *Electric surface heating— Part 1: Specification for electric surface heating devices.*

BS 6351-2:1983, *Electric surface heating — Part 2: Guide to the design of electric surface heating systems.*

BS 6351-3, *Electric surface heating — Part 3: Code of practice for the installation, testing and maintenance of electric surface heating systems.*

BS 6500, *Electric cables — Flexible cords rated up to 300/500 V, for use with appliances and equipment intended for domestic, office and similar environments.*

BS 6622, *Specification for cables with extruded cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3.8/6.6 kV up to 19/33 kV.*

BS 6626, *Code of practice for maintenance of electrical switchgear and control gear for voltages above 1 kV and up to and including 36 kV.*

BS 6724, *Electric cables — Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire.*

BS 6883, *Elastomer insulated cables for fixed wiring in ships and on mobile and fixed offshore units — Requirements and test methods.*

BS 7027, *Specification for limits and methods of measurement of the immunity of marine electrical and electronic equipment to conducted and radiated electromagnetic interference.*

BS 7211, *Electric cables — Thermosetting insulated, non-armoured cables for voltages up to and including 450/750 V, for electric power, lighting and internal wiring, and having low emission of smoke and corrosive gases when affected by fire.*

BS 7629 (all parts), *Specification for 300/500 V fire resistant electric cables having low emission of smoke and corrosive gases when affected by fire.*

BS 7655-2 (all parts), *Specification for insulating and sheathing materials for cables — Part 2: Cross-linked elastomeric sheathing compounds.*

BS 7671, *Requirements for electrical installations — IEE Wiring Regulations.*

BS 7846, *Electric cables — 600/1000 V armoured fire-resistant cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.*

BS 7889, *Electric cables — Thermosetting insulated, unarmoured cables for a voltage of 600/1000 V.*

BS 7917, *Elastomer insulated fire resistant (limited circuit integrity) cables for fixed wiring in ships and on mobile and fixed offshore units — Requirements and test methods.*

BS 7919, *Electric cables - Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments.*

BS EN 50085-1, *Cable trunking systems and cable ducting systems for electrical installations — General requirements.*

BS EN 50086-1, *Specification for conduit systems for cable management — Part 1: General requirements.*

BS EN 50086-2 (all parts), *Specification for conduit systems for cable management — Part 2: Particular requirements.*

BS EN 50117 (all parts), *Coaxial cables.*

BS EN 60034-15, *Rotating electrical machines — Part 15: Impulse voltage withstand levels of rotating a.c. machines with form-wound stator coils.*

BS EN 60045-1, *Guide to steam turbine procurement — Part 1: Guide to steam turbine procurement.*

BS EN 60079-10, *Electrical apparatus for explosive gas atmospheres — Part 10: Classification of hazardous areas.*

BS EN 60079-14, *Electrical apparatus for explosive gas atmospheres — Part 14: Electrical installations in hazardous areas (other than mines).*

BS EN 60228, *Conductors of insulated cables.*

BS EN 60298, *A.C. metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.*

BS EN 60309-2, *Plugs, socket-outlets and couplers for industrial purposes — Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories.*

BS EN 60335 (all parts), *Specification for safety of household and similar electrical appliances.*

BS EN 60335-2-36, *Specification for safety of household and similar electrical appliances — Part 2-36 — Particular requirements —*

Particular requirements for commercial electric cooking ranges, ovens, hobs and hob elements.

BS EN 60335-2-37, Specification for safety of household and similar electrical appliances — Part 2-37 — Particular requirements — Particular requirements for commercial electric deep fat fryers.

BS EN 60335-2-38, Specification for safety of household and similar electrical appliances — Part 2-38 — Particular requirements — Particular requirements for commercial griddles and griddle grills.

BS EN 60335-2-39, Specification for safety of household and similar electrical appliances — Part 2-39 — Particular requirements — Particular requirements for commercial multi-purpose cooking pans.

BS EN 60439 (all parts), Specification for low-voltage switchgear and controlgear assemblies.

BS EN 60622, Secondary cells and batteries containing alkaline or other non-acid electrolytes — Sealed nickel-cadmium prismatic rechargeable single cells.

