

INTERNATIONAL ELECTROTECHNICAL COMMISSION

(affiliated to the International Organization for Standardization - I.S.O.)

Publication 92

First Edition

1957

Recommendations for electrical installations in ships



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Central Office of the International Electrotechnical Commission

1 rue de Varembe

GENEVA, Switzerland

Withdrawn

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RECOMMENDATIONS
FOR
ELECTRICAL INSTALLATIONS
IN SHIPS

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Withdrawn

FOREWORD

- (1) The formal decisions or agreements of the IEC on technical matters, prepared by Technical Committees on which all the National Committees having a special interest therein are represented, express, as nearly as possible, an international consensus of opinion on the subjects dealt with.
- (2) They have the form of recommendations for international use and they are accepted by the National Committees in that sense.
- (3) In order to promote this international unification, the IEC expresses the wish that all National Committees having as yet no national rules, when preparing such rules, should use the IEC recommendations as the fundamental basis for these rules in so far as national conditions will permit.
- (4) The desirability is recognized of extending international agreement on these matters through an endeavour to harmonize national standardization rules with these recommendations in so far as national conditions will permit. The National Committees pledge their influence towards that end.

PREFACE

Delegates from twelve nations with interests in marine applications met at The Hague in June 1935 and decided that an international set of regulations relating to electrical installations in ships would be an advantage to the many interests involved. They fixed on the order of importance of the subjects to be dealt with as :-

- (a) Safety
- (b) Reliability
- (c) Simplicity
- (d) Ease of maintenance

The United Kingdom was asked to appoint the Chairman of Technical Committee No. 18 and the Netherlands was entrusted with the Secretariat.

Eight sub-committees were appointed and a further meeting was held in London in June 1936. Some progress had been made in the preparation of draft regulations when the work was interrupted by the Second World War.

At a meeting held in London in July 1948 immediately following the 1948 Convention on Safety of Life at Sea, it was resolved to make a fresh start and ten sub-committees, each based on a National Committee, were appointed to prepare preliminary drafts. These were subsequently combined by a Co-ordinating and Editing Committee into a first comprehensive draft of 25 chapters. Thus no further plenary session was held until the Jubilee IEC meeting at Philadelphia in September 1954, when comments which had been submitted by National Committees on the first comprehensive draft were considered.

It was then resolved that the decisions then taken should be embodied in a second draft and that in view of the length of time which had elapsed it was highly desirable to publish a 1st edition and to continue in the meantime with the consideration of matters still unresolved with a view to a 2nd edition.

The second draft was accordingly circulated to National Committees in August 1955 for approval under the Six Months' Rule. The following 16 countries voted in favour of publication but in every case, except one, comments were submitted.

Australia	Italy	Union of South Africa
Austria	Japan	Union of Soviet Socialist
Belgium	Netherlands	Republics
Denmark	Norway	United Kingdom
France	Sweden	United States of America
German Federal		Yugoslavia
Republic		

Against approval : Nil

The comments were submitted to the Chairman who recommended the acceptance of those which dealt with technical errors and inconsistencies. In the meantime the Committee had met at The Hague in December 1955 and had agreed certain amendments and had recommended that these be embodied in the 1st edition.

These matters were accordingly submitted to National Committees under the Two Months' Procedure and the following countries voted explicitly in favour of publication.

Austria	German Federal	Sweden
Belgium	Republic	Union of South Africa
Denmark	Italy	Union of Soviet Socialist
Finland	Netherlands	Republics
France	Norway	United Kingdom
	Poland	United States of America
		Yugoslavia

Against approval : Nil

The comments of a purely editorial nature which were submitted with the votes have been accepted. The remainder have, on the Authority of the Chairman of Technical Committee No. 18, been withheld for consideration for the second edition.

INTRODUCTION

The operating conditions in ships sailing the seven seas as far as they affect electrical appliances are the same regardless of where the ship is built. Except for variations in quality the materials used in the construction of electrical appliances are similar and are subject to the same natural laws. The characteristics of electric circuits and the behaviour of appliances are likewise predeterminable and follow the same fundamental laws irrespective of the country of origin. It is accordingly feasible to establish international standards to secure that degree of performance, reliability and safety which are essential for the well-being of crews and passengers alike and for the safe carriage of valuable cargoes.

It is for the fulfilment of these ends that the present recommendations have been formulated. Shipbuilders, electrical contractors and manufacturers engaged in the building of ships for the international market are faced at present with several codes of rules and regulations with which to comply although as already stated the conditions of service are identical. It is recognized that apparatus manufactured in various countries will inevitably differ in appearance and conception but for the same duties similar apparatus and materials will necessarily have to meet the same service conditions. This code has therefore been drafted in the form of "recommendations" thus allowing the fullest possible scope for the manufacturer to use his initiative in the design and development of his product and to use existing tools and patterns so far as they are suitable.

The preparatory work was divided between subcommittees on a National basis with instructions to prepare their drafts as far as practicable on the basis of existing National Standards and the published requirements of Classification Societies.

Complete and progressive cooperation between the naval architect, the shipbuilder, the owner and the designer and installer of the electrical installation are essential from the earliest stages right through to completion to ensure not only that all services required of the electrical appliances are met but that proper and suitable space and accommodation is provided for electric cables and appliances.

It is not intended to exclude new materials, appliances or methods or to discourage invention.

It cannot be too strongly emphasized that good technical design, the correct choice of apparatus, good and suitable materials and, above all, good workmanship are essential for a sound installation. The recommendations are not intended to take the place of a detailed specification or to instruct untrained persons.

NOTE 1:- As some problems could not be resolved satisfactorily without involving considerable delay this first edition has been published embodying the matters on which agreement has been reached. It is intended to proceed immediately with outstanding items which will be embodied in due course in the second edition.

NOTE 2:- All dimensions in these Recommendations are, in the first place, given in metric units; figures in brackets in British and American units are not exact numerical equivalents of the metric quantities, but are the nearest dimensions in practical use in the respective countries.

CHAPTER 1

DEFINITIONS

NOTE: The following definitions indicate the sense in which the expressions defined are used in this International Code. All other expressions are used in the sense defined in IEC Publication No.50 "International Electrotechnical Vocabulary"

GENERAL

1.01 - Accommodation spaces. Accommodation spaces are those used for public spaces, corridors, lavatories, cabins, offices, crew quarters, barber shops, isolated pantries and lockers, and similar spaces.

1.02 - Appropriate authority. A governmental body or a classification society with whose rules a ship is required to comply.

1.03 - Bond. To connect together non-current-carrying parts such as the armour or lead sheath of consecutive or adjacent lengths of cable or the metal plates, for example, comprising the walls etc. of a radio-receiving room in order to ensure continuity of electrical connection or to equalize the potential between the parts concerned.

1.04 - Cargo spaces. Cargo spaces are all spaces used for cargo (including cargo oil-tanks) and trunks to such spaces.

1.05 - Dangerous spaces in tankers. Dangerous spaces in a tanker are all those where inflammable or explosive vapour or gas may normally be expected to accumulate, such as :-

- cargo oil tanks
- cofferdams
- cargo pump-rooms
- spaces immediately above tank crowns (e.g. between decks)
- spaces adjacent to a tank not extended from a side to the other side of the ship
- zones within 3m (or 10 ft.) of any oil tank outlet or vapour outlet.

1.06 - Degree, electrical. $1/360$ of a complete electrical cycle.

NOTE: If P = number of poles of an alternator, the number of electrical cycles in a revolution is $P/2$, so that 360 mechanical degrees correspond to $P/2 \times 360$ electrical degrees, or one mechanical degree = $P/2$ electrical degrees.

1.07 - Diversity factor (Demand factor). The ratio of the estimated consumption of a group of power-consuming appliances under their normal working conditions to the sum of their normal ratings.

1.08 - Insulation, double. A portable appliance which is partially or wholly metal-clad is said to have double insulation when every live part, besides being mounted upon or surrounded by a suitable insulation support with adequate creepage path, is so separated from the external casing by means of insulating material or adequate spacing that no live part can be touched, no accessible metal part can become live in the event of failure of the said insulating support.

1.09 - Live conductor or circuit. A conductor or circuit electrically connected to a source of potential difference between it and earth.

1.10 - Machinery spaces. Machinery spaces include all spaces used for propelling, auxiliary or refrigeration machinery, boilers, pumps, workshops, generators, ventilating and air-conditioning machinery, oil-filling stations and similar spaces, and trunks to such spaces.

1.11 - Prospective current. The r.m.s. value of the alternating component of an alternating current, or the value of the direct current which would flow in a circuit, on the occurrence of a short-circuit immediately on the supply side of the fuse or other protective device, under given voltage conditions and supply network conditions.

1.12 - Public spaces. Public spaces are those portions of the accommodation which are used for halls, dining-rooms, lounges, and similar permanently enclosed spaces.

1.13 - Sea-going ship. Any ship not exclusively employed in the navigation of rivers or inland waters.

1.14 - Service spaces. Service spaces are those used for galleys, main pantries, stores (except isolated pantries and lockers), mail and specie rooms, and similar spaces and trunks to such spaces.

1.15 - Services, essential. Services essential to the safety of life, and to the navigation and propulsion of a ship.

1.16 - Tanker. A cargo ship constructed (or adapted) and intended for the carriage in bulk of liquid cargoes having a flash-point (closed test) of 65 °C or less.

1.17 - Voltage, extra low. Applies to systems in which the voltage does not normally exceed 30 volts r.m.s., a.c. or 50 volts d.c.

APPARATUS

1.18 - Accessory. Any device, other than a lighting fitting (see Clause 1.64) associated with the wiring and current-using appliances of an installation; for example, a switch, a fuse, a plug, a socket-outlet, a lampholder, or a ceiling rose.

CABLES

1.19 - Bunched. Cables are said to be bunched when two or more are contained within a single conduit, duct or groove, or, if not enclosed, are not separated from each other.

