भारतीय मानक

Indian Standard

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IEC 60092-401 : 1980

जहाजों में विद्युत संस्थापन — विशिष्टि

भाग 4 संस्थापन और पूर्ण हुए संस्थापनों के परीक्षण

(पहला पुनरीक्षण)

Electrical Installation in Ships — Specification

Part 4 Installation and Test of Completed Installation

(First Revision)

ICS 47.020.60

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Electrical Installation Sectional Committee, ETD 20

NATIONAL FOREWORD

This Indian Standard (Part 4) (Second Revision) which is identical to IEC 60092-401 : 1980 Electrical installations in ships — Part 401: Installation and test of completed installation' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Electrical Installation Sectional Committee and approval of the Electrotechnical Division Council.

The text of the IEC standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appears referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker, while in Indian Standards the current practice is to use a point (.) as the decimal marker.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated expressing the result of a test, shall be rounded off in accordance with IS 2 : 2022 'Rules for rounding off numerical values (*second revision*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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ELECTRICAL INSTALLATION IN SHIPS — SPECIFICATION

PART 4 INSTALLATION AND TEST OF COMPLETED INSTALLATION

(First Revision)

INTRODUCTION

IEC Publication 92: Electrical Installations in Ships, forms a series of international standards for electrical installations in sea-going ships, incorporating good practice and co-ordinating as far as possible existing rules.

These standards form a code of practical interpretation and amplification of the requirements of the International Convention on Safety of Life at Sea, a guide for future regulations which may be prepared and a statement of practice for use by shipowners, shipbuilders and appropriate organizations.

1. Scope

This standard is applicable to the installation of electrical equipment for use in ships and to the testing of the complete installation.

SECTION ONE — DEFINITIONS

2. Definitions

2.1 *Earth-continuity conductor*

A wire, cable or other conductor connecting to each other or to the earthing-lead those parts which have to be earthed. For example it may be in whole or in part the metal conduit or the metal sheath of the cables, or the special earth continuity conductor of a cable or flexible cord incorporating such a conductor.

2.2 *Earthing-lead*

A conductor by which the connection is made to the metal hull of the ship.

SECTION TWO — EARTHING

3. Parts for which earthing is required

3.1 Unless specifically exempted in the following exemptions, all accessible metal parts of the electrical installation, other than current-carrying accessible parts, shall be earthed.

Exemptions:

— lamp caps;

— shades, reflectors and guards, supported on lampholders or luminaires constructed of, or shrouded in, non-conducting material;

— metal parts on, or screws in or through, non-conducting material, which are separated by such material from current-carrying parts, and from earthed non-current-carrying parts;

— portable appliances having double and/or reinforced insulation (see IEC Publication 92-101: Definitions and General Requirements) provided that the appliances conform with recognized safety requirements;

— bearing housings which are insulated in order to prevent circulation of current in the bearings;

— clips for fluorescent lighting tubes;

— apparatus supplied at safety voltage (see Sub-clause 2.19 of IEC Publication 92-101);

— cable clips.

Note. — Consideration shall be given to the earthing of the non-current-carrying parts which are not accessible but which under fault conditions might become live and hence constitute a fire hazard, such as a metal junction-box mounted on a wooden panel.

3.2 To minimize shock from high-frequency voltage induced by the radio transmitter, handles, hand-rails, etc., of metal on the bridge or upper decks shall be in good electrical connection with the hull or superstructure.

Note. — See IEC Publication 533: Electromagnetic Compatibility of Electrical and Electronic Installations in Ships.

3.3 Secondary windings of instrument transformers shall be earthed.

4. Methods of earthing

Accessible non-current-carrying metal parts not exempted under Sub-clause 3.1 shall be earthed as described below.

4.1 Metal frames or enclosures of apparatus may be fixed to, and in metallic contact with, the ship's structure, provided that the surfaces in contact are clean and free from rust, scale or paint when installed and are firmly bolted together. Alternatively, they may be connected to the hull by a connection complying with Clauses 5 and 7.

A lead cable sheath shall not be solely relied upon for this purpose.

4.2 For requirements concerning earthing of metal coverings of cables and earthing of mechanical protection of cables, see Clause 36.

5. Earthing connections

5.1 Every earthing connection shall be of copper or other corrosion-resistant material and shall be securely installed and protected where necessary against damage and also, where necessary, against galvanic corrosion.

5.2 The nominal cross-sectional area of every copper earthing connection shall be not less than is required in Table I. Every other earthing connection shall have a conductance not less than that specified for a copper earthing connection.

5.3 Metal parts of portable appliances, other than current-carrying parts and parts exempted in Sub-clause 3.1, shall be earthed by means of an earth-continuity conductor in the flexible cable or cord, which complies with Table I and which is earthed for example through the associated plug and socket-outlet.

5.4 Under no circumstances shall the lead sheathing of cables be relied upon as the sole means for earthing.

TABLE I

Sizes of earth-continuity conductors and earthing connections

<table>
<tr><th>Type of earthing connection</th><th>Cross-sectional area of associated current-carrying conductor</th><th>Minimum cross-sectional area of copper earthing connection</th></tr>
<tr><td>1. Earth-continuity conductor in flexible cable or flexible cord</td><td>Any</td><td>Same as current-carrying conductor up to and including 16 mm² or one-half above 16 mm² but at least 16 mm²</td></tr>
<tr><td>2. Earth-continuity conductor incorporated in fixed cable</td><td>Any</td><td>2.1 For cables having an insulated earth-continuity conductor:
2.1.1 a cross-section equal to the main conductors up to and including 16 mm² but minimum 1.5 mm²
2.1.2 a cross-section not less than 50% of the cross-section of the main conductor when the latter is more than 16 mm², but at least 16 mm²
2.2 For cables with a bare earth wire in direct contact with the lead sheath:
<table>
<tr><th>Cross-section of main conductor</th><th>Earthing conductor</th></tr>
<tr><td>1 to 2.5 mm²</td><td>1 mm²</td></tr>
<tr><td>4 to 6 mm²</td><td>1.5 mm²</td></tr>
</table></td></tr>
<tr><td rowspan="3">3. Separate fixed earthing-conductor</td><td>3.1 Not exceeding 3 mm²</td><td>Same as current-carrying conductor subject to minimum of 1.5 mm² for stranded earthing connection, or 3 mm² for unstranded earthing connection</td></tr>
<tr><td>3.2 Exceeding 3 mm² but not exceeding 125 mm²</td><td>One-half the cross-sectional area of the current-carrying conductor, subject to a minimum of 3 mm²</td></tr>
<tr><td>3.3 Exceeding 125 mm²</td><td>64 mm²</td></tr>
</table>

