

**SPECIFICATION FOR
ROTATING ELECTRICAL
MACHINES
FOR USE IN SHIPS**

B.S. 2949 : 1960

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BRITISH STANDARDS INSTITUTION

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THIS BRITISH STANDARD, having been approved by the Electrical Industry Standards Committee and endorsed by the Chairman of the Engineering Divisional Council, was published under the authority of the General Council on 14th April, 1960.

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The Institution desires to call attention to the fact that this British Standard does not purport to include all the necessary provisions of a contract.

In order to keep abreast of progress in the industries concerned, British Standards are subject to periodical review. Suggestions for improvements will be recorded and in due course brought to the notice of the committees charged with the revision of the standards to which they refer.

A complete list of British Standards, numbering over 600, indexed and cross-indexed for reference, together with an abstract of each standard, will be found in the Institution's Yearbook.

This standard makes reference to the following British Standards:

- B.S. 229** Flameproof enclosure of electrical apparatus.
- B.S. 269** Rules for methods of declaring efficiency of electrical machinery (excluding traction motors).
- B.S. 358** Rules for the measurement of voltage with sphere-gaps.
- B.S. 587** Motor starters and controllers.
- B.S. 649** The performance of reciprocating compression-ignition (diesel) engines, utilizing liquid fuel only, for general purposes.
- B.S. 822** Recommendations for terminal markings for electrical machinery and apparatus.
- B.S. 1597** Radio interference suppression on marine installations.
- B.S. 2613** The electrical performance of rotating electrical machinery.

- B.S. 2725** Memorandum on the measurement of cooling-medium temperature when testing electrical machines, transformers and other electrical apparatus.
- B.S. 2787** Classification of insulating materials for electrical machinery and apparatus on the basis of thermal stability in service.

British Standards are revised, when necessary, by the issue either of amendment slips or of revised editions. It is important that users of British Standards should ascertain that they are in possession of the latest amendments or editions.

The following B.S.I. references relate to the work on this standard:
Committee references ELE/1 and ELE/1/10
Draft for comment CY(ELE)8330

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CO-OPERATING ORGANIZATIONS

The Electrical Industry Standards Committee, under whose supervision this British Standard was prepared, consists of representatives from the following Government departments and scientific and industrial organizations:

- Admiralty
- Air Ministry
 - Associated Offices' Technical Committee
- Association of Consulting Engineers (Incorporated)
- Association of Supervising Electrical Engineers
 - British Electrical and Allied Industries Research Association
- British Electrical and Allied Manufacturers' Association
 - British Electrical Development Association
- British Railways, The British Transport Commission
 - Cable Makers' Association
- Crown Agents for Oversea Governments and Administrations
 - Electric Lamp Industry Council
 - Electric Light Fittings Association
 - Electrical Contractors' Association (Incorporated)
 - Electrical Contractors' Association of Scotland
- Electricity Council, Generating Board and the Area Boards in England and Wales
 - Electronic Engineering Association
- Engineering Equipment Users' Association
 - Independent Cable Makers' Association
- Institution of Electrical Engineers
- Ministry of Aviation
- Ministry of Labour (Factory Inspectorate)
- Ministry of Power
- Ministry of Works
 - National Inspection Council for Electrical Installation Contracting
- National Physical Laboratory (D.S.I.R.)
- Oil Companies Materials Association
- Post Office
 - Public Transport Association (Incorporated)
 - South of Scotland Electricity Board
- War Office

The Government departments and scientific and industrial organizations marked with an asterisk in the above list, together with the following, were directly represented on the committee entrusted with the preparation of the standard.

