

Australian/New Zealand Standard™

Electrical installations—Marinas and boats

Part 2: Boat installations



AS/NZS 3004.2:2014

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee EL-057, Boating and Boating Marinas Installations. It was approved on behalf of the Council of Standards Australia on 7 May 2014 and on behalf of the Council of Standards New Zealand on 6 June 2014.
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The following are represented on Committee EL-057:

Australian Corrosion Association
Australian Industry Group
Boating Industries Alliance of Australia
Electrical Contractors Association of New Zealand
Electrical Regulatory Authorities Council
Electrical Safety Organisation, New Zealand
Energy Networks Association
Marina Industries Association of Australia
Marine Queensland
New Zealand Marina Operators
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This Standard was issued in draft form for comment as DR AS/NZS 3004.2.

Australian/New Zealand Standard™

Electrical installations—Marinas and boats

Part 2: Boat installations

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EL-057, Boating and Boating Marinas Installations, to supersede AS/NZS 3004.2:2008, *Electrical installations—Marinas and recreational boats, Part 2: Recreational boats installations*.

This Standard incorporates Amendment No. 1 (July 2015). The changes required by the Amendment are indicated in the text by a marginal bar and amendment number against the clause, note, table, figure or part thereof affected.

The objective of this Standard is to provide designers, manufacturers, boat builders and regulators with safety requirements for small boats.

This Standard is part of a series, which includes the following:

AS/NZS

3004 Electrical installations—Marinas and boats

3004.1 Part 1: Marinas

3004.2 Part 2: Boat installations (this Standard)

In the preparation of this Standard reference was made to the following:

- (a) IEC 60092-507: Ed.1.0 (2000), *Electrical installations in ships, Part 507: Pleasure craft*.
- (b) ISO 10133, *Small craft—Electrical systems—Extra-low-voltage d.c. installations*.
- (c) ISO 13297, *Small craft—Electrical systems—Alternating current installations*.
- (d) American Boat and Yacht Council (ABYC) Standards and Technical Information Reports for Small Craft:
 - (i) A-28, *Galvanic isolators*.
 - (ii) A-32, *AC power conversion equipment and systems*.
 - (iii) E-11, *AC and DC electrical systems on boats*.
 - (iv) S-31, *Environmental considerations for systems and components installed onboard boats*.

and acknowledgement is made of the assistance received therefrom.

Compliance with this Standard may be required by legislation, from a date to be set by the relevant regulating authority.

If work on an installation was commenced before publication of this edition, permission can be granted by the relevant regulatory authority or electricity distributor for the installation to be completed under AS/NZS 3004:2008.

It is not the intention of this Standard to limit the introduction and use of emerging technologies. However, designers are reminded that it is essential that the basic tenets of electrical and marine safety be addressed before any other equipment and installation design elements are considered.

Any requirements that may be applicable in Australia only or New Zealand only are indicated in the text and by a symbol in the right margin as follows:

‘In Australia.....’

‘In New Zealand.....’



Statements expressed in mandatory terms in footnotes to Tables are deemed to be requirements of this Standard.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is for information and guidance only.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard
Electrical installations—Marinas and boats

Part 2: Boat installations

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for the design, construction and installation of electrical systems in boats that have a length of up to 50 m, and are designed for use on inland waters or at sea.

NOTES:

- 1 This Standard is not intended to apply to small boats equipped with a battery supplying circuits for engine starting and navigation lighting only that is recharged from an inboard or outboard engine driven alternator.
- 2 Attention is drawn to the *International Regulations for Preventing Collisions at Sea*, 1972 (COLREGs) as amended, which govern specific requirements for navigation lights for boats.
- 3 Attention is drawn to regulations in Australia and New Zealand that govern specific requirements for the safety of electronic and electrical equipment; electromagnetic compatibility requirements; marine safety requirements; energy and water usage; telecommunications and radio communication requirements.
For high speed boats, attention is drawn to the *Australian National Standard for Commercial Vessels (NSCV)*, Part F: *Special Vessels, Section 1—Fast craft and the Maritime New Zealand Rules*.
- 4 Attention is drawn to the regulatory requirements for the issue of an electrical warrant of fitness for New Zealand boats connected to shore power.

This Standard applies to the following types of d.c. and a.c. electrical systems, individually or in combination:

- (a) Direct current systems that operate at a nominal voltage not exceeding 1500 V.
NOTE: For example, for many small boats this will be the main electrical system. Alternatively a boat equipped with an a.c. system as its principal electrical system may also be equipped with a d.c. system for navigation and communications equipment supplied from batteries.
- (b) Single-phase alternating current systems that operate at a nominal voltage not exceeding 1000 V.
NOTE: Such a system may be the principal electrical power system of a boat, or a system which may only be energized when connected to a shore supply, a.c. extra-low voltage, safety extra-low voltage etc. circuits may also comprise part of a single-phase a.c. system. A boat may also be equipped with d.c. system(s) as in (a) above.
- (c) Three-phase alternating current systems that operate at a nominal voltage not exceeding 1000 V.
NOTE: Three-phase systems are likely to be the principal electrical power system of a boat's electrical installation. Such a boat may also be equipped with single-phase a.c. subsystem(s) and d.c. subsystem(s).