6. Earthed distribution systems

6.1 The system earthing connection in an earthed distribution system, in which the earthing connection does not normally carry current, shall conform with the recommendation of Clause 5 except that the upper limit of 64 mm² does not apply (see Table I, Item 3.3).

6.2 The system earthing of earthed distribution systems shall be effected by means independent of any earthing arrangements of non-current-carrying parts.

7. **Connections to the ship's structure**

Every connection of an earth-continuity conductor or earthing lead to the ship's structure shall be made in an accessible position, and shall be secured by a screw of brass or other corrosion-resistant material of diameter not less than 6 mm which shall be used for this purpose only. In all circumstances care shall be taken to ensure bright metallic surfaces at the contact areas immediately before the screw is tightened.

8. **Aluminium superstructures**

Methods of securing aluminium superstructures to the steel hull of a ship often include insulation to prevent galvanic corrosion between these materials. In such case, a separate bonding connection should be provided between superstructure and hull which should be made in such a manner that galvanic corrosion is avoided and the points of connection may be readily inspected.

Note. — See IEC Pubiication 533.

9. **Single-wire systems with hull return**

Where hull return systems are permitted, all final sub-circuits shall consist of two insulated wires, the hull return being achieved by connecting to the hull one of the busbars of the distribution board from which they originate.

Earth wires shall be in accessible locations to permit their ready examination and to enable their disconnection for the testing of insulation.

In d.c. hull return systems, all cables inside the magnetic compass zone shall be arranged in a bipolar manner, i.e. the outgoing and the returning wire shall be arranged in one cable or be directly side by side.

Depending on the current of the respective circuit, this shall apply to the following spherical radii around the magnetic compass, except where a steel bulkhead or deck intervenes.

Current (A)	Spherical radius (m)
Up to 10	5
Over 10 up to 50	7
Over 50	9

For radio telegraph installations or other essential radio apparatus including direction-finders, the manufacturer's data are valid.

SECTION THREE — SWITCHGEAR AND CONTROLGEAR ASSEMBLIES

10. **Insulating mats**

When the voltage exceeds the safety voltage specified in Sub-clause 2.19 of IEC Publication 92-101 an insulated mat, grating or deck of impregnated wood shall be provided in front of switchgear and controlgear assemblies and also at the rear if access from the rear is required. The insulated mats, grating or deck shall be oil-resistant and non-slip.

11. **Passage-ways in front of switchgear and controlgear assemblies**

An unobstructed passage-way not less than 1 m wide extending from the furthest projection shall be provided in front of any assembly.

Note. — For small ships, the unobstructed passage-way may be reduced subject to agreement by the appropriate authority.

12. **Space at the rear and passage-ways**

When a space is provided at the rear of switchgear and controlgear assemblies, it shall be ample to permit maintenance and in general shall be not less than 0.6 m in the clear, except that the width may be reduced to 0.5 m, where there are stiffeners and frames. For nominal voltages exceeding 500 V, it is recommended to increase this space.

Passage-ways behind main and emergency switchboards shall be of ample height and shall where practicable, be provided at each end with an access door fitted with an external lock which can at all times be opened from the interior. The access doors shall carry a permanent and prominent indication of the maximum voltage.

13. **Position relative to pipes and tanks**

In addition to complying with the appropriate requirements of I E C Publication 92-101 all switchgear and controlgear assemblies shall be so installed that no pipes or tanks are above them within the same space and at their rear. Where this is unavoidable, pipes shall be continuous and without openings in such locations.

14. **Positions of section and distribution boards**

In accommodation spaces where open-type assemblies are surrounded by combustible material, a fire barrier of incombustible material shall be provided.

SECTION FOUR — TRANSFORMERS

15. **Installation and location**

15.1 Transformers shall be installed in well-ventilated compartments, accessible only to authorized personnel except that air-cooled transformers provided with means of protection against accidental contact with live parts need not be installed in special compartments.

15.2 Liquid-immersed transformers shall be housed in a metallic compartment having adequate means for the drainage of liquid leakage.

When flammable liquid such as oil is used, the space where the transformer is located shall be protected by an automatic fire-extinguishing system.

15.3 Suitable arrangements shall be provided for cooling and containing all the liquid which might escape from a damaged tank. Contamination of bilges is to be precluded by the provision of suitable drip-trays or save-alls.

15.4 Transformers and their connections shall be protected against such mechanical damage, condensation and corrosion as may reasonably be expected.

SECTION FIVE — SEMICONDUCTOR CONVERTORS

16. **Installation and location**

16.1 Semiconductor convertor stacks or equipment shall be installed in such a manner that the circulation of air to and from the stacks, associated equipment or enclosures (if any) is not impeded and that the temperature of the cooling inlet air to convertor stacks does not exceed the ambient temperature for which the stacks are specified.

Naturally air-cooled cabinets shall be designed with sufficient ventilating openings, or with sufficient radiating surface in the case of totally enclosed convertor equipment to operate within allowable temperature limits.

16.2 Convertor stacks and associated equipment shall not be mounted near sources of radiant heat energy, such as resistors, steampipes and engine exhaust pipes.