1.20 - Cable. A length of insulated single conductor (solid or stranded), or of two or more such conductors, each provided with its own insulation, which are laid up together. The insulated conductor or conductors may or may not be provided with an overall mechanical protective covering.

1.21 - Core (of a cable). The conductor with its insulation but not including any mechanical protective covering.

1.22 - Earth-continuity conductor. The wire, cable, or other conductor connecting to each other or to the earthing-lead (see Clause 1.23) those parts which have to be earthed. It may be in whole or in part the metal conduit or the metal sheath of the cables, or the special continuity wire of a cable or flexible cord incorporating such a wire.

1.23 - Earthing-lead. The conductor by which the connection is made to the hull of the ship.

1.24 - Flexible cable. A cable containing one or more cores each formed of a group of wires. The diameters of the cores and of the wires being sufficiently small to afford flexibility.

1.25 - Flexible cord. A flexible cable in which the cross-sectional area of each conductor does not exceed 4 mm^2 (or 0.007 in^2).

1.26 - Length of lay. The axial length of one complete turn of the helix formed by the core, in the case of a cable, or of the wire, in the case of a stranded conductor.

DISTRIBUTION

1.27 - Branch circuit. A branch circuit is that portion of a wiring system extending beyond the final automatic overload protective device of the circuit.

1.28 - Earthed (U.S. Grounded). Connected to the general mass of the hull of the ship in such a manner as will ensure at all times an immediate discharge of electrical energy without danger.

NOTE: A conductor is said to be "solidly-earthed" when it is electrically connected to the hull without a fuse-link, switch, circuit-breaker, resistor, or impedance, in the earth connection.

1.29 - Earth (U.S. Ground). A connection to the general mass of the hull of the ship.

1.30 - Hull return. The use of the hull or other permanently-earthed structure to conduct the current on one pole of the system.
(See also 1.32).

1.31 - Point (in wiring). Any termination of the fixed wiring intended for the attachment of a lighting fitting or of a device for connecting to the supply a current-using appliance.

1.32 - Systems of distribution.

- (a) Hull-return system. A system in which insulated conductors are provided for connection to one pole of the supply, the hull of the ship or other permanently-earthed structure being used for effecting connections to the other pole.
- (b) 2-wire system. A d.c. or single-phase a.c. system comprising two conductors only, between which the load is connected.

- (c) 3-wire system. A d.c. or single-phase a.c. system comprising two conductors and a middle or neutral wire, the supply being taken from the two outer conductors at full voltage or from the middle wire and either outer conductor, the middle wire carrying only the difference-current and being usually connected to earth.
- (d) 3-phase 3-wire system. A system comprising three conductors connected to a 3-phase supply.
- (e) 3-phase 4-wire system. A system comprising four conductors, of which three are connected to a three-phase supply and the fourth to a neutral point in the sources of supply.

ENCLOSURES

1.33 - Drip-proof apparatus. Apparatus which is so constructed that when it is inclined in any direction at an angle not exceeding 15° any drop of liquid or a solid particle falling vertically cannot enter the apparatus either directly or by striking and running along a surface.

1.34 - Flameproof enclosure. An enclosure for electrical apparatus which will withstand an internal explosion of the inflammable gas or vapour which may enter or which may originate inside the enclosure without suffering damage and without communicating the internal flame to the external inflammable gas or vapour for which it is designed, through any joints or structural openings in the enclosure.

NOTE 1: The term "flameproof" is synonymous with the term "explosion-proof" as used in the U.S.A. for the class of apparatus dealt with in this Code.

NOTE 2: A flameproof enclosure in accordance with the foregoing definition will not necessarily or ordinarily be watertight, dust-tight or pressure-tight.

1.35 - Immersible apparatus (submersible apparatus). Apparatus so constructed that it will operate successfully when submerged in water under specified conditions of pressure and time.

1.36 - Watertight apparatus. Apparatus having all live parts enclosed by a cover or covers so constructed as to exclude water under prescribed conditions (see Clause 3.13).

1.37 - Weatherproof apparatus. Apparatus having all live parts enclosed by a cover or covers so constructed as to exclude rain, snow and external splashings.

MACHINES

1.38 - Generator. Stabilized shunt-wound. A d.c. generator in which the field excitation is derived from a winding connected in parallel with the armature circuit and from a series winding of such proportion that equalizers are not required when the generator operates in parallel with similar generators.

1.39 - Generator. Service. A generator, which may be an emergency generator, primarily intended to supply the ship's service system.

MATERIALS

1.40 - Non-inflammable material. Material which, when tested in a prescribed manner, does not glow or carry flame and is neither charred nor scorched in excess of the permitted amount.

1.41 - Flame retarding material. Flame retarding materials and structures have such fire-resisting properties that they will not convey flame or continue to burn for longer times than specified in the appropriate flame test.

1.42 - Incombustible material. Material which neither burns nor gives off inflammable vapours in sufficient quantity to ignite at a pilot flame when heated to approximately 750 °C. Any other material is a "combustible material".

RADIO

1.43 - Radio direction-finding. Radiolocation in which only the direction of a station is determined by means of its emissions.

1.44 - Radio-receiving room. A room in which radio reception is carried out for the purpose of the operation and control of the radio-communication and radionavigation services.

1.45 - Radiolocation. Determination of a position or of a direction by means of the constant-velocity or rectilinear propagation properties of Hertzian waves.

SWITCHGEAR

1.46 - Distribution board (U.S. Panel Board). An assemblage of parts including one or more fuses (or other overload-protective devices) arranged for the distribution of electrical energy to final sub-circuits rated at not more than 16 amperes.

1.47 - Section board (U.S. Distribution Panel). A switchboard for controlling the supply of electrical energy to other section boards, distribution boards, or devices normally consuming more than 16 amperes. A section board may obtain its supply from a main switchboard, an emergency switchboard, or another section board.

1.48 - Switch-and-fuse. A unit comprising a switch and one or more fuses, the fuses not being carried on the moving part of the switch.

1.49 - Switch. Isolating. A switch for making and breaking, non-automatically, a circuit, when it is not on load.

1.50 - Switchboard. The assembly of switchgear with or without instruments designed to operate and control electrical circuits.

1.51 - Switchboard. Dead-front. A switchboard having no exposed live parts.

1.52 - Switchboard. Open-type. A switchboard in which the current-carrying parts of the switchgear are not provided with protecting covers.

1.53 - Switchgear. A general term applicable to apparatus for the operation, regulation and control of electrical installations.

FUSES

1.54 - Fuse. A device which, by the fusion of one or more of its specially designed and proportioned components, opens the circuit in which it is inserted when the current through it exceeds a certain value for a sufficient time. The fuse comprises all the parts that form the complete device.

1.55 - Fuse. Filled. A fuse in which the arc is extinguished in a powdered, granular or fibrous substance.

1.56 - Fuse. Indicating. A fuse which incorporates a device to indicate that the fuse has opened the circuit.

1.57 - Fuse. Non-interchangeable. A fuse so designed and proportioned as to accept only a fuse-link of a predetermined type of a rated current not exceeding a certain value and provided with a means to make it impossible for the user accidentally to insert a fuse-link of any higher rated current.

1.58 - Fuse with enclosed element. (Commonly known as enclosed fuse). A fuse in which the fuse-element is totally enclosed in such a way that at the time of operation it cannot produce any external effect harmful to persons or objects in the immediate vicinity when it operates within its rated breaking capacity.

1.59 - Fuse with semi-enclosed element. (Commonly known as semi-enclosed fuse).

A fuse in which the development of an arc, the release of gas and the ejection of flame or metal particles caused by the operation, are so controlled as to limit danger to persons.

1.60 - Fuse-link. The part of a fuse which requires replacement after the fuse has operated and before the fuse is put back into service and which comprises the fuse-element and a container, if any, and which is capable of being connected to the fuse-carrier contacts, if any, or otherwise of engaging directly with the fuse-base contacts.

1.61 - Fuse-link. Cartridge. (Abbreviation: Cartridge).

A fuse-link having an insulating enclosure, usually cylindrical, provided at its ends with metal contacts, the shape of which varies according to the type of fuse.

1.62 - Fuse-switch. A switch the moving part of which carries one or more fuse-links. (See also Switch-and-fuse).

LAMPS, LIGHTING

1.63 - Electric discharge lamp. An electric lamp comprising a hermetically sealed bulb or tube containing gas and/or metal intended to be vaporized during operation, and fitted with electrodes between which a discharge of electricity takes place, the useful light being emitted from, and/or excited by, the discharge through the gas or vapour.

1.64 - Fitting. Lighting. A device for supporting or containing a lamp or lamps, together with any holder, shade or reflector.

CHAPTER 2

GRAPHICAL SYMBOLS

2.01 - I.E.C. Publications Nos. 35 and 42. Graphical symbols for the representation of electrical installations on shipboard should be in accordance with those given in I.E.C. Publication No. 35 "Graphical symbols for heavy current systems", and Publication No. 42 "Graphical symbols for weak current systems".

2.02 - Additional graphical symbols. Additional symbols used should be based as far as possible on circuit elements depicted in Publications Nos. 35 and 42. Where doubt may arise, the use of simple circles or squares containing letters or numbers referring to an explanatory table is recommended.

NOTE: "Heavy current systems" refer to power and lighting systems; "weak current systems" refer to telephone and communication systems.

001 002 003 004 005 006

CHAPTER 3

GENERAL REQUIREMENTS AND CONDITIONS

NOTE: This chapter contains conditions and requirements which :

- (a) are common to all apparatus and installations, or
- (b) are primarily the concern of the shipbuilder or installation contractor.

GENERAL

3.01 - Workmanship. Good workmanship is an essential requirement for compliance with this code.

3.02 - Applicability of the code to a.c. and d.c. Except where a specific statement is made to the contrary, all recommendations made in the present code are equally applicable to a.c. and d.c. installations.