BS EN 60470, High-voltage alternating current contactors and contactor-based motor starters.

BS EN 60669-1, Switches for household and similar fixed electrical installations — Part 1: General requirements.

BS EN 60702-1, Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V — Part 1: Cables.

BS EN 60945, Maritime navigation and radio communication equipment and systems — General requirements — Methods of testing and required test results.

BS EN 60947-4-1, Specification for low-voltage switchgear and controlgear — Part 4-1: Contactors and motor-starters — Electromechanical contactors and motor-starters.

BS EN 60953-1, Rules for steam turbine thermal acceptance tests — Part 1: High accuracy for large condensing steam turbines.

BS EN 60953-2, Rules for steam turbine thermal acceptance tests — Part 2: Wide range of accuracy for various types and sizes of turbines.

BS EN 61008-1, Specification for residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) — Part 1: General rules.

BS EN 61056-1, Portable lead-acid cells and batteries (valve-regulated types) — Part 1: General requirements, functional characteristics — Methods of test.

BS EN 61241-1, Electrical apparatus for use in the presence of combustible dust — Part 1: Protection by enclosures “tD”.

BS EN 61241-14, Electrical apparatus for use in the presence of combustible dust — Part 14: Selection and installation.

BS EN 61386-1, Conduit systems for cable management — Part 1: General requirements.

BS EN 61386-21, Conduit systems for cable management — Part 21: Particular requirements — Rigid conduit systems.

BS EN 61386-22, *Conduit systems for cable management — Part 22: Particular requirements — Pliable conduit systems.*

BS EN 61386-23, *Conduit systems for cable management — Part 23: Particular requirements — Flexible conduit systems.*

BS EN 61558-2-5, *Safety of power transformers, power supply units and similar — Part 2-5: Particular requirements for shaver transformers and shaver supply units.*

BS EN 61951-1, *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Portable sealed rechargeable single cells — Part 1: Nickel-cadmium.*

BS EN 62271-200, *High-voltage switchgear and controlgear — Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV.*

BS ISO 3046 (all parts), *Reciprocating internal combustion engines.*

BS IEC 60092-303, *Electrical installation in ships — Part 303: Equipment — Transformers for power and lighting.*

BS IEC 60092-304, *Electrical installation in ships — Part 304: Equipment — Semiconductor converters.*

BS IEC 60092-401:1980, *Electrical installation in ships — Part 401: Installation and test of completed installation.*

BS IEC 60092-502, *Electrical installation in ships — Part 502: Tankers — Special features.*

BS IEC 60092-504:2001, *Electrical installation in ships — Part 504: Special features — Control and instrumentation.*

BS IEC 60533:1999, *Electrical and electronic installations in ships — Electromagnetic compatibility.*

IEC 60092-352, *Electrical installation in ships — Part 352: Choice and installation of cables for low-voltage power systems.*

IEC 60502-1, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) — Part 1: Cables for rated voltages of 1 kV ($U_m = 1,2$ kV) and 3 kV ($U_m = 3,6$ kV).*

IEC 60502-2, *Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV) — Part 2: Cables for rated voltages from 6 kV ($U_m = 7,2$ kV) up to 30 kV ($U_m = 36$ kV).*

IEC 62281, *Safety of primary and secondary lithium batteries during transport.*

3 Terms and definitions

For the purposes of this British Standard, the following terms and definitions apply.

3.1 appropriate authority

governmental body, or Classification Society, or both, to whose rules and regulations ships have to conform

3.2 dynamic position control system

control computer(s), input sensors (including manual control of set points) and output actuators, together with associated cabling and power supplies

3.3 vented cell

secondary battery cell having a cover provided with an opening through which products of electrolysis and evaporation are allowed to escape freely to the atmosphere

3.4 sealed cell

battery cell which remains closed and does not release either gas or liquid when operated within the limits specified by the manufacturer

NOTE The cell might be equipped with a safety device to prevent a dangerously high internal pressure and designed to operate during its life in its original sealed state.

3.5 valve-regulated battery

secondary battery in which cells are closed but have an arrangement (valve) which allows the escape of gas if the internal pressure exceeds a predetermined value

NOTE The cell or battery cannot normally receive additions to the electrolyte.