16.3 Semiconductor convertor stacks or semiconductor components shall be mounted in such a manner that they may be removed from equipment without dismantling the complete unit.

16.4 For liquid-immersed-type convertors, the same installation precautions as specified in Clause 15 for liquid-cooled transformers apply.

SECTION SIX — ACCUMULATOR (STORAGE) BATTERIES

17. **Location**

17.1 Batteries shall be located where they are not exposed to excessive heat, extreme cold, spray, steam or other conditions which would impair performance or accelerate deterioration. Batteries for emergency service, including emergency diesel-engine starting, shall be located where they are protected as far as practicable from damage caused by collision, fire or other casualty (in accordance with the International Convention for Safety of Life at Sea).

Batteries shall be located in such a way that no harm may be done to surrounding appliances by the vapours generated.

17.2 Batteries connected to a charging device shall be installed dependent on the output power of the device (calculated from the maximum obtainable charging current and the nominal voltage of the battery) as follows:

— power more than 2 kW, in a room assigned to batteries only or if a room is not available, in a suitable well-ventilated locker on deck;

— power between 0.2 kW and 2 kW, as above, may be installed in a box or locker in some suitable space, or, if protected from falling objects, in the machinery space or in a similar well-ventilated compartment;

— power less than 0.2 kW as above, but may also be installed open, if protected from falling objects, or in a battery box in any suitable space.

Note. — See also Clause 22.

17.3 Starter batteries shall be located as close as practicable to the engine or engines served, to limit voltage drop in cables at the high current required.

17.4 Batteries (unless of the hermetically sealed type) shall not be placed in sleeping quarters.

17.5 Lead-acid batteries and alkaline batteries shall not be placed in the same battery compartment.

17.6 A danger notice shall be permanently secured to doors or covers of battery compartments, lockers and boxes, indicating that a naked light or smoking in these rooms or in their vicinity is prohibited.

18. Access

Batteries shall be arranged to permit ready access for replacing, inspection, testing, replenishing and cleaning.

19. Electrical installation in battery compartments

19.1 Cables, with the exception of those appertaining to the battery or the battery compartment lighting, should, as far as possible, not be installed in the battery compartments. If however, such an installation is necessary, the cables shall have a protective covering resistant to the vapours developed by the electrolyte or shall be otherwise protected against these vapours.

19.2 Lighting equipment should be in accordance with Table V of IEC Publication 92-201: System Design — General.

19.3 Devices liable to arc shall not be installed in any compartment assigned principally to accumulator (storage) batteries.

20. Protection against corrosion

20.1 The interior of battery compartments including crates, trays, boxes, shelves and other structural parts therein shall be protected against the deteriorating effect of the electrolyte by:

— electrolyte-resistant coating, or

— lining of electrolyte-resistant material, for example lead sheet for lead-acid, steel for alkaline batteries.

Alternatively, the floor of battery compartments may be lined with electrolyte-resistant material spanning the entire floor. The lining shall be watertight and carried up to at least 150 mm on all sides. Walls and deck-heads of battery compartments shall be protected with electrolyte-resistant coating.

20.2 Interior surface of metal shelves for lead cells, whether or not grouped in crates or trays, or for alkaline batteries, shall be protected by a lining of electrolyte-resistant material. The lining shall be watertight and carried up to at least 75 mm on all sides. Linings shall have a minimum thickness of 1.5 mm if of lead sheet, and of 0.8 mm if of steel.

Exterior surfaces of metal shelves should have at least an electrolyte-resistant coating.

20.3 Deck boxes shall be lined in accordance with the above alternative methods. Boxes for small batteries shall be lined to a depth of 75 mm consistent with the methods described above.

20.4 Materials used for coating and lining shall not be likely to emit vapours detrimental to the batteries.

21. Fixing and supports

Batteries shall be securely chocked, with wood blocks or the equivalent, to prevent movement. The trays shall be arranged to give access of air to them from all sides. The isolating supports shall be non-absorbent to the electrolyte.

22. Ventilation

22.1 All rooms, lockers and boxes for storage batteries shall be arranged and/or ventilated to avoid accumulation of flammable gas. Particular attention shall be given to the fact that the gas emitted is lighter than air and will tend to accumulate in any pockets at the top of the space. When batteries are arranged in two or more tiers, all shelves shall have not less than 50 mm space, front and back, for circulation of air.

22.2 Natural ventilation may be employed if ducts can be run directly from the top of the room or locker to the open air above, with no part of the duct more than 45° from the vertical. These ducts shall not contain appliances (for example for barring flames) which may impede the free passage of air or gas mixtures.

Where lockers are provided for batteries, the duct shall terminate not less than 0.9 m above the top of the battery enclosure.

If natural ventilation is impracticable or insufficient, mechanical exhaust-ventilation shall be provided with exhaust at the top of the room. Adequate openings, whether connected to ducts or not, for air inlets shall be provided near the floor of battery rooms or the bottom of lockers or boxes.

22.3 In every case the quantity of the air expelled shall be at least equal to:

$$Q = 110 \cdot I \cdot n$$

where:

Q = quantity of expelled air in litres per hour

I = maximum charging current during gas formation, however at least one-quarter of the maximum obtainable charging current of the charging facility in amperes.

n = number of cells

22.4 Rooms, lockers and boxes for batteries connected to a charging device with a power output according to Sub-clause 17.2 shall be ventilated as follows:

— power more than 2 kW, according to Sub-clauses 22.2 and 22.3 above, preferably by mechanical exhaust, independent of ventilation systems for other spaces;

— power between 0.2 kW and 2 kW, according to Sub-clauses 22.2 and 22.3 above, except for batteries located open in the engine room or in a similar well ventilated compartment;

— power less than 0.2 kW, boxes require openings near the top to permit escape of gas;

— deck boxes may be naturally ventilated. Natural ventilation by means of a duct of ample dimensions, terminating at least 1.25 m above in a goose-neck, mushroom-head or the equivalent will be sufficient. Holes for air inlet should be provided on at least two opposite sides of the box.