Chamber of Shipping of the United Kingdom
 Engineer Surveyors' Association
 Federation of British Industries
 High Commission of India
 Institution of Naval Architects
 Liverpool Steamship Owners' Association
 Lloyd's Register of Shipping
 London Transport Executive, The British Transport Commission
 North-East Coast Institution of Engineers and Shipbuilders
 Shipbuilding Conference

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BRITISH STANDARD SPECIFICATION FOR ROTATING ELECTRICAL MACHINES FOR USE IN SHIPS

FOREWORD

This British Standard has been prepared at the request of the Institution of Electrical Engineers, whose Committee on the Regulations for the Electrical Equipment of Ships considered it desirable that a specification covering motors and generators for marine use should be prepared. During the work of preparation, alignment with B.S. 2613* has been maintained as far as possible.

C.M.R. (continuous maximum rating) generators complying with this specification will meet the conditions of the note at the beginning of Clause 9 of B.S. 649.†

The revision of the first (1958) edition, has been undertaken principally to include requirements for propulsion machines and electro-magnetic slip couplings.

Attention is drawn to Appendix B of the standard, where details are given of the kind of information that should be given with enquiry and order.

NOTE. Where metric equivalents are stated the figures in British units are to be regarded as the standard. The metric conversions are approximate. More accurate conversions should be based on B.S. 350, 'Conversion factors and tables'.

SPECIFICATION

SECTION ONE: GENERAL

SCOPE

1. This standard applies to marine electric generators, motors, rotary converters and electro-magnetic slip couplings, which are rated for 1 hp, 0.75 kW or 0.75 kVA or greater per 1000 rev/min. No upper limit is placed on the power rating.

The machines are suitable for specified service conditions and are assigned either a continuous maximum rating or a short-time rating.

The various types of enclosure which may be employed are classified.

* B.S. 2613, 'The electrical performance of rotating electrical machinery'.

† B.S. 649, 'The performance of reciprocating compression-ignition (diesel) engines, utilizing liquid fuel only, for general purposes'.

DEFINITIONS

2. For the purposes of this British Standard the following definitions apply:

1. *Essential services.* Services essential to the safety of life and to the navigation and propulsion of a ship.

2. *Machinery spaces.* All spaces used for propelling, auxiliary, or refrigeration machinery, for boilers, pumps, workshops, generators, ventilating and air conditioning machinery, and similar spaces and trunks to such spaces.

3. *Machine.* Any electric motor, generator or rotary convertor to which this standard applies.

4. *Rotary convertor.* A machine with a single armature winding having a commutator and slip rings; used for converting alternating current into direct current and vice versa.

5. *Electric propulsion machine.* A motor which provides propulsive power to a ship. Also any generator from which such power is derived.

6. *Electro-magnetic slip coupling.* A coupling having a permanent air gap between its two members, one member being associated with the driving shaft, and the other with the driven shaft. Power is transmitted across the air gap between the two members as a result of the electro-magnetic interaction of a magnetic flux generated in and associated with one member and currents induced in the other member because of a difference in speed (slip) between the two members.

7. *Rating.* Of an electrical machine. A statement of the operating limitations assigned to it by the manufacturer. These limitations, together with the associated conditions which jointly constitute the rating, are marked on the rating plate. For generators with two limits of voltage, see Sub-clause 12 a.

8. *Continuous maximum rating* (abbreviation: c.m.r.). A statement of operating limits, assigned to the machine by the manufacturer, defining the load at which the machine may be operated for an unlimited period under the conditions specified on the rating plate, while complying with the requirements of this standard. Such a machine has no overload rating.

9. *Short-time rating.* A statement of the operating limits assigned to the machine by the manufacturer, defining the load at which the machine may be operated (starting at the ambient temperature) for the period and under the conditions specified on the rating plate.

10. *Overload.* Any load in excess of the rated load. Usually expressed numerically as the amount of the excess, measured as percentage excess current for generators and as percentage excess torque for motors.

a. *Sustained overload.* An overload sustained for a sufficiently long period to affect appreciably the temperature of the machine.

b. *Momentary overload.* An overload the duration of which is so short as not to affect appreciably the temperature of the machine.

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11. Multi-speed motor (change-speed motor). A motor which can be operated at more than one distinct speed, substantially independent of the load, such as an induction motor the speed of which is varied by changing the number of its poles.