3.6 extra low voltage (1)

voltage not exceeding 50 V a.c. r.m.s between conductors or between any conductor and earth in a circuit isolated from the electricity supply by means such as a safety isolating transformer or converter with separate windings

3.7 extra low voltage (2)

voltage not exceeding 50 V d.c. between conductors or between any conductor and earth in a circuit isolated from higher voltage circuits

3.8 low voltage

voltage normally exceeding extra-low voltage, but not exceeding 1 000 V a.c. or 1 500 V d.c. between conductors or 600 V a.c. or 900 V d.c. between any conductor and earth

3.9 high voltage

voltage normally exceeding low voltage

4 General requirements

NOTE This clause supplements the provisions of BS IEC 60092-101.

4.1 Voltage and frequency

- 4.1.1** Voltage and frequency variations within electrical systems are prescribed in BS IEC 60092-101.
- 4.1.2** In circuits supplied by batteries, the voltage variations given in BS IEC 60092-101 are likely to be exceeded, particularly where the battery is normally on floating service. The apparatus supplied should function satisfactorily within the maximum voltage variations likely to be met in all operating conditions.

NOTE Batteries supplying the emergency services required by SOLAS [1] should be capable of carrying the emergency electrical load without recharging whilst maintaining the voltage of the battery throughout the discharge period within 12% above or below the rated voltage.

- 4.1.3** All apparatus should function satisfactorily during sustained voltage variations within 10% below or 6% above the rated voltage of the system and a.c. apparatus should function satisfactorily at frequencies within plus or minus 5% of the rated frequency of the system.
- 4.1.4** The supply system should be arranged so that the transient conditions during starting of machines, etc., which are greater than those defined in **4.1.3** will not cause maloperation of or damage to other equipment, e.g.:
- i) where pole changing deck machinery is involved, a dip of 15% and a recovery time of less than 0.2 second may be suitable;
 - ii) where pole changing deck machinery is not involved, a dip of 15% and a recovery time of less than 1 second may be suitable.

4.2 Design of equipment

- 4.2.1** All apparatus should be of a design appropriate to the situation in which it is likely to be used and its mode of installation should take account of the conditions likely to be encountered in service. Examples of such conditions are:
- i) exposure to moisture and salt laden atmosphere, sea spray, high wind velocity or ice formation;
 - ii) exposure to abnormal vibration or shock;
 - iii) exposure to excessively high or low temperatures; and
 - iv) exposure to explosive mixtures of gases, dusts and circumstances where there is an abnormal risk of fire or explosion.
- 4.2.2** The design of equipment should provide accessibility to all parts requiring inspection or replacement in service.
- 4.2.3** Electrical and electronic equipment which may operate under automatic or remote control should do so without risk of damage to plant or injury to personnel.
- 4.2.4** Cognisance shall be taken of the requirements of BS IEC 60533 and BS EN 60945, as appropriate, with respect to EMC of the electrical equipment and systems of the installation.

4.2.5 Cooling air and water temperatures

Apply the latest version of SOLAS [1].

4.2.6 Inclination of ship

Apply the latest version of SOLAS [1].

- 4.2.7** Special consideration should be given to materials for items associated with systems which would be required to operate as long as possible in a fire, e.g. cables for certain alarms and shutdown systems, navigation lights, communication systems, emergency lighting, etc.

- 4.2.8** Where liquid coolants are used, consideration should be given to the detection of liquids in an equipment enclosure and provision of an alarm indication. In addition, for semiconductor converters, flow of coolant should be monitored to operate an alarm in the event of significant reduction of flow.

NOTE Attention is drawn to the need to guard against the leakage of coolant into the cooling liquid, e.g. where liquid to liquid heat exchangers are fitted.

- 4.2.9** Apparatus should be provided with suitable cable glands, bushings or conduit entries. All entries should maintain the degree of protection provided by the enclosure of the associated apparatus. (See **8.2.8**.)

- 4.2.10** The means of fixing current-carrying parts should be independent of the means of making electrical connection thereto.