For degree of protection see IEC Publication 92-201, Table V.

22.5 Fans of accumulator compartments shall be so constructed and be of a material such as to render sparking impossible in the event of the impeller touching the fan casing. Steel or aluminium impellers shall not be used.

22.6 Ducts shall be made of a corrosion-resisting material or their interior surfaces shall be painted with corrosion-resistant paint.

22.7 Any fan motor associated with a duct used to exhaust the air from an accumulator space shall be placed external to the duct. Adequate means shall be provided to prevent entrance of gas into the motor. The duct shall be arranged to discharge into the open air.

SECTION SEVEN — LUMINAIRES

23. Degree of protection

Depending on their location, luminaires shall as a minimum have the degree of protection given in Table V of IEC Publication 92-201.

Luminaires likely to be exposed to more than ordinary risk of mechanical damage shall be protected against such damage or be of specially robust construction.

24. Discharge lamp luminaires of voltage above 250 V

24.1 *General*

Discharge lamps operating at voltages above 250 V should be used only in fixed luminaires. Discharge lamp installations should, where practicable, be provided with durable and suitable notices bearing the inscription:

24.2 *Protection of live parts*

All live parts of discharge lamp luminaires shall be so designed, placed and installed that they cannot be touched accidentally or inadvertently, the creepage distance along the surface of the glass tube being taken into consideration.

24.3 *Wiring installation*

Bare metal conductors or cables, neither metal-sheathed nor armoured, should be properly supported and separated according to the voltage but not less than 20 mm from other conductors, cables or earthed metalwork and should be covered by a suitable protection.

Where otherwise not readily identifiable, cables or their protective covering, shall be distinguished by tabs or labels marked "DANGER" securely attached at intervals not greater than 1.5 m. The letters shall be red on a white background, and shall be not less than 10 mm high.

24.4 *Earthing*

All non-current-carrying metallic parts of the installation shall be effectively earthed. It is, however, not always necessary to earth metallic clips or clamps used in positions remote from terminals to support discharge lamps but it may be found desirable to earth such clips or clamps in order to reduce interference with radio reception. See also Section Two — Earthing.

24.5 *Switches*

Each discharge lamp luminaire or installation shall be provided with a multipole (all poles) disconnecting switch in an accessible location. Such switch shall be clearly marked and a warning notice shall be placed nearby.

Switches or other current-interrupting devices shall not be installed in the secondary circuit of transformers.

25. Searchlights and arc lamps

Disconnection of every searchlight or arc lamp shall be by a multipole (all poles) disconnecting switch. If a series resistor is used with an arc lamp, the disconnecting switch should be so placed in the supply circuit that both the series resistor and the arc lamp are disconnected when the switch is in the "off" position.

26. Emergency lighting

Emergency lights shall be marked for easy identification.

SECTION EIGHT — HEATING AND COOKING APPLIANCES

27. Guarding of combustible materials

All combustible materials in the vicinity of heating and cooking appliances shall be protected by suitable incombustible and thermal insulating materials.

28. **Position of controlgear and switchgear**

The position of fuses, switches and other control elements fitted in or near appliances shall be such that they will not be subject to temperatures above that for which they are designed and they shall be accessible for inspection, for example through separate covers.

29. **Mounting of space-heating appliances**

Space-heating appliances shall be so mounted that there will be no risk of dangerous heating of the deck or bulkhead or other surroundings.

30. **Combustible gases and dust**

In positions where combustible gases or dust are likely to accumulate, heating appliances capable of igniting them shall not be installed.

SECTION NINE — CABLES

31. **Cable-runs — General**

31.1 Cable-runs shall be selected so as to be as far as possible straight and accessible.

31.2 Cable-runs shall be selected so as to avoid action from condensed moisture or dripping water. Cables shall, as far as possible, be remote from sources of heat such as boilers, hot pipes, resistors, etc., and protected from avoidable risks of mechanical damage. Where installation of cables near sources of heat cannot be avoided, and where there is consequently a risk of damage to the cables by heat, suitable shields should be installed, or other precautions to avoid overheating should be taken, for example use of special ventilation, installation of heat insulation materials, or use of special heat-resisting cables.

31.3 Cables shall not be installed across expansion joints. If, however, it is unavoidable, a loop of cable having a length proportional to the expansion of the joint should be provided. The minimum internal radius of the loop during operation shall never be less than twelve times the external diameter of the cable.

31.4 In the construction of cable-runs, account should be taken of the need for protection against destructive pests or rodents.

31.5 When cables are installed in bunches and the risk of fire propagation is high, special installation precautions shall be taken to prevent fire propagation regardless of whether or not any or all of the cables are declared flame-retardant.

31.6 Cables having insulating materials with different maximum permissible conductor temperatures (see Table VI of I E C Publication 92-201) shall not be bunched in a common clip, gland, conduit, trunking or duct.

When this is impracticable, the cables shall be so selected that no cable reaches a temperature higher than its rating.

31.7 Cables having a protective covering which may damage the covering of more vulnerable cables shall not be bunched with the latter in a common clip, gland, trunking or duct.

31.8 Cables having a bare metallic sheath or braid or armour shall be installed in such a way that galvanic corrosion by contact with other metals is prevented.

31.9 Cables for safety voltages shall not be bunched together with or run through the same pipes as cables for voltages above 500 V. Cables for voltages up to 1 kV shall not be bunched together with or run through the same pipes as cables for higher voltages.

32. Cable-runs for essential and emergency services

32.1 In the case of essential electrical equipment for which it is mandatory to have at least two supplies, for example steering gear installations, the supply and any associated control cables shall follow different routes, which shall be separated both vertically and horizontally as far as practicable.