3.03 - Acceptance of substitutes or alternatives. Where in this Code any special type of appliance, construction or arrangement is specified the use of any other appliance, construction or arrangement is admissible provided it is not less effective and reliable.

3.04 - Provision for maximum load. All conductors, switchgear, and accessories, should be of such size as to be capable of carrying, without their respective ratings being exceeded, the maximum current which can normally flow through them.

3.05 - Addition to an installation. An addition, temporary or permanent, should not be made to the authorized load of an existing installation until it has been definitely ascertained that the current-carrying capacity and the condition of the existing accessories, conductors, switchgear, etc., affected, are adequate for the increased load.

3.06 - Ambient-air and cooling-water temperatures. For the purpose of this code the following temperatures are assumed :

- (a) For all ocean-going ships a temperature of ambient-air or cooling-water as follows :
 - 1. Primary cooling water supply 30°C.
 - 2. Ambient air temperature of 45°C for all equipment (except machines) located in machinery spaces (engine rooms - boiler rooms), and for all equipment located in galleys, or on weather decks.
Ambient air temperature of 50°C for machines located in machinery spaces.
 - 3. Ambient air temperature of 40°C for equipment located in all other spaces.
- (b) For vessels such as coasters, ferries and harbour craft intended solely for use in Northern or Southern waters outside the tropical belt an ambient air temperature of 40°C and a temperature of primary cooling-water supply of 25°C.
- (c) Where adverse and unusual ambients are expected to exist, special consideration should be given.

NOTE: In the above clause the term "ambient air" refers to the air responsible for dissipating the heat losses from the equipment or cables concerned.
This ambient air may be in the case of a ventilated machine the air drawn in by the cooling vent or in the case of cables the comparatively still air surrounding the cables.

DESIGN OF EQUIPMENT

3.07 - Construction. In general all electrical equipment should be constructed of durable, flame-retarding, non-hygroscopic materials which are not subject to deterioration in the atmospheres and at the temperatures to which it is likely to be exposed.

3.08 - Electrical clearances. The distances between live parts of different potential, and between live parts and the case of other earthed metal, whether across surfaces or in air, should be adequate for the working voltage under the conditions of installation, and should be not less than those specified for marine service by an appropriate authority.

Any parts of the case in proximity to the arc from line contactors, circuit-breakers or other contacts liable to arc, or in proximity to re-wirable fuses of non-filled type, should be lined with arc-resisting insulating material.

3.09 - Insulation. Insulating materials and insulated windings should be resistant to moisture, sea-air and oil vapour unless special precautions are taken to protect insulants against such agencies.

3.10 - Accessibility. The design of equipment should provide for accessibility to all parts requiring inspection.

3.11 - Enclosures. Enclosing cases for electrical equipment, junction-boxes, joint-boxes, etc. should be of adequate mechanical strength and rigidity to protect the contents and to prevent distortion under all likely conditions of service.

3.12 - Cable entries. Cable glands or bushings, or fittings for screwed conduit, should be provided according to the way in which the cables enter the apparatus. Enclosures of drip-proof apparatus should not have cable-entries on the top, unless the cable-entry plate and/or cable-attachment is so made as to exclude water.

3.13 - Watertight apparatus. Watertight apparatus is totally enclosed apparatus so constructed that leakage to the interior does not occur when a stream of water from a hose not less than 25 mm (or 1 in.) in diameter, under a head of 4 - 10 m (or 13 - 35 ft) is played on the apparatus from any direction for a period of 15 minutes from a distance of 2 m (or 6 ft) for a head of 4 m (or 13 ft), or 3 m (or 10 ft) for a head of 10 m (or 33 ft), or a proportionate distance for intermediate values of head. Nevertheless for rotating machines leakage which may occur round the shaft is considered admissible provided water is prevented from entering the oil reservoir and provision is made for automatic drainage. During the test the hose nozzle should be adjusted to give as far as practicable a solid stream at the enclosure. The apparatus should be provided with a check valve for drainage or a tapped hole at the lowest part of the frame which will serve for the application of a drain pipe or drain plug.

INSTALLATION LOCATION AND PROJECTION OF EQUIPMENT

3.14 - Position in ship. Compartments in which electrical apparatus is placed should be well ventilated. Except where the installation of flameproof apparatus is permitted in this code, electrical apparatus should not be installed where inflammable gases are liable to accumulate.

3.15 - Compartments. Compartments in which engine-driven generating sets are placed should be constructed of metal or other incombustible material. Compartments or cupboards containing switchboards should be constructed of or lined with incombustible material.

3.16 - Mechanical protection. Electrical equipment should be so placed that as far as practicable it is not exposed to risk of mechanical injury.

3.17 - Protection from water, steam and oil. Electrical equipment should be so selected and located that it is unaffected by any water, steam, oil and oil fumes to which it is likely to be exposed.

3.18 - Protection from drip. Where necessary open-type electrical equipment should be provided with a canopy or other suitable means to protect the current-carrying parts and their insulation from drip.

3.19 - Protection against electric shock. Where the voltage to earth exceeds or can exceed under fault conditions 250 V d.c. or 150 V a.c. all electrical equipment should be so enclosed that live parts cannot inadvertently be touched, unless its construction is such as to render this precaution unnecessary.

3.20 - Axes of rotation. Every horizontal rotating machine should preferably be installed with the shaft in the fore-and-aft direction. Where a machine is installed athwartships it should be ensured that the design of the bearings and the arrangements for lubrication are satisfactory to withstand the rolling encountered in heavy weather. The manufacturer should be informed when a machine for installation athwartships is ordered.

3.21 - Precautions against vibration and mechanical shock. Screws and nuts securing current-carrying parts should be effectively locked so that they cannot work loose by vibration. Machines and apparatus should be unaffected by vibration and shock likely to arise under normal service.

3.22 - Space for maintenance. Electrical apparatus should be so installed that sufficient space is available for maintenance; for example, it should be possible to remove the armature or rotor of a rotating machine.

3.23 - Adjacent material. Unprotected woodwork or readily combustible material should not be placed within 30 cm (or 12 in.) measured horizontally, or 120 cm (or 4 ft.) measured vertically, from any open-type electrical apparatus.

3.24 - Handrails. Open-type machines, open-type switchboards or open-type control gear should be provided with handrails where these are necessary to obviate risk of injury to persons.

3.25 - Inclination of ship. Machines and apparatus should operate satisfactorily under all conditions with the ship at the following inclinations from the normal :

Transversely : 15° Rolling: up to $22^{\circ} 30'$

Longitudinally: 10° or for ships of length exceeding 150 m (or 500 ft.)
: 5° .

Emergency units should in addition operate satisfactorily with the ship at a permanent list up to 30° .

3.26 - Magnetic compasses. Conductors and equipment should be placed at such a distance from the compass or should be so screened that the interfering external magnetic field is negligible (deviation less than 0.5°), even when circuits are switched on and off.

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CHAPTER 4

EARTHING OF NON-CURRENT-CARRYING PARTS

4.01 - Parts for which earthing is recommended. Unless specifically exempted in the following exemptions (i) - (vii) all metal of the electrical installation, other than current-carrying parts, should be earthed.

Exemptions.

- (i) Lamp caps.
- (ii) Shades, reflectors, and guards, supported on lampholders or lighting fittings of non-conducting material.
- (iii) 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 in such a way that in normal use they cannot become live or come into contact with earthed parts.
- (iv) Portable appliances having double insulation (see definition, Chapter 1), provided that the appliances conform with recognized safety requirements.
- (v) Bearing housings which are insulated in order to prevent circulation of current in the bearings.
- (vi) Clips for fluorescent lighting tubes.
- (vii) Apparatus supplied at extra low voltage (see 1.17).

4.02 - Earthing connections. All exposed metal of the electrical installation not exempted in Clause 4.01, unless its method of installation ensures positive earthing, should be permanently connected to earth.

Every earthing connection should be of copper or other non-magnetic corrosion-resistant material and should be securely installed and protected against damage. The nominal cross-sectional area of every copper earthing connection should be not less than is recommended in Clauses 4.03 - 4.04 below. Every other earthing connection should have a resistance not greater than that of the corresponding copper conductor.

4.03 - Earthing connections in insulated systems. Every copper earthing connection in a system where the earth connection normally carries no current should be of the minimum cross-sectional area given in (a), (b) or (c) below, as appropriate.

- (a) Every bare copper earthing-lead should be of the same cross-sectional area as the associated current-carrying conductors, subject to a minimum of 1.5 mm^2 (or 0.0023 in^2).
Where, however, the cross-sectional area of the associated current-carrying conductors exceeds 6 mm^2 (or 0.01 in^2), the cross-sectional area of the copper earthing-lead need not exceed 4 mm^2 (or 0.007 in^2) per 50 A normal current flowing in the associated current-carrying conductors. In no circumstances need the size of the copper earthing-lead exceed 64 mm^2 (or 0.1 in^2).

- (b) Every insulated copper earth-continuity conductor which forms part of a multi-core cable or is a cable similar to the associated current-carrying cable or cables, should have a nominal cross-sectional area equal to that of the associated current-carrying conductors.
- (c) Metal of portable appliances other than current-carrying parts and parts exempted in Clause 4.01 should be earthed by means of an earth-continuity conductor in the flexible cable or cord, which complies with (b) above, and which is earthed through the associated plug and socket-outlet.
Plugs and socket-outlets should be so designed that the earthing-pin of the plug and the earth contact-tube of the socket-outlet make contact before, and break contact after, the associated current-carrying pins and contact-tubes.

4.04 - Earthing connections in earthed distribution systems. The earthing connections in systems where one pole is earthed but in which the earthing connection does not normally carry current, should conform with the recommendations of Clause 4.03, except that no upper limit of 64 mm^2 (or 0.1 in^2) is recommended.

4.05 - Connections to the ship's structure. Every connection to the ship's structure should be made in an accessible position, and should be secured by a brass screw of diameter not less than 6 mm (or $1/4 \text{ in.}$) which should be used for this purpose only. Where a cable socket is not used, the wires should be formed into a hook and placed under a tinned brass washer. In all circumstances care should be taken to ensure bright metallic surfaces at the contact areas immediately before the nut is tightened.