12. Variable-speed motor with shunt characteristics. A motor, the speed of which can be varied gradually over a specified range, but which, when once adjusted, remains substantially unaffected by the load, e.g. a shunt motor designed for a range of speed variation.

13. Variable-speed motor with series characteristics. A motor, the speed of which can be varied gradually over a specified range, but which will decrease when the load increases, as with a series-wound or heavily-compounded motor, or a slipping induction motor with rheostatic control.

14. Starting current. The initial current, excluding any transients, when starting from rest.

15. Starting torque. The available torque developed by a motor under rated conditions at the instant of starting, irrespective of the angular position of the rotor.

16. Excitation voltage. The voltage marked on the rating plate of the machine being excited.

SECTION TWO: CLASSIFICATIONS

SHIP CLASSIFICATION

3. For the purposes of this British Standard, ships are divided into the following groups:

Group 1. Ocean-going ships and all ships operating in tropical waters.

Group 2. All ships other than Group 1 ships (e.g. ships solely for use in temperate waters, on duties such as coastal and harbour service, inland waters and cross-channel services).

SERVICE CONDITIONS

4. This standard provides for machines to be installed in ships intended for unrestricted service and for service in tropical waters and also for ships solely for use in temperate waters (see Clause 3). The service conditions are as follows:

a. Service condition 1. Except for motors driving machine tools, applies to all machines in Group 1 vessels where the machines are located:

- (i) in machinery spaces;
- (ii) on weather decks.

b. Service condition 2. Applies to all machines in Group 2 vessels and to the following machines in Group 1 vessels:

- (i) machine-tool motors;
- (ii) all machines other than those situated in machinery spaces or on weather decks.

LETTER SYMBOLS FOR TYPES OF ENCLOSURES

5. For convenience of reference, letter symbols have been assigned to types of enclosure as set out below:

Letter symbol	Item No. of Clause No. 6	Type of enclosure
OP	2.	Open pedestal machine
OEB	3.	Open end-bracket machine
P	4.	Protected machine
SP	5.	Screen-protected machine
EV	6.	Enclosed ventilated machine
DP	7.	Drip-proof machine
EVDP	8.	Enclosed ventilated drip-proof machine
SPLP	9.	Splash-proof machine
HSP	10.	Hose-proof machine
PV	11.	Pipe- or duct-ventilation machine with self ventilation
PVFD	11.	Pipe- or duct-ventilated machine with forced draught, with air supplied by external pressure
PVID	11.	Pipe- or duct-ventilated machine with induced draught, with air drawn through the machine by external means
TE	12.	Totally-enclosed machine
TEFC	13.	Totally-enclosed fan-cooled machine
TESAC	14.	Totally-enclosed separately air-cooled machine
TEWC	15.	Totally-enclosed water- or other liquid-cooled machine
CACA	16.	Totally-enclosed closed air circuit machine with air-cooled air cooler
CACW	16.	Totally-enclosed closed air circuit machine with water-cooled air cooler
WP	17.	Weatherproof machine
WT	18.	Watertight machine
DWT	19.	Deck watertight machine
FLP	21.	Flameproof machine

TYPES OF ENCLOSURE

6. All types of enclosure, other than 1, 2 and 3 below, shall be such that rotating and live parts are protected against accidental or inadvertent contact, and shall comply with one of the following types:

1. *Open machine**. A machine in which there is no restriction to ventilation other than that necessitated by good mechanical construction.

2. *Open pedestal machine (OP)**. An open machine which has pedestal bearings supported independently of the machine frame.

3. *Open end-bracket machine (OEB)**. An open machine having end-brackets of which the bearings form an integral part.

4. *A protected machine (P)*. A machine in which the internal rotating parts and live parts are protected mechanically from accidental or inadvertent contact, while ventilation is not materially impeded.