32.2 Where it is required to divide a ship into fire zones (such as is generally the case on passenger ships), cable-runs shall be so arranged that a fire in any main vertical fire zone will not interfere with essential services in any other such zone. This is met if main and emergency cables passing through any zone are separated both vertically and horizontally as widely as is practicable.

32.3 Cables and wiring serving essential or emergency power, lighting, internal communications or signals shall so far as practicable be routed clear of galleys, laundries, machinery spaces and their casings and other high fire risk areas, except for supplying equipment in those spaces.

Where possible they shall be run in such a manner as to preclude their being rendered unserviceable by heating of the bulkheads that may be caused by a fire in an adjacent space.

In respect of the prevention of fire damage to cables, special attention should be given to the protection of main cable routes for essential circuits as, for example, between machinery spaces and the navigation bridge area.

33. Cable installation methods in relation to electromagnetic interference

In order to avoid as much as possible the effects of unwanted electromagnetic interference, the indications given in I E C Publication 533 shall be taken into consideration. This might be of particular importance for the installation of cables in the vicinity of radio equipment and for the installation of cables belonging to sensitive electronic control and monitoring systems.

34. Cables for submersible permanently installed bilge-pumps

Cables and their connections to submersible, permanently installed bilge-pumps shall be capable of operating under a head of water equal to their distance below the bulkhead deck. The cables

shall be impervious-sheathed and armoured and shall be installed in continuous lengths from above the bulkhead to the motor terminals and shall enter the air bell from the bottom.

35. Mechanical protection

35.1 In situations where there could be a risk of mechanical damage, cables shall be enclosed in suitable conduits or casings, unless the cable covering (for example armour or sheath) provides adequate mechanical protection.

35.2 In situations where there would be an exceptional risk of mechanical damage, for example in holds, storage spaces, cargo spaces, etc., cables shall be protected by steel casing, trunking or conduits, even when armoured, if the ship's structure or attached parts do not afford sufficient protection for the cables.

35.3 Metal casing used for mechanical protection of cables shall be effectively protected against corrosion.

36. Earthing of metal coverings and of mechanical protection of cables (see Clause 4)

36.1 All metal coverings of cables shall be electrically connected to the metal hull of the ship at both ends, except in so far as the provisions given in Sub-clause 45.2.1 apply. Single-point earthing is admitted for final sub-circuits (at the supply end) and in those installations (control and instrumentation cables, mineral-insulated cables, intrinsically safe circuits, control circuits, etc.) where it is required for technical or security reasons, if any.

36.2 Earthing connections shall be carried out with conductors having cross-sectional areas (see Table I) related to the current ratings of the cables, or by equivalent means, such as metal clamps gripping the metal covering of the cable and connected to the metal hull of the ship.

The metal covering of cables may be earthed by means of glands intended for the purpose and so designed as to ensure an effective earth connection.

The glands shall be firmly attached to, and in effective electrical contact with, a metal structure earthed in accordance with these standards.

36.3 The electrical continuity of all metal coverings throughout the length of the cables, particularly at joints and tappings, shall be ensured.

36.4 The lead of lead-sheathed cables shall never be used as the sole means of earthing non-current-carrying parts (see Clause 5).

36.5 Metal casings, pipes and conduits or trunking shall be effectively earthed.

36.6 Conduits may be earthed by being screwed into a metal enclosure, or by nuts on both sides of the wall of a metallic enclosure, provided the surfaces in contact are clean and free from rust, scale or paint and that the enclosure is in accordance with these recommendations on earthing.

The connection shall be painted immediately after assembly in order to inhibit corrosion.

36.7 Cable sheaths and armour, and conduit, may be earthed by means of clamps or clips of corrosion-resistant metal making effective contact with sheath or armour and earthed metal.

36.8 All joints in metal conduits and ducts and in metallic sheath of cables used for earth continuity shall be soundly made and protected, where necessary, against corrosion.

37. Radius of bend

The internal radius of bend for the installation of cables shall be chosen according to the type of cable as recommended by the manufacturer and shall be not less than the figures given in Table II.

TABLE II

Bending radii

Cable construction		Overall diameter of cable (*D*)	Minimum internal bending radius (times overall diameter *D*)
Insulation	Outer covering		
Thermoplastic and elastomeric	Metal-sheathed armoured or braided	Any	6
	Other finishes	⩽ 25 mm > 25 mm	4 6
Mineral	Hard metal-sheathed	Any	6

38. Fixing

38.1 With the exception of cables for portable appliances and of those installed in pipes, conduits, trunkings or special casings, cables shall be fixed by means of clips, saddles or straps of suitable flame-retardant material, and having a surface area so large and shaped that the cables remain tight without their coverings being damaged.

38.2 The distances between supports shall be suitably chosen according to the type of cable and the probability of vibration, and shall not exceed 40 cm; for a horizontal cable-run where the cables are laid on cable supports in the form of tray plates, separate support brackets or hanger ladders, the spacing between the fixing points may be up to 90 cm, provided that there are supports with maximum spacing as specified above. This exemption shall not apply to cable-runs along weather decks, when the cable-run is arranged so that the cables can be subjected to forces by water washing over the deck. In the case of vertical runs, the distance between supports may be increased to 50 cm.

Note. — The above given distances between cable supports are not necessarily adequate for single-core cables.

38.3 The supports and the corresponding accessories shall be robust and shall be of corrosion-resistant material or suitably treated before erection to resist corrosion.

38.4 Cable clips or straps made from a material other than metal (such as polyamide, polyvinyl chloride, etc.) may be used. Requirements concerning the characteristics of the material are under consideration.

38.5 When cables are fixed by means of clips or straps referred to in Sub-clause 38.4 and these cables are not laid on top of horizontal cable trays or cable supports, suitable metal clips or saddles shall be added at regular distances (for example 1 m to 2 m) in order to prevent the release of cables during a fire. This also applies to the fixing of non-metallic conduits or pipes.