CHAPTER 5

APPLICATION OF DIVERSITY (DEMAND) FACTORS

5.01 - Final sub-circuits. The cables of final sub-circuits should be rated in accordance with the total connected load.

5.02 - Circuits other than final sub-circuits. Circuits supplying two or more final sub-circuits should be rated in accordance with the total connected load subject where justified to the application of a diversity (demand) factor in accordance with Clauses 5.03 - 5.04 below.

Where spare ways are provided on a section or distribution board, an allowance for future increase in load should be added to the total connected load, before the application of any diversity factor. The allowance should be calculated on the assumption that each spare circuit requires not less than 50 % of the average load on each of the active circuits of corresponding rating.

5.03 - Application of diversity (demand) factors. A diversity (demand) factor may be applied to the calculation of the cross-sectional area of conductors and to the rating of switchgear provided that the known or anticipated conditions in a particular part of an installation are suitable for the application of diversity.

5.04 - Motive-power circuits - general. The diversity factor should be determined according to circumstances. The normal full-load should be determined on the basis of the name-plate ratings of motors; if these ratings are not available the ratings given in the following Table 5.1 (page 18) should be assumed. In the assessment of diversity factors of a.c. motive power circuits account should be taken of the relatively small decrease in current consumption of partially-loaded motors.

Table 5.1

Approximate full-load currents of d.c. and 3-phase a.c. motors

Mechanical output of motors	D.C.		3-phase A.C.	
	Approx. full-load current		Approx. full-load current at line voltage shown	
	at 110 volts	at 220 volts	at 220 volts	at 440 volts
kW	amp.	amp.	amp.	amp.
1	4.2	2.1	-	1.5
1½	7.6	3.8	1.7	2.5
2	13	6.7	2.8	4.2
3	24	12	4.9	6.1
4	35	18	7.0	8.1
5	46	23	9.3	9.8
7½	56	28	12	15
10	81	41	17	18
12½	108	54	21	22
15	133	67	25	27
20	157	79	31	35
25	206	103	41	44
30	256	128	51	53
35	304	152	61	61
40	354	177	71	70
45	402	201	81	79
50	455	228	91	88
60	503	252	101	105
70	602	301	121	122
80	696	348	141	139
90	798	399	160	155
100	891	446	180	172
125	992	496	200	212
150	1200	600	246	252
	-	736	292	

Note: It should be understood that the figures in the Table are not necessarily those of particular motors, but are average values and that particular values will be affected by speed, efficiency and power factor, e.g. the efficiencies of slower (and larger) machines are necessarily somewhat less than those of faster (and smaller) models having the same output rating. The figures may, however, be taken as sufficiently near the individual currents for the purpose of these Recommendations.

5.05 - Winch circuits. For winches the diversity factor should be not less than the values in the following Table 5.II.

Table 5.II

DIVERSITY FACTORS FOR WINCH CABLES

Number of motors	Current to be provided for	
two	plus	100 % full-load of the larger motor 30 % full-load of the second motor
	or	65 % of the combined full-load if the motors are of equal size
three	plus	100 % full-load of the largest motor 25 % full-load of each of the remaining motors
	or	50 % of the combined full-load, if the motors are of equal size
four	plus	100 % full-load of the largest motor 20 % full-load of each of the remaining motors
	or	40 % of the combined full-load, if the motors are of equal size
five	plus	100 % full-load of the largest motor 20 % full-load of each of the remaining motors
	or	36 % of the combined full-load if the motors are of equal size
six or more		33 % of the combined full-load of the motors

CHAPTER 6

D.C. SHIP'S SERVICE SYSTEM OF SUPPLY

6.01 - Normal distribution systems. The following systems are considered as standard :

- (a) 2-wire insulated
- (b) Single-wire with hull return
- (c) 2-wire with one pole earthed
- (d) 3-wire with middle wire earthed but without hull return
- (e) 3-wire with middle wire earthed and with hull return.

NOTE: In accordance with Chapter II Regulation 24(a) of the Convention for Safety of Life at Sea, Systems (b) and (e) are not allowed in passenger ships.

6.02 - Voltages. The following schedule gives recommended and maximum system voltages :

Application	Recommended voltages	Maximum voltages
Power	110, 220	500
Cooking	110, 220	250
Heating	110, 220	250
Lighting	24, 110, 220	250
Internal Communications	6, 12, 24, 50, 60, 110, 220	250

For small installations of less than 2 kW, 24 V. is recommended.

For internal communications 24 V. is specially recommended.

NOTE 1: The voltages stated are the mean voltages at the consuming devices.

NOTE 2: For tankers, see Chapter 23

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CHAPTER 7

A.C. SHIP'S SERVICE SYSTEM OF SUPPLY

7.01 - Normal distribution systems. The following systems are considered as standard :

Single phase

- (a) 2-wire insulated
- (b) 2-wire with mid-point earthed for lighting and socket outlets
- (c) 2-wire with one pole earthed
- (d) 3-wire with mid-wire insulated
- (e) 3-wire with mid-wire earthed but without hull return.

Three phase

- (f) 3-wire insulated
- (g) 3-wire with neutral earthed
- (h) 4-wire with neutral earthed but without hull return.

7.02 - Voltages. The following schedule gives recommended and maximum system voltages :

Application	Recommended voltages	Maximum voltages
Power, Cooking and Heating	Single Phase 110 127 220 250 Three Phase 220 380 440	Single Phase 250 Three Phase 500
Lighting	Single Phase 110 127 220* 250*	Single Phase 250*
Socket Outlets	Single Phase 110 127 250*	Single Phase 250*
Internal Communications	Single Phase 12 24 42 48 110 220 250	Single Phase 250

* provided the voltage to earth does not exceed 150

NOTE 1: The voltages stated are the mean voltages at the consuming devices.

NOTE 2: For tankers, see Chapter 23.

7.03 - Frequency. The standard frequency should be 50 or 60 c/s.

CHAPTER 8

SWITCHGEAR, SWITCHBOARDS, SECTION BOARDS AND DISTRIBUTION BOARDS

MAIN AND EMERGENCY SWITCHBOARDS

8.01 - Position of switchboards. An unobstructed space not less than 0.9 m (or 3 ft.) wide should be left in front of switchboards. Pipes should as far as possible not be installed directly above, or in front of or behind switchboards. If such placing is unavoidable the pipes should be without joints on these positions (see also Clause 3.18).

8.02 - Gangways. If fuses or parts which require maintenance are mounted at the rear of a switchboard, a gangway not less than 0.6 m (or 2 ft.) in width should be provided, but where beams or struts occur a width of 0.5 m (or 1 ft. 6 in.) is admissible.

8.03 - Mats. Where there is any risk of accidental contact with live parts during operation, inspection, or maintenance, a rubber insulating-mat or a grating of impregnated wood should be provided.

8.04 - Insulating materials. Insulating material used in the construction of switchboards should be durable and mechanically strong, flame-retarding, non-absorbent, and of satisfactory insulating qualities.

8.05 - Bus-bars, etc. Bus-bars and their connections should be of copper unless otherwise specified. All connections should be so made as to inhibit corrosion as far as possible. Bus-bars should be strengthened to withstand mechanical stresses which may arise from short-circuits. The cross-section of current-carrying parts should be such that the maximum permissible temperature-rise is not exceeded when the parts are carrying their full-load current. The maximum permissible temperature-rise for bare conductors is 40 Centigrade degrees.

8.06 - Rating of equalizer connections. The current rating of each equalizer connector and equalizer switch should be not less than half the rated full-load current of the generator. The current rating of equalizer bus-bars should be not less than half the rated full-load current of the largest generator in the group.

8.07 - Distinguishing colours for d.c. Bare current-carrying parts of differing polarity should be clearly marked with distinguishing colours. The following colours are recommended for d.c. switchboards:

Red for positive pole
Blue for negative pole
White for middle wire
Black for earth connections.

The equalizer connection should be marked by white bands in addition to the appropriate colour as given above.

8.08 - Distinguishing colours for a.c. Bare current-carrying parts of different phases should be clearly marked with distinguishing colours. The following colours are recommended for a.c. switchboards :

Green	for phase 1
Yellow	for phase 2
Brown or violet	for phase 3
Grey	for insulated neutral
Black	for earth connections.

8.09 - Construction of switchboards. Switchboards should be of solid and durable construction and should be capable of withstanding mechanical stresses which may arise from short-circuits. For voltages between poles, or to earth, above 150 V. a.c. or 250 V. d.c. dead-front switchboards should always be used. Live parts should be mounted at such a distance from, or shielded from, parts of opposite polarity and earthed metal, in such a way that an arc cannot be maintained and that the length of creepage path is adequate. Where live parts on a switchboard are adjacent to a gangway, an insulated handrail should be provided to prevent accidental contact with live parts. (See also Clause 3.19). All the parts, including connections, should be readily accessible for inspection, maintenance, or replacement. (See also Clause 3.09).

8.10 - Labels. All apparatus, instruments, and operating handles, should be provided with labels of durable flame-retarding material, bearing clear and indelible indications. The rating of fuses and settings of adjustable protective devices should be indicated.

8.11 - Cable-entries, etc. Cable-entries, ducts and conduits, should comply with the recommendations of Chapter 11. Cable-entries should be suitable for the method of construction of the switchboard etc., to which the cable is connected.

8.12 - Measuring instruments for d.c. generators. For generators not operated in parallel, at least one voltmeter and one ammeter should be provided for every generator. For parallel operation, one ammeter should be provided for each generator and one voltmeter with a changeover switch for measuring the generator and bus-bar voltages. For compound-wound generators fitted with equalizer connections, the ammeter should be connected to the pole opposite to that connected to the series winding of the generator. For 3-wire generators, the ammeter should be located between the equalizer connection and the generator. For 3-wire systems supplied by a 3-wire generator or by a balancing booster an ammeter should be connected to each outer pole of each balancing generator and a voltmeter between each pole of the bus-bars and the middle wire.