- 4.2.11** Apparatus should be provided with suitable terminals, clearly marked, placed in an accessible position convenient for external connections. The terminals should be effectively secured and should be so spaced and/or shielded as to minimize the risk of accidental earthing or short-circuiting. Adequate clearance should be allowed between the cable entries and terminals so that cables can be drawn in and connected without damage.

Enclosures containing delicate apparatus should be provided with means to allow easy termination of cables without exposing such apparatus to the possibility of damage.

- 4.2.12** Enclosures of fixed apparatus which are liable to exceed a temperature of 80 °C should be so located or guarded as to prevent persons coming accidentally into contact with such equipment.

4.3 Installation, location and protection of equipment

- 4.3.1** Electrical equipment should, as far as practicable, be so placed that it is not exposed to risk of mechanical damage or excessive vibration. If equipment must be installed in locations subject to vibration, e.g. steering compartments, consideration should be given to mounting it on anti-vibration mountings. In this case, metal enclosures are to be provided with flexible arrangements for earthing.

- 4.3.2** Electrical equipment should be so selected and located or protected that the effects of exposure to sea air, water, steam, oil or oil fumes, spray, ice formation, etc., is minimized. It should be located well clear of boilers, steam, oil or water pipes, and engine exhaust pipes or manifolds, unless specifically designed for such locations. If pipes must

be run adjacent to electrical equipment there should be no joints in the immediate vicinity of the equipment.

NOTE Where sprinkler heads or water spraying devices are fitted for fire-fighting, consideration should be given to the siting of electrical equipment which would be seriously affected by the inadvertent operation of the extinguishing arrangement. This is particularly applicable to switchgear and switch rooms, where a suitable alternative method of extinguishing should be used.

- 4.3.3** Horizontal rotating machines should, where practicable, be installed fore-and-aft to minimize the effects of rolling. Where a machine is installed athwartships or vertically, the design of bearings and the arrangement for their lubrication should be adequate to withstand the rolling encountered in heavy weather and operation for prolonged periods under the conditions specified by the appropriate authority.
- 4.3.4** Where an item of equipment or enclosure contains live parts that are not capable of being isolated by a single device, a warning notice should be placed in such a position that any person gaining access to live parts will be warned of the need to use the appropriate isolating devices, unless an interlocking arrangement is provided so that all the circuits concerned are isolated.
- 4.3.5** In every ship in which electric power is used for essential services the generators, switchgear, motors and associated control gear for such services should be so situated or protected that they will continue to operate satisfactorily in the event of partial flooding by bilge water above the tank top in the space in which they are situated. The design criterion for "partial flooding" should be assumed to be a depth of water 1/12th beam, but not exceeding a depth of 1.5 m. Where this recommendation is impracticable for horizontally mounted propulsion motors, the minimum requirement is watertight to underside of the motor shaft.

4.4 Electrical equipment in flammable and/or explosive dust atmospheres

- 4.4.1** BS IEC 60092 gives details of electrical equipment permitted on board tankers intended for the carriage in bulk of oil cargoes and other types of ships where oil or liquids of similar hazards are processed, handled or stored.
NOTE Reference should be made to BS IEC 60092-506 and BS IEC 60092-502.
- 4.4.2** Because of the potential dangers introduced by electrical equipment and the difficulty in maintaining its safe characteristics in service, such equipment should not be installed where flammable gases/vapours or explosive dusts are liable to accumulate, except where it is essential and it conforms to **4.4.3**.
- 4.4.3** Where risk of explosion from flammable gases/vapours could arise, equipment should be of a safe type, certified for the gases/vapours involved and should conform to BS EN 60079 or with an equivalent national or international standard.
- 4.4.4** Where a risk of explosion from combustible dusts could arise, equipment should conform to BS EN 61241-1 and BS EN 61241-14, or with an equivalent national or international standard.