Note. — Sub-clause 38.5 does not necessarily apply in the case of cable-runs with only one or a few cables with small diameters for the connection of a luminaire, alarm transducer, etc.

39. Cables penetrating bulkheads and decks

39.1 Penetration of watertight decks and bulkheads shall be effected in a watertight manner. Either individual stuffed glands or boxes containing several cables and filled with a flame-retardant packing may be used for this purpose.

Whichever type of cable is used, the glands or boxes and the packing shall be such that the assembly complies with a gland-watertightness test.*

Note. — Care should be taken in choosing packings, to avoid cables being adversely affected (for example by high temperature arising from the pouring of the compound, chemical reaction, etc.).

39.2 Cables passing through decks shall be protected to a suitable height above the deck.

39.3 If cables have to pass through non-watertight bulkheads and generally through holes drilled in sheets of structural steel, these holes shall be fitted (if necessary in order to avoid damage to cables) with glands or bushings of any suitable material.

The choice of the materials for glands and bushings shall be such that there is no risk of corrosion or damage to the cables or to the ship's materials.

39.4 Vertical trunking for electrical cables shall be so constructed as not to afford passage of fire from one between-deck or compartment to another.

39.5 Penetration of decks and bulkheads, which are required to have some degree of fire integrity, shall be so effected as to ensure that the required degree of fire integrity is not impaired.

40. Cables in metallic pipes of conduits or trunking

40.1 When cables are installed in metal pipes, conduits or trunking, the following precautions shall be observed (see also Sub-clauses 31.6 and 31.7 for bunching of cables).

40.2 The pipes, conduits or trunking shall be suitably smooth on the interior and protected against corrosion.

40.3 The pipes of conduits or trunkings shall have their ends shaped or bushed in such a way as not to damage the cable covering.

* This test is under consideration.

40.4 The pipes or conduits or trunking shall have such internal dimensions and radii of bend as will permit the easy drawing in and out of the cables which they are to contain; the internal radii of bend shall be not less than those permitted for cables (see Clause 37) and for pipes exceeding 63 mm external diameter, not less than twice the external diameter of the pipe.

40.5 Pipes, conduits and trunking shall be so arranged that water cannot accumulate inside them (account being taken of possible condensation).

40.6 The space factor (ratio of the sum of the cross-sectional areas corresponding to the external diameters of the cables to the internal cross-sectional areas of the pipe or conduit or trunking) shall be not greater than 0.4.

40.7 If necessary, ventilating openings shall be provided, preferably at the highest and lowest points, so as to permit air circulation and to obviate the possibility of water accumulating at any part of the pipe or conduit run. This may be done only if the fire-risk will not be increased thereby.

40.8 Drawing of lead-sheathed cables without any covering into pipes, conduits or trunking is to be avoided.

40.9 If there is reason to fear that a pipe may break because of its length, appropriate expansion joints shall be provided. This may be the case when cable pipes are fitted along weather decks.

40.10 Where cables are to be drawn into pipes or conduits or trunking, draw boxes should be installed where necessary in order to ensure that the cables are not damaged during installation.

41. Cables in non-metallic pipes, conduits, trunking, ducts or cappings and casings

Cables may be installed in non-metallic pipes, conduits, trunking, ducts or cappings and casings either on surface or concealed behind ceilings or panelling, provided the following precautions are observed.

41.1 All cables or insulated wiring shall be flame-retardant.

41.2 If the fixing of capping is by means of screws they shall be of non-rusting material arranged so as not to damage the cables. The capping shall be readily accessible.

41.3 Non-metallic pipes, conduits, trunkings, ducts or cappings and casings shall be flame-retardant in accordance with I E C Publication 92-101.

41.4 Cables shall be fixed if necessary with clips as described in Clause 38.

41.5 The precautions recommended in Sub-clauses 31.6 and 31.7 should be observed also for installation in non-metallic casings.

42. Cables in store rooms

When it is necessary to install cables in store rooms, they are to be adequately protected against mechanical damage.

43. Cables in refrigeration spaces

43.1 Cables to be installed in refrigeration spaces shall include an impervious sheath and shall be protected against mechanical damage. Cables insulated or sheathed with polyvinyl chloride shall not be used in refrigerated spaces unless the relevant polyvinyl chloride compounds are appropriate to the low temperature expected.

If the armour is made of non-corrosion-resisting material, it shall be protected against corrosion by a moisture-resisting and low-temperature resisting covering.

43.2 Cables installed in refrigeration spaces shall not be covered by thermal insulation. They shall be secured to perforated tray plates (made for instance of galvanized steel) or other suitable supports which shall be so placed as to leave a space between the back of the plates and the face of the refrigeration space.

If a cable has thermoplastic or elastomeric extruded sheath, it may be placed directly on the face of the refrigeration space. The casual use of cables as a means of suspension shall be obviated by the provision of guards surrounding the cables.

Care shall be taken to avoid the possibility of galvanic action if the refrigeration space has an aluminium facing.

43.3 If the cables pass through the thermal insulation of the compartments, they shall do so at right angles, in tubes provided with entries of material protected against oxidation.

44. Tensile stress

44.1 Cables shall be so installed that the tensile stress applied to them either by reason of their own weight or for any other reason, is minimized.

44.2 These precautions are particularly important for cables of small cross-section and for cables on vertical runs, or in vertical pipes. These cables shall be suitably supported.

The maximum allowable value, in N/mm^2 of the mechanical stress on the conductor is under consideration.

45. Special precautions for single-core cables

45.1 *Electrodynamic forces*

In order to guard against the effects of electrodynamic forces developing on the occurrence of a short circuit, single-core cables shall be firmly fixed, using supports of strength adequate to withstand forces corresponding to the values of prospective short-circuit currents.

45.2 *Single-core cables for a.c. wiring*

A.C. wiring shall be carried out, as far as possible, in twin or multicore cables. When, however, it is necessary to use single-core cables for circuits rated in excess of 20 A, the following precautions should be observed.