5. *A screen-protected machine (SP)*. A protected machine, designed to prevent danger of contact with internal rotating parts and live parts, in which the ventilating openings shall not exceed $\frac{1}{2}$ in (13 mm) in any direction. Such protection may be provided by screens of wire mesh, expanded metal, perforated metal or other suitable covers. The use of openings smaller than $1\frac{1}{16}$ sq in (0.65 cm²) is not recognized, as such openings are liable to become clogged in service.

6. *An enclosed ventilated machine (EV)*. A machine with a substantially complete total enclosure with ventilated openings. The openings, which may be screened with wire mesh, expanded metal or other perforated material shall not exceed $\frac{1}{2}$ in in any direction.

7. *A drip-proof machine (DP)*. A protected machine in which the openings for ventilation are so protected as to exclude vertically falling water or dirt when the machine is tilted $22\frac{1}{2}$ degrees from the vertical in any direction.

8. *An enclosed ventilated drip-proof machine (EVDP)*. An enclosed ventilated machine in which the openings for ventilation are so protected as to exclude vertically falling water or dirt when the machine is tilted $22\frac{1}{2}$ degrees from the vertical in any direction.

9. *A splash-proof machine (SPLP)*. A protected machine in which the ventilating openings are so constructed that drops of liquid or solid particles falling on or reaching any part of the machine at any angle between the vertical downward direction and 100° from that direction cannot enter the machine, whether the machine is running or at rest, by splashing, or otherwise, either directly or by striking and running along a surface.

10. *A hose-proof machine (HSP)*. A protected machine so enclosed as to exclude water when washed by a hose having a $\frac{3}{4}$ in (19.5 mm) in diameter nozzle with a maximum pressure of 50 lb/sq in (3.5 kg/cm²) for a period not exceeding 30 seconds from a minimum distance of 6 ft (1.8 m).

* These types of enclosure do not include any necessary protection against accidental or inadvertent contact with rotating parts and live parts. The responsibility for the provision of such protection is a matter for the user.

11. A pipe-ventilated or duct-ventilated machine. A machine in which there is a continuous supply of fresh ventilating air, the frame being so arranged that the ventilating air may be conveyed to and/or from the machine through pipes or ducts attached to the enclosing case.

a. A pipe- or duct-ventilated machine may be one of three types:

- (i) With provision for inlet duct only.
- (ii) With provision for inlet and outlet ducts.
- (iii) With provision for outlet duct only.

b. A pipe- or duct-ventilated machine may be cooled by means of:

- (i) Self ventilation (PV).
- (ii) Forced-draught with air supplied by external pressure (PVFD).
- (iii) Induced draught with air drawn through the machine by external means (PVID).

Unless otherwise specified, self-ventilated machines with inlet duct only shall be assumed. In all other cases the essential features shall be clearly specified, e.g. PV with provision for inlet and outlet ducts.

12. A totally-enclosed machine (TE)*. A machine which is constructed so that while it is not necessarily 'air tight' the enclosed air has no connection, except for the provision for draining or breathing, with external air.

13. A totally-enclosed fan-cooled machine (TEFC)*. A totally-enclosed machine with augmented cooling by means of a fan driven by the motor itself, blowing external air over the cooling surfaces and/or through the cooling passages, if any, incorporated in the machine.

14. A totally-enclosed separately air-cooled machine (TESAC)*. A totally-enclosed machine with augmented cooling by means of a separately-driven fan, blowing external air over the cooling surfaces and/or through the cooling passages, if any, incorporated in the machine.

15. A totally-enclosed water- or other liquid-cooled machine (TEWC)*. A totally-enclosed machine with augmented cooling by means of water-cooled or other liquid-cooled surfaces embodied in the machine itself.

16. A totally-enclosed closed air circuit machine*. A totally-enclosed machine having special provision for cooling the enclosed air by passing it through its own cooler, usually external to the machine. The cooler may be of any recognized form using:

- a.** Air (CACA).
- b.** Water (CACW).
- c.** Other suitable cooling medium.

* Provision for breathing may be provided if required; for provision for draining, see Clause 23.