Boats whose electrical installation complies with the requirements of an international maritime classification society that is recognized by Australian Maritime Safety Authority (AMSA) or Maritime New Zealand (MNZ) can be used to show compliance, provided safety of the installation is equivalent to, or exceeds, the requirements of this Standard.

NOTE: Applications for exemptions based on the above paragraph need to be supported by appropriate and current certification documents.

1.2 APPLICATION

Electrical installations in boats shall be carried out in accordance with AS/NZS 3000, except as varied herein, and with the applicable additional requirements of this Standard.

NOTE: The relevant safety authority might choose to apply this Standard to other installations.

The relevant electricity distributor or supplier may have additional requirements.

1.3 REFERENCED AND RELATED DOCUMENTS

1.3.1 Referenced documents

The following documents are referred to in this Standard.

AS	
2676	Guide to the installation, maintenance, testing and replacement of secondary batteries in buildings (series)
2832	Cathodic protection of metals (series)
3011	Electrical installations—Secondary batteries installed in buildings (series)
60092	Electrical installations in ships
60092.350	Part 350: Shipboard power cables—General construction and test requirements
60529	Degrees of protection provided by enclosures (IP Code)
60947	Low-voltage switchgear and controlgear
60947.7.1	Part 7.1: Ancillary equipment—Terminal blocks for copper conductors
61010	Safety requirements for electrical equipment for measurement, control and laboratory use (series)
62040	Uninterruptible power systems (UPS)
62040.1.1	Part 1.1: General and safety requirements for UPS used in operator access areas
AS/NZS	
1125	Conductors in insulated electric cables and flexible cords
3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
3004	Electrical installations—Marinas and boats
3004.1	Part 1: Marinas
3008	Electrical installations—Selection of cables
3008.1.1	Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV—Typical Australian installation conditions
3008.1.2	Part 1.2: Cables for alternating voltages up to and including 0.6/1 kV—Typical New Zealand installation conditions
3017	Electrical installations—Verification guidelines
3111	Approval and test specification—Miniature overcurrent circuit-breakers
3112	Approval and test specification—Plugs and socket-outlets

AS/NZS	
3120	Approval and test specification—Cord extension sockets
3123	Approval and test specification—Plugs, socket-outlets and couplers for general industrial application
3191	Electric flexible cords
3760	In-service safety inspection and testing of electrical equipment
5000	Electric cables—Polymeric insulated
5000.1	Part 1: For working voltages up to and including 0.6/1 (1.2) kV
5601	Gas installations
5601.2	Part 2: LP Gas installations in caravans and boats for non-propulsive purposes
60320	Appliance couplers for household and similar general purposes
60320.1	Part 1: General requirements (IEC 60320-1, Ed. 2.1 (2007) MOD)
60335	Household and similar electrical appliances—Safety (series)
60335.2.29	Part 2.29: Particular requirements for battery chargers
60598	Luminaires (series)
60898	Electrical accessories—Circuit-breakers for overcurrent protection for household and similar installations
60898.1	Part 1: Circuit-breakers for a.c. operation (IEC 60898-1 Ed.1.2 (2003) MOD)
60950	Information technology equipment—Safety
60950.1	Part 1: General requirements (IEC 60950-1, Ed.2.0 (2005), MOD)
61008	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs)
61008.1	Part 1: General rules (IEC 61008-1 Ed.2.1 (2002) MOD)
61009	Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs)
61009.1	Part 1: General rules (IEC 61009-1 Ed.3.0 (2010) MOD)
61241	Electrical apparatus for use in the presence of combustible dust (series)
61558	Safety of power transformers, power supplies, reactors and similar products (series)
IEC	
60050	International Electrotechnical Vocabulary
60050-826	Part 826: Electrical installations
60092	Electrical installations in ships
60092-101	Part 101: Definitions and general requirements
60092-201	Part 201: System design—General
60092-202	Part 202: System design—Protection
60092-301	Part 301: Equipment—Generators and motors
60092-304	Part 304: Equipment—Semiconductor converters
60092-306	Part 306: Equipment—Luminaires and lighting accessories
60092-307	Part 307: Equipment—Heating and cooking appliances
60092-352	Part 352: Choice and installation of electrical cables
60092-502	Part 502: Tankers—Special features
60092-504	Part 504: Special features—Control and instrumentation
60092-507	Part 507: Small vessels