45.2.1 The cables shall either be non-armoured or they shall be armoured with non-magnetic material. In order to avoid current loops, the metallic screen shall be earthed at one point only.

45.2.2 Conductors belonging to the same circuit shall be contained within the same pipe, conduit or trunking, or the clamps which fix them should include all the phases, unless they are made of non-magnetic material.

45.2.3 In the installing of two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits, or three-phase and neutral circuits, the cables shall as far as possible be in contact with one another.

In every case, the distance measured between the external covering of two adjacent cables shall be not greater than one cable diameter.

45.2.4 When single-core cables having a current rating greater than 250 A shall be installed near a steel bulkhead, the clearance between the cables and the bulkhead shall be at least 50 mm, unless the cables belonging to the same a.c. circuit are installed in trefoil formation.

45.2.5 Magnetic material shall not be used between single-core cables of a group. Where cables pass through steel plates, all the conductors of the same circuit shall pass through a plate or gland, so made that there is no magnetic material between the cables, and the clearance between the cables and the magnetic material shall be not less than 75 mm, unless the cables belonging to the same a.c. circuit are installed in trefoil formation.

45.2.6 In order to equalize to some degree the impedance of three-phase circuits of considerable length consisting of single-core cables of a conductor cross-section of 185 mm^2 or over, a transposition of the phases shall be effected at intervals not exceeding 15 m. Alternatively, the cables may be installed in trefoil formation.

The above precautions are, however, not necessary when the length of the run is less than 30 m.

45.2.7 In circuits involving several single-core cables in parallel per phase, all cables shall follow the same route and have the same cross-sectional area.

Further, the cables pertaining to the same phase shall be as far as practicable alternated with those of the other phases so that unequal division of the current is avoided. For instance, in the case of two cables per phase, correct dispositions are:

123321 or 123	and not 112233 or 123
321	123

46. Cable ends

46.1 Where mechanical clamps are not used, the ends of all cable conductors shall be fitted with soldering sockets or compression-type sockets of sufficient size to contain all the strands of the conductor. Where soldering is adopted, corrosive fluxes shall not be used.

46.2 All protective coverings should be removed for at least 13 mm from the ends of the insulation but not more than necessary. For mineral-insulated cables see Sub-clause 46.8.

46.3 Cables sockets and connecting terminals shall be of such design and dimensions that the maximum current likely to flow through them will not produce heat which would be injurious to the insulation. In general, the temperature shall not exceed that allowed for the cable in relation to the insulation.

46.4 In the case of cables with a supplementary insulating belt beneath the protective sheath, at the ends where the belt has been removed, an additional insulation shall be added at the points where the insulation of each core enters, or may enter, into contact with earthed metal.

46.5 The fixing of conductors in terminals, at joints and at tappings shall withstand the thermal and dynamic effects of short-circuit currents.

46.6 When required, cable ends shall be marked for identification.

46.7 The ends of mineral-insulated cables shall be prepared in accordance with the instructions issued by the manufacturers of these cables.

46.8 Cables not having a moisture-resistant insulation (for example mineral-insulated) shall have their ends effectively sealed against ingress of moisture.

47. Joints and tappings (branch circuit)

47.1 Cable runs shall not normally include joints. If, in the case of repair or sectional construction of the ship, a joint is necessary, the joint shall be of such a type that electrical continuity, insulation, mechanical strength and protection, earthing and fire-resisting or flame-retardant characteristics are not less than those required for the cables.

47.2 Tappings (branch circuits) shall be made in suitable boxes, of such design that the conductors remain suitably insulated and protected from atmospheric action, and fitted with terminals or busbars of dimensions appropriate to the current rating.

47.3 Joints and tappings shall be clearly marked to identify the cable(s) and core(s).

48. Joint boxes

48.1 Live parts shall be mounted on durable flame-retardant moisture-resistant material, of permanently high dielectric strength and high insulation resistance.

48.2 The live parts shall be so arranged by suitable spacing or shielding with flame-retardant insulating material, that short circuits cannot readily occur between conductors of different polarity or between conductors and earthed metal.

48.3 Joint boxes shall be made of flame-retardant material. Joint boxes shall be clearly identified defining their function and voltage.

48.4 Cables for safety voltages shall preferably not terminate in the same joint box as cables for higher voltages. Cables for voltages up to 1 kV shall not terminate in the same joint box as cables for higher voltages.

SECTION TEN — LIGHTNING CONDUCTORS

49. Ships requiring lightning conductors

Lightning conductors shall be fitted to each mast of all wooden, composite and steel ships having wooden masts or topmasts. They need not be fitted to steel masts in steel ships.

50. Size of conductors

In wooden and composite ships fitted with wooden masts, the lightning conductors shall be composed of continuous copper tape or rope having a section not less than 75 mm^2 which shall be riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 12 mm in diameter, projecting at least 150 mm above the top of the mast.

Where tape is used, the lower end of the tape shall terminate at the point at which the shrouds leave the mast, and shall be clamped to a copper rope having a section not less than 75 mm^2.

The copper rope shall be led down the shrouds and shall be securely clamped to a copper plate not less than 0.2 m^2 in area, fixed well below the lightload waterline and attached to the ship's side in such a manner that it shall remain immersed under all conditions of heel.

51. Wooden ships with steel masts

In wooden and composite ships fitted with steel masts, each mast shall be connected to a copper plate in accordance with Clause 50, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

52. Steel ships with wooden masts

In steel ships fitted with wooden masts, the lightning conductors shall be composed of copper tape or rope terminating in a spike, as set forth in Clause 50. At the lower end, this copper tape or rope shall be securely clamped to the nearest metal forming part of the hull of the ship.

53. Installation details

Lightning conductors shall be run as straight as possible, and sharp bends in the conductors shall be avoided. All clamps used shall be of brass or copper, preferably of the serrated contact type, and effectively locked. No connection shall be dependent on a soldered joint.