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17. A weatherproof machine (WP). A machine so constructed that it can work without further protection when fully exposed to sun, rain, mist, snow, salt spray and airborne particles.

18. A watertight machine (WT). A machine so constructed that it will withstand, without damage or sign of leakage, complete immersion in water to a depth of not less than 3 ft (0.9 m) or subjection to an external water pressure of 1.5 lb/sq in (0.1 kg/cm²) for a period of one hour. The test for watertightness shall be made with the machine stationary and the temperature of the machine shall not exceed the temperature of the water in which it is immersed.

19. A deck watertight machine (DWT). A machine which is similar to a watertight machine and is tested in the same manner except for the period of immersion which is for one minute instead of one hour.

20. A submersible machine. A machine capable of working for an indefinitely long period when submerged under a specified head of water.

21. A flameproof machine (FLP). A machine which complies with the requirements of B.S. 229, 'Flameproof enclosure of electrical apparatus'.

SECTION THREE: STANDARD PHASES AND WAVE FORM

STANDARD NUMBER OF PHASES

7. The standard number of phases for alternating current machines, with the exception of small single-phase machines, is three.

VOLTAGE WAVE FORM OF SYNCHRONOUS MACHINES

8. When the wave form is of importance the permissible deviation (as measured along the ordinates or by a suitable harmonic analyser) from sine wave shape of the voltage wave form at rated voltage on open circuit when driven at uniform speed shall be limited as follows:

The maximum deviation of the wave form of voltage between line terminals from the equivalent sine wave, when superimposed so as to give the least difference, shall not exceed 10 per cent of the maximum ordinate of the equivalent sine wave.

The equivalent sine wave shall be taken as one having the same root-mean-square (r.m.s.) value and the same wavelength.

NOTE. When the wave form is of importance it is necessary to state this at the time of ordering a machine, and it should be noted that compliance with the above rule does not necessarily preclude the possibility of interference with communication circuits by such machines.

SECTION FOUR: RATING

ASSIGNMENT OF RATINGS

9. Ratings shall be assigned in accordance with the requirements of this section and marked on the rating plate as required in Section Eleven.

CLASSES OF RATINGS

10. The following classes of rating are recognized:

- a. Continuous maximum rating (see Definition 8.).
- b. Short-time rating (see Definition 9.). Two short-time ratings are recognized:

- (i) *One-hour rating.* The output at which a machine can work for one hour and comply with this standard.

- (ii) *Half-hour rating.* The output at which a machine can work for one half-hour and comply with this standard.

NOTE 1. It may not be possible to apply any of the above classes of rating to a particular motor subject to an intermittent or duty-cycle service. In such a case the purchaser should provide the manufacturer with details of the required duty cycle, so that, by agreement, the appropriate rating of the motor can be established. Tests to be carried out at the maker's works should also be agreed (see Appendix B).

NOTE 2. The rated voltage is one of the associated conditions to be marked on the rating plate and is the voltage between lines at rated load measured at the terminals of the machine. For polyphase machines with separate phases, an indication of the phase connection (star, delta, etc.) should be included in the statement of the rated voltage.

POWER RATING

11. a. *D.C. generators.* The output shall be expressed in kilowatts (kW) available at the terminals.

b. *A.C. generators.* The output shall be expressed in kilovolt amperes (kVA) or megavolt amperes (MVA) available at the terminals, at a power factor of 0.8 lagging unless otherwise specified (see Appendix B, 4. Item 17.).

c. *Motors.* The mechanical output shall be expressed in horse-power (hp) available at the shaft, one horse-power being taken as equivalent to 746.0 watts.

d. *Rotary converters.* For rotary converters operating a.c. to d.c. the output rating shall be expressed in kW. When operating d.c. to a.c. the output rating shall be expressed in kVA at rated power factor.

MULTIPLE RATINGS

12. a. *Current and output rating for generator with two limits of voltage.* A generator rated for two limits of voltage shall have its rated current and output determined at the higher voltage unless otherwise specified.