- 4.4.5** Clause **13** gives details of electrical equipment permitted in battery compartments.
- 4.4.6** Sub-clause **14.2** details the requirements for trace heating systems.
- 4.4.7** Statutory requirements as listed in [1], [3], [9] and [18], govern the electrical equipment permitted on board the following types of ships:
- ships carrying dangerous chemicals in bulk;
 - ships carrying liquefied gases in bulk;
 - ships carrying dangerous goods and materials hazardous only in bulk;
 - ships with spaces for carrying vehicles with fuel in their tanks for their own propulsion.
- 4.4.8** Electrical equipment for use in stores containing paint or other flammable fluids should be of a certified safe type. All switches and protective devices should interrupt all poles or phases and should be located in a non-hazardous area. Such switches and protective devices should be suitably labelled for identification purposes.
- 4.4.9** Electrical equipment for use in other spaces/areas where flammable gases/vapours and/or explosive dusts are liable to accumulate or where explosive materials are handled or stored is to be of a type acceptable to the appropriate authority.

NOTE 1 BS EN 60079-10, BS EN 60079-14 and BS EN 60079-17 give guidance on the installation and maintenance of electrical equipment for use in potentially explosive atmospheres.

NOTE 2 Special precautions may be necessary where risk of explosion from combustible dusts and flammable gases/vapours could arise simultaneously.

NOTE 3 Radio/radar transmitters coexist frequently in many shipping operations, particularly where bulk flammable cargoes are being transported. BS 6656:2002, 12.3 and Table 9, give guidance on the precautions to be taken to avoid inadvertent ignition of flammable materials by radio frequency radiation.

5 Earthing and bonding

NOTE This clause supplements the provisions of BS IEC 60092-401 and BS EN 60092-507. The details given in 5.1 to 5.4 apply directly to ships with metallic hulls. Additional requirements for ships with non-metallic hulls are detailed in 5.5.

5.1 System earthing

NOTE 5.1 should apply to earthed d.c. systems in so far as it is appropriate.

- 5.1.1** Earthed neutral or insulated systems are acceptable. For earthed systems in tankers and in other ships of similar hazard, see BS IEC 60092-502.

NOTE For further information see Annex B.

- 5.1.2** Earthed neutral systems should be so designed that the potential earth fault current:
- a) will not exceed the design capacity of any part of the systems; and
 - b) is of sufficient magnitude to operate any protection or indication device.

- 5.1.3** The earthing system adopted must take account of, and limit to acceptable values, possible harmonic circulating currents.
- 5.1.4** L.V. earthed neutral systems may be achieved by connecting the neutral point directly to earth. The earth loop impedance should be low enough to permit the passage of a current at least three times the fuse rating for fuse protected circuits or 1.5 times the tripping current of any excess current circuit breaker used to protect the circuit.
- 5.1.5** H.V. earthed neutral systems should be achieved by inserting impedance in the neutral connection to earth to limit the earth fault current to an acceptable level. The prospective earth fault current should be at least three times the value of current required to operate any earth fault protection devices. In the case of high impedance earthing, the impedance should be such that the earth fault current is slightly higher than the capacitive current of the system. Solid earthing is not recommended for H.V. systems.
- 5.1.6** Where an earthed system is divided into two or more sections, means for neutral earthing should be provided for each section.
- 5.1.7** All earthing resistors/impedances should be connected to the ship's hull. In addition, earthing resistors/impedances should be bonded together on the hull side of the resistance/impedance. The means of bonding should be separate from that provided at the ship's hull for radio, radar and communications circuits in order to minimize possible interference.
- 5.1.8** Efficient means should be provided for detecting defects in the insulation of the system. For systems where the earth fault current exceeds 5 A, automatic tripping devices are to be provided. Where the earth fault current does not exceed 5 A, an indicator may be provided as an alternative to an automatic tripping device (see also **5.3** and **B.3.2.2**).

5.2 Earthing of non-current-carrying parts

- 5.2.1** Unless specifically included in the exemptions listed in BS IEC 60092-401, all exposed-conductive-parts and extraneous-conductive-parts should be bonded to the ship's hull. The bonding should be such as to give a substantially equal potential and a sufficiently low earth fault loop impedance to ensure correct operation of protective devices. The bonding should be achieved by means of a separate earth conductor unless the parts under consideration are installed as follows.

Metal frames or enclosures of apparatus mounted in direct contact with the ship's hull will normally exhibit a low resistance to earth and no supplementary bonding should be necessary if the supplies to the apparatus and their protection arrangements are in accordance with Table 1.
- 5.2.2** Extraneous-conductive parts which are connected to the ship's hull by permanent and reliable metal-to-metal joints of negligible impedance need not be bonded by separate earthing conductors. Separate supplementary bonding should be provided in situations where this addition is deemed to be necessary.