54. **Resistance**

The resistance of the lightning conductor measured between the masthead and the point on the earth plate or hull to which the lightning conductor is connected shall not exceed 0.02 Ω.

55. **Earthing in dry dock**

Suitable means shall be provided to enable ships when in dry dock, or on a slipway, to have their lightning conductors or steel hulls connected to an efficient earth on shore.

SECTION ELEVEN — TESTS OF COMPLETED INSTALLATION

56. **General**

After the electrical installation is complete and before the ship is placed in commission, the entire electrical equipment shall be tested. Such tests are intended to indicate the general condition of the installation at the time of completion; satisfactory test results do not in themselves necessarily ensure that the installation is satisfactory in all respects.

57. **Insulation-testing instruments**

It is recommended that insulation resistance be measured by self-contained instruments such as a direct-reading ohmmeter of the generator type, applying a voltage of at least 500 V. When an insulation test is made on a circuit incorporating capacitors of a total capacitance exceeding 2 μF, an insulation tester of the constant-voltage type shall be used in order to ensure that accurate test readings are obtained.

58. **Switchboards, section boards and distribution boards**

Before switchboards, section boards and distribution boards are put into service, their insulation resistance shall be not less than 1 MΩ when measured between each busbar and earth and between each insulated busbar and the busbar connected to the other pole or poles.

This test shall be made with all circuit-breakers and switches open and all fuselinks for pilot lamps, earth-fault indicating lamps, voltmeters, etc. removed and voltage coils temporarily disconnected.

59. **Lighting and power circuits**

A test for insulation resistance between all insulated poles and earth and, where practicable, between poles, shall be applied to all permanent wiring. It is not considered practicable to specify minimum values for insulation resistance as these will depend on climatic conditions at the time of the test, but a minimum value of 1 MΩ shall be obtainable under average conditions. The installation may be subdivided to any desired extent and appliances may be disconnected if initial tests give results lower than that indicated above.

60. **Generators**

All generating sets shall be run at rated load for a duration sufficient to demonstrate that commutation, electrical characteristics, overspeed trips, governing, range of excitation control, lubrication and absence of vibration are satisfactory. If sets are intended to operate in parallel, they shall be tested over a range of loading sufficient to demonstrate that load sharing and parallel operation are satisfactory. Voltage and speed regulation when load is suddenly thrown on and taken off shall be satisfactory (see IEC Publication 92-301: Equipment — Generators and Motors).

61. **Switchgear**

All switchgear shall be loaded as nearly as practicable to its working load in order to ensure that no overheating takes place owing to faulty connections or incorrect rating. Switches and circuit-breakers shall be operated on load to test their suitability and to demonstrate that the operation of over-current, under-voltage and reverse-current or reverse-power protective devices is electrically and mechanically satisfactory.

62. **Insulation resistance of generators and motors**

The insulation resistance of generators and motors shall be measured in warm condition immediately after running with normal load. The results obtained depend not only on the characteristics of the insulation materials and on the way in which they are applied, but also on the test conditions. It is therefore necessary that the obtained values be completed by recording these conditions, particularly those concerning the ambient temperature and the degree of humidity at the moment of the test.

63. **Lighting, heating and galley equipment**

All electrical devices and circuits shall be tested under operating conditions to ensure that they are suitable and satisfactory for their purposes.

64. **Voltage drop**

When it is considered that the voltage of a consuming device may be unduly low, tests shall be taken to verify that the allowable voltage drop has not been exceeded (see IEC Publication 92-201).

65. **Communication systems**

Each communication system shall be thoroughly tested to determine its suitability and to verify its specified functioning.

Particular attention shall be paid to the testing of the operation of the ship's essential electric communication systems, which include mechanical engine-order telegraphs, docking telegraphs, etc., and similar signal or alarm systems and fire-detection systems.

66. **Internal communication circuits**

Each circuit operating at a voltage of 55 V and above shall have an insulation resistance between conductors and between each conductor and earth of not less than 1 MΩ. For circuits operating at voltages below 55 V, the insulation shall be not less than one-third MΩ. If necessary, any or all appliances connected to the circuit may be disconnected while the test is being made.

67. **Earthing**

Tests shall be made to verify that all earth-continuity conductors and earthing leads are connected to the frames of apparatus and to the hull, and that in socket-outlets having earthing contacts, these are connected to earth.

68. **Requirements of international conventions on safety of life at sea**

Equipment installed to implement the international conventions in force shall be specially tested to ensure that all requirements have been met. Where operation is required to be maintained from emergency sources, correct functioning from and by such emergency supply shall be tested and the duration of emergency supply, where specified, shall also be tested.

69. **Tests after commissioning**

Constant maintenance of electrical equipment and circuits so that the physical condition of the installation is kept as nearly as possible in its initial integrity is of the utmost importance. It is strongly recommended that periodic testing and inspection be made of all equipment and cables for purpose of detecting in the early stages the possible development of physical deterioration or changes. The values of insulation resistance will afford useful indications as to whether or not the apparatus or circuit shall be kept in service, and timely action will tend to prevent failures in service.

The best indication as to whether deterioration has taken place is a comparison of the observed insulation resistance with previously recorded values. The change from the last measured value is far more significant than the absolute value of the resistance. For the comparison of values, it is also important to know the condition of the machine and climatic conditions at the time of testing, i.e. whether the machine or apparatus was hot or cold, the cooling-air temperature and whether the atmosphere was dry or humid.

Any significant facts such as "cables detached", "machine recently cleaned or blown out", "brushes lifted", etc., shall be recorded. Dirty, oily or wet conditions are frequently the cause of low insulation-resistance readings on cables or apparatus which are otherwise sound. Any large and abrupt decrease in insulation resistance shall be regarded as serious and worthy of further investigation and all defects thus discovered shall be made good without loss of time.

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