8.13 - Measuring instruments for a.c. generators. For generators not operated in parallel each generator should be provided with at least one voltmeter with a changeover switch for measuring the voltage of each phase, one ammeter with an ammeter switch to enable the current in each phase to be read or an ammeter in each phase and for generators above 50 kVA a wattmeter, together with a frequency meter, unless there are other effective means of indicating the revolutions per minute. For parallel operation there should be provided in addition a synchronizing device with changeover switch for connecting it to any generator. The provision of an ammeter in the exciter circuit of each generator is recommended.

8.14 - Instrument scales. The upper limit of the scale of every volt-meter should be not less than 120 % of the normal voltage of the circuit, and the scale should be provided with a red line to indicate normal voltage.

The upper limit of the scale of every ammeter and wattmeter should be not less than 150 % of the normal rating of the circuit in which it is installed. The scale should be provided with a red line indicating the normal full-load. Ammeters for use with d.c. generators and kW meters for use with a.c. generators which may be operated in parallel should be capable of indicating reverse current or power respectively.

8.15 - Earth indication. For insulated systems, the main switchboard should be provided with means to indicate the state of insulation from earth of the system.

8.16 - Overcurrent protection of a.c. and d.c. generators. All a.c. and d.c. generator circuits should be provided with overcurrent protection in each insulated pole. The following protective gear should be provided as a minimum :

(a) For generators not arranged to operate in parallel:

a circuit-breaker arranged to open simultaneously all insulated poles or a multi-pole linked switch with a fuse in each insulated pole

(b) For generators arranged to operate in parallel :

a circuit-breaker arranged to open simultaneously all insulated poles and, for generators rated above 150 kVA, provided with reverse power protection with a time lag to prevent the tripping of circuit breakers during switching operations and mechanical shocks. The reverse power relays should be adjustable to the circumstances of reverse power between the limits of 3 % and 15 % of full-load that may be expected.

NOTE: The reverse power protection should be adequate to deal effectively with reverse power conditions emanating from the ship's network (e.g. cargo winches).

(c) In place of overcurrent protection to an earthed conductor or middle wire of a 3-wire d.c. system or 4-wire a.c. system :

an alarm relay arranged to operate when the current in the middle wire exceeds the permitted value.

8.17 - Tripping of non-essential load. Where the load includes essential services consideration should be given to an arrangement which will automatically trip sufficient non-essential load when the total load exceeds the connected generator capacity. If required this load shedding may be accomplished in or more stages.

8.18 - Additional requirements for d.c. generators. In addition to the protective gear specified in Clause 8.16 the following should be provided for generators arranged to operate in parallel :

- (a) Where an equalizer connection is in use, the reverse current protection should be provided in the pole opposite to that in which the series winding is connected.
- (b) For level-compounded generators an equalizer switch for each generator, so interlocked that it closes before, and opens after, the main contacts of the circuit-breaker with which it is associated.
- (c) In 3-wire systems a switch in the connection to the middle wire, so interlocked with the generator switch or circuit-breaker connected to the "outers" as to operate simultaneously with them.

8.19 - Protection of outgoing a.c. or d.c. circuits. For all outgoing circuits the following should be provided as a minimum :

- (a) Overcurrent and short circuit protection in each insulated pole.
- (b) An automatic circuit-breaker so constructed as to open simultaneously all insulated poles or alternatively for currents of 300 A or less, a linked switch with fuses.

Overcurrent protection should be provided in such a manner that effective selectivity or discrimination is achieved as far as is practicable.

8.20 - Protection of meters, pilot-lamps, etc. Protection should be provided where practicable for voltmeters, voltage coils of measuring instruments, earth-indicating lamps and pilot-lamps together with their connecting leads. Fuses used for this purpose should be placed as near as practicable to the tapping from the supply.

8.21 - Breaking capacity of fuses and circuit-breakers. Circuit-breakers and fuses should be suitable for operation at the maximum short-circuit current which can pass through them.

8.22 - Moving parts of circuit-breakers, etc. Circuit-breakers and contactors in outgoing circuits if practicable should be so installed that their moving parts and corresponding relays are not live when the circuit-breaker etc. is in the "off" position, so that inspection, adjustment, and replacement of parts is facilitated. In essential circuits, the provision of isolating-switches is recommended.

8.23 - Testing. Before installation, switchboards complete with all components should pass the following tests. A high-voltage test should be carried out on all switching and control apparatus for systems of 60 - 500 volts at an alternating voltage of 1000 plus twice the rated voltage at 25 - 60 c/s for one minute applied between current-carrying parts connected together and earth, and between current-carrying parts of opposite polarity. For systems of 60 volts or less the test should be at 500 volts for one minute.

Immediately after the high-voltage tests, the insulation-resistance between current-carrying parts connected together and earth and

between current-carrying parts of opposite polarity should be not less than one megohm when tested with a d.c. voltage of not less than 500 V.

NOTE: Instruments and other ancillary apparatus may be disconnected during the high-voltage test and tested separately in accordance with the requirements of the appropriate standards.

SECTION AND DISTRIBUTION BOARDS

8.24 - Section and distribution boards. Section and distribution boards should comply with the recommendations made for main switch-boards in Clauses 8.01 to 8.23 above as far as they apply. Matters particularly applicable to section and distribution boards are dealt with in the following Clauses 8.25 - 8.27.

8.25 - Position of section and distribution boards. Section and distribution boards should be accessible to authorized personnel at all times. They should be suitable enclosed unless they are installed in a cupboard or compartment to which only authorized personnel can have access. Section and distribution boards should be so placed that the maximum permissible temperature is not exceeded.

8.26 - Enclosure of section and distribution boards. The enclosure should be of non-hygroscopic and non-inflammable material, and in accommodation spaces where the enclosure is surrounded by inflammable material a layer of non-hygroscopic non-inflammable material which is also thermal-insulating should be provided. The enclosure should be of adequate mechanical strength and should be so constructed that it can be opened only by authorized personnel. Protection should be provided against accidental contact with live parts.

NOTE: Enclosures should preferably not be placed in contact with or should not be surrounded by inflammable material.

8.27 - Construction of section and distribution boards. All connections should be readily accessible when the protecting covers, if any, are removed. The replacement of parts should not necessitate the removal of the case or the disconnection of cables. If the bus-bars of any section or distribution board carry "through" load, the size of the bus-bars should be of the same rating as the supply cable.

SWITCHGEAR AND FUSEGEAR

8.28 - Circuit-breakers, fuses and switches - general.

- (a) The temperature of current-carrying parts will be dealt with in a later edition when IEC temperature limits have been established.
- (b) The temperature limits of release, blowout, contactor-operating and relay coils which are left in circuit continuously at rated voltage and/or current should satisfy the requirements of an appropriate authority.
- (c) Where the current to be interrupted by a switch or circuit-breaker is of such magnitude as to cause damage to the contacts, suitable arrangements should be made for the ready renewal of the damaged parts.

- (d) The handles and operating mechanism of switches and circuit-breakers should be mechanically strong, and should be so designed and arranged that the hand of the operator, when using the device, cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit-breaker or the blowing of an adjacent fuse. If switches are enclosed, their handles should not operate through unprotected slots.
- (e) Metal cases should be well clear of live parts, and where switches are required to operate at voltages exceeding 125 V, and are rated for currents exceeding 6 A, any parts of metal cases which are adjacent to arcing contacts should be lined with incombustible insulating material.
- (f) Each circuit-opening device should be so constructed and arranged that when placed in the "off" position it cannot accidentally move sufficiently to close the circuit.
- (g) The means of fixing current-carrying parts should be independent from the means of making electrical connections thereto.
- (h) Every circuit-breaker and fuse is to have an interrupting capacity not less than the prospective short-circuit current at the point in the circuit at which it is installed unless it is backed up by a fuse of suitable category of duty or by a circuit-breaker with an instantaneous trip-setting of not more than 90 % of the interrupting capacity of the device protected. The back-up protection is to have an interrupting capacity not less than the prospective short-circuit current at the point where it is installed. Reports of tests to establish the maximum interrupting capacity of circuit-breakers are to be submitted for consideration when required.

8.29 - Prospective current. In the absence of precise data, the following values of short circuit contributions may be assumed in estimating the total prospective current :-

D.C. generators	- 10 times rated full load current
D.C. motors	- 6 times " " " "
A.C. generators	- (with amortisseur windings) -
	10 times rated full load current
A.C. generators	- (without amortisseur windings) -
	6 times rated full load current
A.C. motors	- 3 times rated full load current.

8.30 - Circuit-breakers.

- (a) The over-current releases of circuit-breakers for generators and circuits with "preference" tripping should be adjustable.
- (b) Where reverse power or reverse-current protection is provided the device should operate at not more than 15 % of the rated full-load current or nominal rating (kW) of the generator with rated voltage across the voltage coil, at any permissible temperature within the range. A fall of 50 % in the applied voltage should not render the reverse-current mechanism inoperative, although it may alter the amount of reverse current required to open the breaker.

- (c) Every circuit-breaker rated at more than 16 A should be of the free-handle type.
- (d) Every circuit-breaker should be so constructed that, irrespective of the method of tripping and the conditions of load, it will when operated break the circuit effectively and without undue arcing.

8.31 - Switches.

- (a) Every switch should be capable of breaking a load current 50 % in excess of its rated current at rated voltage, 100 times for switches of rating not exceeding 60 A, and 10 times for larger switches, and be capable of being put into service subsequently without injurious overheating. For d.c. the test load should be resistive and for a.c. it should have a power factor 0.3. The stated number of interruptions should be carried out at equal intervals within one hour.
- (b) Every switch should have the contacts and hinges dowed or otherwise locked to prevent movement out of alignment by rotation on the panel.