Table 1 **Supply conditions for which supplementary bonding is not required**

System voltage	Protection arrangements not requiring supplementary bonding
110 V up to and including 440 V	Protective device rating 32 A or less; or RCD protected
55-0-55 V	Fuse rating 16 A or less; or MCB rating 32 A or less; or RCD protected
24 V	Fuse rating 6 A or less; or MCB rating 10 A or less; or RCD protected

- 5.2.3** The earthing of installations in hazardous areas should conform to the requirements of the appropriate authority or BS EN 60079-10 or BS EN 60079-14 where appropriate.

5.3 Earth indication

- 5.3.1** Every insulated distribution system, whether primary or secondary, should be provided with means to give initially audible and visual, then continuous visual, warning of abnormally low levels of insulation.
- 5.3.2** Every earth indicating device should be so designed that the flow of current to earth through it is as low as practicable, but in no case should exceed 30 mA.
- 5.3.3** Where an earth-indicating system using either two or three lamps, as appropriate, is adopted, earth-indicating lamps should be of the metal filament type. The system employing a single lamp should not be used. To facilitate comparison of the brilliance of earth-indicating lamps they should be of clear glass and should be placed not more than 150 mm apart.

5.4 Cables

Recommendations for the earthing and bonding of cables for electromagnetic compatibility are given in Annex C.

5.5 Additional requirements for ships with non-metallic hulls

- 5.5.1** A main earth conductor bar should be provided at a suitable location, for example, the main switchboard, to which all non-current-carrying parts not exempted in BS IEC 60092-401 should be connected.
- 5.5.2** The main earth conductor bar should be connected to the main earthing plate described in BS IEC 60092-401 by a copper conductor having a minimum cross-sectional area of 64 mm², preferably of solid strip construction.
- 5.5.3** To minimize electromagnetic interference, earthing connections should be run with the associated power cables wherever practical. Three-core cable is preferred for lighting circuits.

- 5.5.4** Earthing connections of equipment, which are sensitive to electromagnetic interference, should be made directly to the main earth conductor bar of the main earthing plate.
- 5.5.5** The earthing system in accordance with this clause and the lightning protective system in accordance with Clause **20** should be run separately down to the pillars at the main earthing plate.
- 5.5.6** To dissipate possible charge build-up in ships with non-metallic hulls constructed of high resistivity materials (surface and volume resistivities greater than 10^8 ohms and 10^6 ohm-metres, respectively) it is recommended that all metallic objects over 0.6 m in length and over 0.4 m^2 in surface area are earthed.

NOTE It may be desirable to bond to the main earth system all metal parts which are in direct contact with the sea, in order to minimize the effects of electrolytic corrosion.

6 Application of diversity factors

NOTE This clause supplements the provisions of BS IEC 60092-201.

6.1 General

- 6.1.1** The diversity factor for power circuits should take account of the known and anticipated conditions. The calculations should be based on the full load ratings of motors and the characteristics of the generators.
- 6.1.2** The diversity factor applied, where justifiable, to the loading calculation of cables, switchgear and generators supplying groups of winch motors or crane motors should be based upon the estimated duty cycle of the motors in the group, taking into account the frequency and duration of motor starting loads.

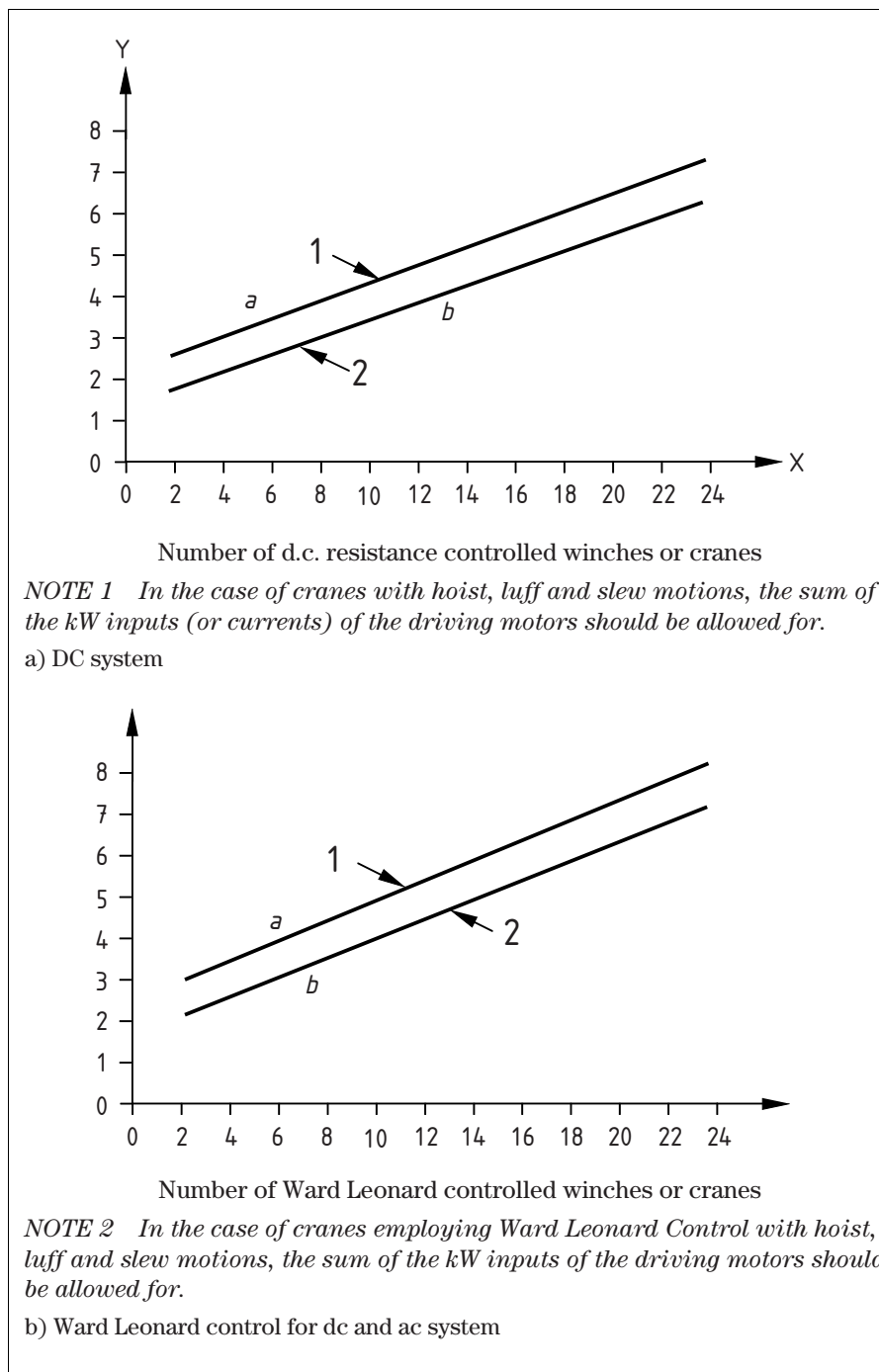
6.2 Assessment curves

- 6.2.1** For series resistance controlled d.c. motors, assessment curves in Figure 1a) have been found to be satisfactory.
- 6.2.2** For variable voltage/current controlled equipment such as Ward Leonard or thyristor apparatus operating on d.c. or a.c. systems, assessment curves in Figure 1b) have been found to be satisfactory.
- 6.2.3** For a.c. cage induction motors, assessment curves in Figure 1c) have been found to be satisfactory if the associated a.c. generators conform to **8.2.10**.
- 6.2.4** In each case, curve “a” represents the factor to be applied for assessing generators and curve “b” applies to cables and switchgear.
- 6.2.5** All the assessment curves are based on motors of equal rating; if they are of different values suitable computations would be necessary. All the diversity factors should be taken as minima, and cables, switchgear and generators supplying winch motors and crane motors should be capable of carrying continuously (subject to voltage drop) the currents calculated by applying a diversity factor to the total connected load of winch motors and/or crane motors.