8.32 - Fuses.

- (a) Every fuse should comply as far as possible with I.E.C. Publication No.66 : "IEC Specification for fuses for voltages not exceeding 1000 V for a.c. and d.c."
- (b) No fuse should be installed in a circuit where the prospective short circuit current is in excess of the rated breaking capacity of the fuse. In determining the prospective short circuit current consideration should be given to the contributions from running motors, which should be added to the short circuit current supplied by the generators.
- (c) When fuses are employed to secure overcurrent protection for multiphase motor circuits an overload device should also be fitted for motors over 0.5 kW which will open the circuit if the current in any phase becomes excessive due to the opening of only one phase by the blowing of a fuse.

CHAPTER 9

DISTRIBUTION

Attention is drawn to the requirements of the International Convention for Safety of Life at Sea 1948.

9.01 - Methods of distribution. Current-consuming appliances should be connected to either :

- (a) a main switchboard, or
- (b) an emergency switchboard, or
- (c) a section board, or
- (d) a distribution board.

9.02 - Ring-main or looped circuits. One or more section or distribution-boards may be connected together to one cable so that this forms a continuous circuit or a ring-main. Such a cable or ring-main should be formed of conductors having an equal cross-section throughout. If a cable supplies several section or distribution-boards in such a manner that the cable is looped from board to board, the cable may be interrupted if required at each board without the provision of additional protection. In such a case the bus-bars of the intermediate distribution-boards should be of sufficient cross-section to carry the full cable load.

9.03 - Balance of circuits for 3-wire d.c. systems. Current-consuming appliances connected between an outer conductor and the middle wire should be grouped in such a way that under normal condition the load on the two halves of the system is balanced within as far as possible 15 % at the individual distribution- and section-boards as well as at the main switchboard.

9.04 - Balance of loads on 3- or 4-wire a.c. systems. For a.c. 3- or 4-wire systems the current-consuming appliances should be so grouped in the final sub-circuits that the load on each phase will under normal conditions be balanced as far as possible within 15 % at the individual distribution- and section-boards as well as at the main switchboard.

9.05 - D.C. single-wire systems with hull return. In d.c. single-wire distribution systems with hull return, it is recommended that all final sub-circuits for lighting should consist of 2 insulated wires, the hull return then being achieved by connecting one of the bus-bars of the distribution-board from which they originate with the hull.

9.06 - Final sub-circuits. A final sub-circuit having a current rating not exceeding 16 A may supply any number of lighting points up to the following maxima :

for 24 V and 48 V : 10 points, for 110 V : 14 points,
for 220 V : 18 points.

In cornice-lighting, panel-lighting and electric signs, where lamp-holders are grouped in close proximity to each other and are connected to the circuit without flexible cords, more than the number of holders specified above may, if desired, be connected to a final sub-circuit, provided that the maximum operating current in each sub-circuit does not exceed 10 A.

9.07 - Socket-outlets in lighting systems. Socket-outlets for portable lamps, small domestic appliances and small heaters, may be grouped together as for lighting points (see 9.06). Motors rated at 0.2 kW or less may be connected to a lighting circuit.

9.08 - Precautions against fire. If a ship is divided into fire zones, at least two separate feeders for lighting should be provided in each zone, one of which may be the feeder for the emergency lighting. The feeders for the different zones should be so arranged that in the event of fire in one zone, the supply to the other zone remains as far as possible unimpaired.

9.09 - Lighting circuits in machinery spaces, passengers' accommodations, etc. In machinery spaces and large galleys, and on passenger ships in the following spaces accessible to passengers :

Corridors,
Stairways leading to boat-decks,
Saloons,
Emigrant spaces,

lamps should be supplied from more than one circuit one of which may be the emergency circuit in such a way that failure of any one circuit does not reduce the lighting to an inadequate level.

9.10 - Cargo-space lighting. The lighting of groups of lamps in cargo-spaces should be controlled by multi-pole switches situated outside these spaces and accessible only to authorized personnel.

9.11 - Radio installations, including direction-finding and similar equipment. It is recommended that where practicable radio installations should be supplied from a separate way on the main switchboard or emergency switchboard.

9.12 - Navigation lights. The masthead, side and stern lights should be connected separately to a distribution board which is reserved for this purpose and which is directly connected to the main or emergency switchboard.

The distribution board should be placed in an accessible position under the control of the officer of the watch.

Each navigation light should be protected by a fuse and a double-pole switch, or alternatively by a double-pole circuit-breaker fitted on the distribution-board referred to above.

Each navigation light should be provided with an automatic indicator which gives aural and/or visual warning in the event of extinction of the light. If an aural device is used it should be connected to a separate source of supply, for example a primary or accumulator (storage) battery. If a visual signal is used which is connected in series with the navigation light, means should be provided to prevent the extinction of the navigation light owing to the failure of the visual signal.

Provision should be made on the bridge for the navigation lights to be transferred to an alternative circuit.

9.13 - Final sub-circuits for motors, etc. A separate final sub-circuit should be provided for every motor engaged on an essential service and for every motor rated at 1.25 kW or more.

9.14 - Steering-gear. Where the steering-gear is operated by two independent mechanisms and electric power is used for the operation of both, the power should be supplied by two sets of cables both from the main switchboard.

The feeders should be separated throughout their length as widely as practicable so that in this respect the continuity of operation of the steering-gear is ensured.

Where electric or electro-hydraulic power is employed for the operation of steering-gear, the failure of supply to the steering-gear motor (or motors) should be indicated to the principal propulsion control station and at the main-steering position.

Apart from the alarm, only short-circuit protection should be provided on steering-gear circuits.

9.15 - Ventilation systems. All power ventilation, except for machinery spaces, should be fitted with master controls so that all fans may be stopped from either of two control stations which should be situated as far apart as practicable. It should be possible to operate one of the master controls for power ventilation serving machinery spaces from a position outside the machinery space. The switchboard feeding power to the equipment for these systems may be considered as the second control point.

NOTE: This clause does not apply to small fans connected to lighting circuits (see Clause 9.07).

9.16 - Fuel-oil pumps. Emergency stop-control for motor-driven fuel-oil pumps should be provided at a readily accessible point outside machinery spaces, or means should be provided for the motors to be stopped automatically by the operation of the corresponding fire-extinguishing system.

9.17 - Fire-pump motors. Feeders supplying fire-pump motors should be so arranged that a fire occurring in any one compartment or fire zone will not put out of action all the fire-pumps.

9.18 - Sprinkler fire-extinguisher systems. The supply to sea-water pumps, air compressors and automatic alarms should be fed through the emergency switchboard by a feeder reserved for this purpose. No switch should be installed in the circuit other than that at the switchboard; this switch should be clearly labelled and should be permanently closed in all normal circumstances.

9.19 - Overboard discharges from motor-driven pumps. Motor-driven pumps designed to discharge above the light-load line and in way of life-boat launching should be provided with emergency switches installed in locked boxes having covers of glass or the equivalent, conveniently located outside machinery spaces.

9.20 - Loading- and unloading-equipment. Should it be decided for practical reasons to connect apparatus required when the ship is under way to the same supply as apparatus not so required, means should be provided for the isolation of the latter.

9.21 - Submersible permanently installed bilge-pumps.

- (a) The motors of submersible, permanently installed, bilge-pumps should be connected to the emergency switchboard.

- (b) Cables and their connections to such pumps should be capable of operating under a head of water equal to their distance below the bulkhead deck. The cables should be lead-sheathed and armoured and should be installed in continuous lengths from above the bulkhead deck to the motor terminals and should enter the air bell from the bottom. Cables of other types but equivalent performance may be used as an alternative to lead-sheathed and armoured cables.
- (c) Under all circumstances it should be possible to start the motor of a submersible, permanently installed, bilge-pump from a convenient point above the bulkhead deck. If an additional local starter is provided at the motor, the circuit should be arranged to provide for the disconnection of all control wires therefrom at the starter installed on deck.

9.22 - Heating. Each heater should be connected to a separate final sub-circuit except that up to 10 small heaters of aggregate current rating not exceeding 16 A may be connected to a single final sub-circuit.

9.23 - Heating and cooking appliances. It should be possible to disconnect every fixed heating or cooking appliance by a switch breaking all insulated poles simultaneously.

9.24 - Junction-boxes. Junction-boxes should be easily accessible and if mounted behind panels their position should be indicated by a label on the relevant panel.

9.25 - Overcurrent protection. Except as prohibited in Clause 9.13, overcurrent protection should be provided at section and distribution boards for each insulated conductor supplied therefrom, and also where a cable is connected to another cable of lower current rating. In all circumstances cables should be protected against short-circuit, in such a way that effective discrimination is secured and the damage is restricted as much as possible.

The current setting of the circuit-breaker should be such that the circuit-breaker trips within a safe time, when the current exceeds the current rating of the conductor.

In order to ensure the discrimination of overcurrent protective devices, it is recommended that the number of such devices placed between the bus-bars of the main board and current-using appliances should be limited. The limit should be 4 for motive-power circuits and 5 for lighting or heating circuits.

9.26 - Protective devices. Protection may be provided by fuses of approved construction, by circuit-breakers provided with overcurrent relays or by circuit-breakers backed up by fuses. Circuit-breakers should open all poles of the supply simultaneously.

Every protective device should be rated for the greatest possible short-circuit current which can pass through it. Circuit-breakers and fuses protecting supply cables for motors may be designed to allow excess current to pass during the normal accelerating period of the motor. No protective device rated at less than 5 A need be installed.

NOTE: It is admissible to short-circuit the adjacent overcurrent releases during this accelerating period.

9.27 - Protection of lighting circuits. Each lighting circuit should be protected by an overcurrent device rated at not more than 16 A.

Protective devices of circuits in which socket-outlets are included should not exceed the rating of the connected socket-outlets.

9.28 - Pilot lamps. A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided that the protective device of the main circuit is rated at not more than 25 A. (See also Clause 8.20).