6.2.6 Where the cables feeding winch motors and/or crane motors supply in addition other equipment, the current upon which the cross-sectional area of the conductors of the cables is based should allow for the coincidence of the various loads.

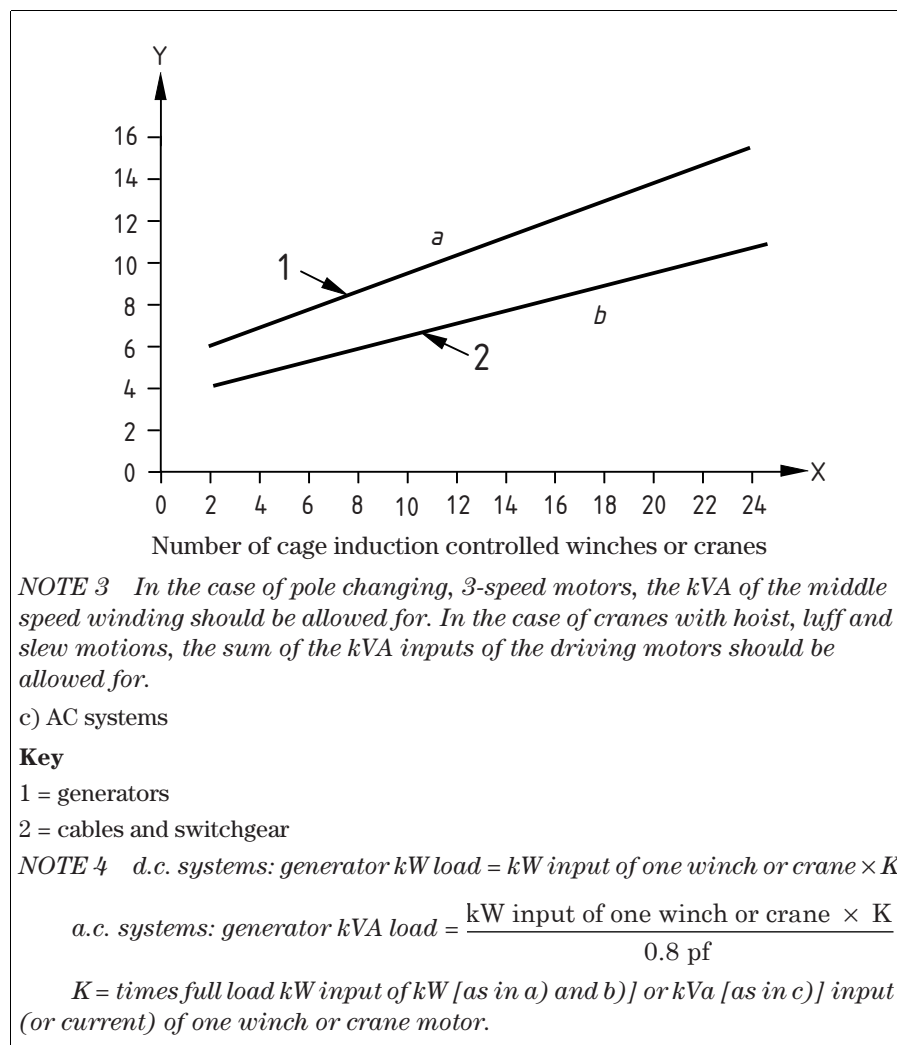
NOTE The term “full load” applies to the full load kW (or current) or full load kVA input of the winch or crane motor at its maximum shaft output rating.

Figure 1 **Assessment curves**



(continued)

Figure 1 Assessment curves (Continued)



6.3 Refrigerated containers

A diversity factor may be applied for refrigerated containers when deciding the capacity of generators and distribution transformers. The final decision can only be reached by consideration of the type of container, the cargo mix between chilled and frozen and the ratio of hot to pre-cooled containers for the applicable trade.

7 Distribution

NOTE This clause supplements the provisions of BS IEC 60092-201 and BS IEC 60092-204.

7.1 General

- 7.1.1** If a cable is looped from board to board without passing through a protective device, the cable conductors should be of the same cross-section throughout.
- 7.1.2** Switches in conductors of insulated distribution systems should open all lines simultaneously.