9.29 - Emergency supply. Where an emergency supply is required, this should comply with the recommendations of the International Convention on Safety of Life at Sea 1948.

An indicator should be provided which indicates when the emergency system is being supplied by the battery. This indicator should preferably be mounted on the main switchboard.

9.30 - Shore connections. Where arrangements are made for the supply of electricity from a source on shore or elsewhere, a suitable connection-box should be installed in a position on the ship convenient for the reception of portable cables from the external source and containing terminals of ample size and suitable shape to facilitate a satisfactory connection.

The circuit should be provided with a multi-pole switch of size appropriate to the current rating of the fixed cable which connects the connection-box to the main switchboard.

Where it is intended to supply electricity through the connection-box to outside loads, a fuse should be fitted on each live pole at the switchboard, or the multi-pole switch specified above may be replaced by a circuit-breaker.

The fixed cable should be provided with an indicator, preferably at the main switchboard, in order to show when the cable is energized.

For three-phase systems with earthed neutral an earth terminal should be provided for connecting the hull to the shore earth.

The connection-box should be provided with means for checking the polarity, if d.c., and the phase sequence, if 3-phase a.c., of the incoming supply in relation to the ship's system.

At the connection-box a notice should be provided giving full information of the system of supply and the normal voltage (and frequency, if a.c.) of the ship's system as well as the requirements for carrying out the connection.

9.31 - Protection of transformers. For transformers above 1 kVA the primary windings should be individually protected in each phase against overcurrents by means of circuit-breakers or fuses.

CHAPTER 10

CABLES, CONSTRUCTION AND TESTS

NOTE : 1 This chapter is not unanimously approved but is published for guidance.
Re-drafting of this chapter is under consideration.

NOTE : 2 The constructions and tests, contained in Chapter 10 are not intended to replace or supplement constructions or tests which are approved by a National Authority for use in ships.

Section 1 - General matters and definitions.

10.01 - Specified values and actual values. In this chapter, the term "specified values" means values which must be met in tests; the term "actual values" is applied to the results of measurements made in accordance with the tests specified.

10.02 - Values specified by these Recommendations and values specified by the Purchaser. When in these Recommendations reference is made to "specified values", it should be understood throughout that these refer to the values specified by the purchaser of the cables (or by the appropriate Authority).

10.03 - Interchangeability of cables.

NOTE: It is under consideration to publish in a later edition a reference table for the choice of interchangeable cables, among those provided for in the most important existing National Standards.

10.04 - Classification of cables.

(a) in relation to voltage rating

The cables dealt with in this chapter are distinguished by the following classes of insulation:

(a1)	for a rated voltage of	110 V
(a2)	" " "	250 V
(a3)	" " "	660 V
(a4)	" " "	1100 V
(a5)	" " "	3300 V
(a6)	" " "	6600 V

(b) in relation to construction

See Sections 6, 7 and 8 of this chapter.

Section 2 - Conductors

10.05 - Characteristics of the metal. The conductors should be composed of copper of conductivity at least equal to 98% of that of standard annealed copper as defined in Publication No. 28 (1925) of the International Electrotechnical Commission; the resistivity of the copper should thus not be higher than $0.01759 \text{ ohm-mm}^2/\text{m}$ ($6.9252 \times 10^{-7} \text{ ohm-in.}$) at 20°C .

The other properties of the copper should be in conformity with the same publication.

10.06 - Formation of conductors. The conductors should be circular and regular in form. For multi-core cables, shaped conductors are admissible when the insulating material permits, and provided that the cross-section is free from sharp projections and other defects liable to damage the insulation.

For cables intended for fixed wiring, circular conductors other than mineral insulated cables should be composed of strands (all of the same diameter) not less in number than Table 10.V (Page 61) requires.

10.07 - Tinning of copper wires. For rubber-insulated cables, the wires forming the conductor should be coated with pure tin or tin alloy.

10.08 - Cross-sectional area of conductors. The cross-sectional area should be checked by a measurement of electrical resistance, in accordance with Clause 10.51 of these Recommendations.

Section 3 - Insulation

10.09 - Types of insulation. The present chapter applies only to cables using the following types of insulation :

- (a) rubber (natural or synthetic)
- (b) varnished cambric
- (c) mineral

The characteristics which the insulation should possess are indicated in Clauses 10.54, 10.55, 10.56 and 10.57.

NOTE: Other types of insulation which may be used in ships are not dealt with in the present edition of the Recommendations, but may be added in a later edition: for example, asbestos with varnished cambric.

10.10 - Rubber-insulation.

(a) Properties of the rubber

The rubber insulation should be composed of a mix of natural or synthetic rubber satisfying the tests specified in Clause 10.55. Polychloroprene is included in the term "synthetic rubber".

(b) Application of the insulation to the conductor

The insulation may be formed by one or more layers of rubber of equal or different quality (including polychloroprene compound but not pure rubber). The use of a single layer is permissible only when it is applied by extrusion. The layers should be bonded together and the insulation should be close-fitting, but not adherent to the copper conductor.

The manufacturer has the right to apply a rubberized tape to the exterior of the rubber insulation.

(c) Thickness of insulation

The actual mean thickness of insulation (determined in accordance with Clause 10.43) should be not less than the thickness specified by the purchaser, and not less than the values given in the following tables :

Table 10.VI Page 62	- cables for a rated voltage of 250 V.
Table 10.VII Page 63	- " " " " " " 660 V.
Table 10.VIII Page 64	- cables for propulsion and communications.

For twin or multi-core cables, the insulation of the conductors may be completed by a belt of rubber insulation, the mean thickness of which (determined in accordance with Clause 10.43) should be not less than the values given in Table 10.IX Page 65.

10.11 - Varnished-cambric insulation.

(a) Properties of the varnished-cambric

Varnished-cambric insulation should be composed of varnished-cambric tapes satisfying the following requirements:

(i) the textile base of the varnished-cambric should be an even weave of cotton or (if explicitly agreed by manufacturer and cable purchaser) of rayon or silk.

(ii) the tape should be well varnished on both sides with an insulating varnish of such quality that the finished cables satisfy the tests specified in the present chapter:

(iii) the nominal thickness of a varnished-cambric tape should be not more than 0.30 mm (or 0.012 in.); the actual thickness should not differ from the nominal thickness by more than $\pm 20\%$;

(iv) the samples of tape, removed from the cables, should satisfy the physical tests specified in Clause 10.56.

(b) Application of the varnished-cambric insulation to the conductors.

Several varnished-cambric tapes (the nominal thickness of which may be the same or different) should be tightly wound helically round the conductor in such a way as to form a uniform layer of insulation, in which the gaps between tapes should not be greater than the thickness of a single tape. Each tape should be coated with a viscous insulating compound to serve as a lubricant. This insulating compound should not harden with age and should not exercise any harmful action on the varnished cambric, on the conductors or on the protective sheath.

(c) Separator

The manufacturer may insert a separator either between the conductor and the insulation, or over the insulation, or in both places. The separator should be composed of tapes of cellophane, oiled paper, woven cotton or glass, or a braid.

(d) Thickness of the varnished-cambric insulation

The actual thickness of insulation at any point, determined in accordance with Clause 10.44 should be not less than the thickness specified by the purchaser, and not less than the values given in Table 10.X Page 66.

When a separator is used, its thickness may be taken into account when the actual thickness of the insulation is determined.

10.12 - Mineral insulation.

(a) Properties of mineral insulation

The mineral insulation should be composed of a powdered mineral substance so compressed as to satisfy the tests specified in the present chapter.

The nature of the substance is left to the choice of the manufacturer.

(b) Thickness of mineral insulation

The mean thickness of the insulation, in the case of a magnesium-based insulant, should be not less than the values given in Table 10.XVI Page 72.

Section 4 - Protective coverings

10.13 - Types of constituent elements of protective coverings. The protective sheath of a cable consists of one or more constituent elements, according to the relevant specification given in Sections 6, 7 and 8 of this chapter.

The types of constituent elements provided for in the present edition of these recommendations are:

(a) non-metallic elements

- impregnated textile braid (Clause 10.15)
- bedding for armour and metal braid (Clause 10.16)
- paint for armour (Clause 10.18)
- polychloroprene sheath (Clause 10.21)
- rubber sheath (Clause 10.22)

(b) metallic elements

- lead or lead-alloy sheath (Clause 10.14)
- metal braid (Clause 10.17)
- galvanized-steel-wire armour (Clause 10.19)
- steel tape armour (Clause 10.20)
- copper sheath (Clause 10.23)

NOTE: Other types of constituent element which may be used for the protective coverings of ships' cables are not provided for in the present edition of these recommendations, but may be added in a later edition.

10.14 - Lead or lead-alloy sheath.

(a) Properties of the metal

The sheath should be composed, according to the circumstances (see 10.14 (b)) of lead or of an approved lead-alloy. "Lead" is defined as lead containing not more than 0.1 per cent of other metals, among which the zinc content should not exceed 0.002% and bismuth 0.05%.

"Approved alloys" are those given in the following table. Other types of alloy are admissible only subject to specific agreement between the manufacturer and the purchaser:

T a b l e 10.I

Type of alloy	Composition (percentage by weight)								Pure lead
	Tin		Antimony		Cadmium		Copper		
	min.	max.	min.	max.	min.	max.	min.	max.	
No. 1	1.8	2.2	—	—	—	—	—	—	The remainder
No. 2	—	—	0.7	0.95	—	—	—	—	
No. 3	0.35	0.45	0.15	0.25	—	—	—	—	
No. 4	0.35	0.45	—	—	0.12	0.18	—	—	
No. 5	—	—	—	—	—	—	0.04	0.08	

(b) Application of the sheath to the cables

The use of "lead" as distinct from lead alloy for cable sheaths is admissible only where there is a further protective covering. (See Table 10.XI Page 67). The sheath should remain close-fitting and truly concentric to the cable, and should be free from cracks and other defects.

(c) Thickness of sheath

The mean actual thickness of the sheath, determined in accordance with Clause 10.46, should be not less than the thickness specified by the purchaser and not less than the values given in Tables 10.XI and 10.XII (Pages 67-68).

Table 10.XI Page 67 applies when the lead or lead-alloy sheath has an outer layer of other protective covering (textile braid is not considered to be a protective covering for the purposes of this clause).

Table 10.XII Page 68 applies when the lead-alloy sheath is bare, that is to say without further external protection (textile braid is not considered to be a protective covering for the purposes of this clause).

10.15 - Impregnated textile braid. The textile braid should be of cotton or hemp, or other equivalent textile fibre, and should be of a strength suitable for the size of the cable. It should be effectively impregnated with a compound which is resistant to moisture, flame-retarding and free from deleterious action upon the various materials constituting the cable.

10.16 - Bedding for armour and metal braid.(a) Bedding for metal braid

(i) A cotton tape wound with an overlap of at least 30 %, or two tapes so wound that the second overlaps by at least 20 % the two edges of the first. The tape may be of glass or other fibre in place of cotton, and should be impregnated or treated with a non-hygroscopic material which is flame-retarding.

(ii) Tapes of polychloroprene may be used in place of textile tapes.

An impregnated textile braid (Clause 10.15) is also a suitable bedding for metal braid.

(iii) When the bedding is applied over a lead sheath, the latter should first be coated with bitumen or other waterproofing material.

(iv) When the metal braid is applied over a protective sheath of polychloroprene (Clause 10.21), no bedding is necessary. A sheath of polychloroprene, even when thinner than that prescribed in Table 10.XI Page 62 may thus be used in place of the above-named covering as a bedding for metal-braid armour.

(b) Bedding for steel wire or tape armour

A wound spiral or braid of jute threads or other textile material (including glass fibre), or a woven tape of the above-mentioned materials, should form a continuous layer of a thickness (measured on the finished cable) equal to at least half the diameter of the steel wires (Table 10.XIV Page 70).

10.17 - Metal braid. The braid should be formed of zinc-coated (galvanized) steel wires of a nominal diameter not less than the value given in Table 10.XIII Page 69.

On special request, the braid may be formed of copper, copper-alloy, or aluminium-alloy wires, whose surface should be protected against corrosion (for example by tinning, galvanizing, or other suitable method). The diameters of such wires should be not less than the values given in Table 10.XIII Page 69.

The braid should be an even weave, free from broken wires and close fitting on the cable. Its density should be such that the weight of the braid is at least 90 per cent of the weight of a tube formed of the same metal, of internal diameter equal to that of the braid, and of thickness equal to the diameter of one of the wires forming the braid.

The metal braid should always be protected externally by a suitable compound (Clause 10.18).

10.18 - Paint for armour and metal braid. The paint should form an effective and durable means of protecting the wires against rust and other chemical corrosion under the conditions of installation normally encountered on shipboard.

10.19 - Galvanized-steel-wire armour. Annealed steel wire should be used and the nominal diameter of the wires should be not less than that specified by the purchaser, and not less than the values given in Table 10.XIV Page 70.

On special request by the purchaser or manufacturer, use may be made of shaped wires in place of circular wires: in that event the mean thickness of the shaped wire should be not less than that specified by the purchaser and not less than the values given in Table 10.XIV Page 70.

On special request, instead of steel wires, wires of the same dimensions but of non-magnetic metal may be used.

The wires should be applied over the bedding so as to form a uniform and substantially uninterrupted cylindrical layer. The lay of the winding formed by each wire should be approximately equal to 10 times the mean pitch circle diameter when the diameter of the wires exceeds 2 mm (or 0.08 in.), or 8 times when it is 2 mm or less.

On request the wire armour should be protected by a suitable compound (Clause 10.18).

10.20 - Steel-tape armour. Annealed steel tape should be used and the mean thickness of the tapes should be not less than that specified by the purchaser and not less than the value given in Table 10.XV Page 71.

On special request, in place of steel tapes, tapes of the same dimensions but of non-magnetic metal may be used.

The armour should be formed of two tapes wound in the same direction over the bedding so that the gap in the first layer is approximately equal to one-third the width of the tape and the second layer covers this gap with an overlap.

For cables whose diameter under the bedding is less than 10 mm (or 0.4 in.) the use of this type of armour is not recommended.

10.21 - Polychloroprene sheath.

(a) Properties of the polychloroprene material

Two types of vulcanized compound based on polychloroprene are provided for in these Recommendations.

Type A - For sheaths having additional external protection;

Type B - For sheaths of all types of cable.

The physical characteristics of both types should satisfy the requirements of the tests specified in Clause 10.60.

(b) Application of sheath

The polychloroprene sheath should be applied to the cables in a manner guaranteeing a high degree of resistance to mechanical damage, close fitting and resistance to moisture, and freedom from air bubbles and other defects.

(c) Thickness of sheath

The mean thickness of the sheath, measured in accordance with Clause 10.48 should be not less than the thickness specified by the purchaser and not less than the values specified in the following tables :

Table 10.XI Page 67 : Polychloroprene sheath combined with other protection for example: direct application over a lead sheath, or protection by external armour (other than textile braid);

Table 10.XII Page 68: Polychloroprene sheath for cables for fixed wiring when this sheath alone (or this sheath combined with a textile braid) forms the protection.

10.22 - Rubber sheath.

(a) Properties of the rubber sheath material

Two types of vulcanized compound based on natural rubber are provided for in these Recommendations.

Type C - For sheaths having further external protection.

Type D - For sheaths for all types of cable.

The physical characteristics of the two types should satisfy the requirements of the tests specified in Clause 10.60.

(b) Application of the sheath

The same requirements apply as for polychloroprene (see Clause 10.21-b)

(c) Thickness of sheath

The same requirements apply as for polychloroprene (see Clause 10.21-c).

NOTE: It is in general preferable to use a polychloroprene sheath rather than a natural-rubber sheath, since it has a stronger resistance to fire, aging and to the action of oils.

10.23 - Copper sheath (for mineral-insulated cables). For mineral insulated cables the sheath over the insulation should be of copper or copper-alloy.

The sheath should be of uniform thickness and free from splits, cracks and other defects. The surface of the metal should be smooth and free from traces of sulphur or foreign matter, particularly chemical substances which may have been used as cleansing agents. The thickness of the copper sheath should be in accordance with Table 10.XVI, Page 72.

Section 5 - Construction of twin and multi-core cables.

10.24 - Types of twin and multi-core cables. Two types of twin and multi-core cables are provided for in this Code: in the first type, an additional belt of insulation is applied over the insulated and cabled cores; in the other type, the protective covering is applied directly to the insulated and cabled cores. For the first type, the thickness of insulation of each core can be lower than for the second type; see for example Table 10.VII, Page 63.

The thickness of the common belt of insulation should be such that the total thickness of insulation between each conductor and the sheath is equal to or greater than the total thickness of insulation between cores: see for example Table 10.X, Page 66.

10.25 - Cabling of insulated cores.

(a) Cables without common belt of insulation

The insulated cores, with the addition of a tape or separator, if required, (Clauses 10.10-b and 10.11-c) and bearing identification markings (Clause 10.26) should be twisted together so as to form a uniform and flexible cylinder. The spaces between the cores should if necessary be filled with suitable wormings (Clause 10.27).

For cross-sectional areas of conductor not exceeding 2.5 mm^2 (or 0.004 in.^2), the construction of twin flat cables is admissible, with or without wormings, and with a flat instead of a round cross-section.

The requirements of this clause do not apply to mineral-insulated cables (for which see Clause 10.29).

(b) Cables with a common belt of insulation.

The same requirements apply as for (a) above, except that the wormings and the common belt must be insulating and the use of a flat cable is not admissible.

10.26 - Identification of insulated cores. Identification may be effected by colouring or by numbering, the insulation or the tape or external separator, if any, or, as a further alternative, by the addition of a coloured binding or braid. The choice of method of identification, (which may also be different from the above systems), is left to the manufacturer, but in any event it should be so carried

out that the various cores are readily identifiable, not only in new cables, but also in those which have been in service for some time.

For the choice of colours the following rule is recommended :

- For twin cables : two distinctive colours
- For three-core cables : grey, red, black
- For cables with more than three cores : grey, red, black and another colour (not red or grey) for the other cores.

For multi-core cables in which the cores are cabled in several concentric layers, it is recommended that in each layer there should be at least two adjacent cores coloured differently from all the others.

In telephone cables cabled in pairs, the two cores of each pair should be distinguished from each other, and in addition any particular pair should be identifiable (for example as indicated above for multi-core cables).

10.27 - Wormings.

(a) Cables without common belt of insulation

The wormings may be composed of fibrous materials (for example jute, cotton, fibre glass) or by rubber-like materials (for example rubber or polychloroprene compounds). The wormings should fill all the spaces and should not have any deleterious effect - from either mechanical or chemical point of view - on the cables, at any temperature in the range 0 °C - 75 °C. In particular the wormings should not form a solid mass with the insulation of the cores.

When the protective sheath of the cable is of polychloroprene or rubber, wormings of the same materials can be integral with the sheath or, alternatively, separated by a binding (Clause 10.28).

(b) Cables with common belt of insulation

When the common belt of insulation is of rubber, the wormings should be of rubber and the wormings in the outermost layer should be integral with the sheath. When the common belt of insulation is a layer of varnished-cambric (that is to say for varnished-cambric-insulated cables) the wormings should be of textile material or paper.

10.28 - Covering or binding.

(a) Cables without common belt of insulation

For these cables the application of a wrapping or covering or separator or other suitable binding on the cabled cores before the application of the protective sheath is optional for the manufacturer. Such covering can be formed, for example, by a tape or binding or an impregnated braid.

(b) Cables with common belt of insulation

The nature and construction of the common belt of insulation for the various types of cable provided for in these Recommendations are defined in Clauses 10.24 and 10.27-b.