IEC

- 60228 Conductors of insulated cables
- 60309 Plugs, socket-outlets and couplers for industrial purposes
- 60309-2 Part 2: Dimensional interchangeability requirements for pin and contact-tube accessories
- 60332 Tests on electric and optical fibre cables under fire conditions
- 60332-1 Part 1: Test for vertical flame propagation for a single insulated wire or cable
- 60332-3-22 Part 3-22: Test for vertical flame spread of vertically-mounted bunched wires or cables—Category A
- 60364 Low-voltage electrical installations
- 60364-6 Part 6: Verification
- 60533 Electric and electronic installations in ships—Electromagnetic compatibility
- 60934 Circuit-breakers for equipment (CBE)
- 60945 Maritime navigation and radiocommunication equipment and systems—General requirements—Methods of testing and required test results
- 60950 Information technology equipment—Safety
- 60950-1 Part 1: General requirements
- 61140 Protection against electric shock—Common aspects for installation and equipment
- 61557 Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c.—Equipment for testing, measuring or monitoring of protective measures (series)
- 62031 LED modules for general lighting—Safety specifications
- 62040 Uninterruptible power systems (UPS)
- 62040-1-1 Part 1-1: General and safety requirements for UPS used in operator access areas (2002)

ISO

- 8846 Small craft—Electrical devices—Protection against ignition of surrounding flammable gases
- 9094 Small craft—Fire protection
- 9094-1 Part 1: Craft with a hull length of up to and including 15 m
- 9094-2 Part 2: Craft with a hull length of over 15 m
- 10133 Small craft—Electrical systems—Extra-low-voltage d.c. installations
- 10239 Small craft—Liquefied petroleum gas (LPG) systems
- 13297 Small craft—Electrical systems—Alternating current installations

EN

- 55015 Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment

ABYC

- A-28 American Boat and Yacht Council
- A-28 Galvanic isolators
- A-31 Battery chargers and inverters
- A-32 AC power conversion equipment and systems
- E-11 AC and DC electrical systems on boats
- S-31 Environmental considerations for systems and components installed onboard boats

1.3.2 Related documents

Attention is drawn to the following related documents:

AS/NZS

60245 Rubber insulated cables—Rated voltage up to and including 450/750 V
60245.4 Part 4: Cords and flexible cables

IEC

60092 Electrical installations in ships
60092-302 Part 302: Low-voltage switchgear and controlgear assemblies
60092-303 Part 303: Equipment—Transformers for power and lighting

ISO

10240 Small craft—Owner's manual

1.4 DEFINITIONS

For the purpose of this Standard, the terms and definitions given in AS/NZS 3000, IEC 60050-826 and IEC 60092-101 and those below apply.

1.4.1 a.c. systems of distribution

1.4.1.1 *Single-phase two-wire a.c. system*

A single-phase a.c. system, comprising two conductors only, between which the load is connected.

1.4.1.2 *Single-phase three-wire a.c. system*

A single-phase a.c. system comprising two conductors and a neutral wire, the supply being taken from the two outer conductors or from the neutral wire and either outer conductor, the neutral wire carrying only the difference-current.

1.4.1.3 *Three-phase three-wire a.c. system*

A system comprising three conductors connected to a three-phase supply.

1.4.1.4 *Three-phase four-wire a.c. 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 source of supply.

1.4.1.5 *Three-phase five-wire a.c. system*

A system comprising five conductors, of which three are connected to a three-phase supply, the fourth to a neutral point in the source of supply and the fifth to the protective earth.

1.4.2 Active conductor

Any conductor that is maintained at a difference of potential to the neutral or earthed conductor. In a system that does not include a neutral or earthed conductor, all conductors shall be considered active conductors.

[AS/NZS 3000]

1.4.3 Boat's earth

Connection to the general mass of the hull of the boat, or to an earth plate complying with Clause 7.1.2, 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 or earth plate without a fuselink, switch, circuit-breaker, resistor, or impedance in the earth connection.

A1

1.4.4 Competent person

A person, who has acquired, through training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the required task correctly.

1.4.5 d.c. systems of distribution

1.4.5.1 *Two-wire d.c. system*

A d.c. system comprising two conductors only, between which the load is connected.

1.4.5.2 *Three-wire d.c. system*

A d.c. system comprising two conductors and a middle wire, the supply being taken from the two outer conductors or from the middle wire and either outer conductor, the middle wire carrying only the difference-current.

1.4.6 Engine negative terminal

Terminal on the engine to which the negative cable of a battery system is connected.

1.4.7 Equipment

1.4.7.1 *Readily accessible*

Capable of being reached quickly for effective use under emergency conditions without the use of tools.

[ABYC E-11]

1.4.7.2 *Battery*

1.4.7.2.1 *Sealed cell*

Cell which remains closed and does not release or take in gas or liquid when operated within the limits specified by the manufacturer. (The cells may be equipped with a safety device to prevent dangerously high internal pressure.)

[IEC 60092-507:2008, Clause 3.5.8.2]

NOTE: If sealed cells are overcharged then gassing will occur. As such, ventilation is required as for a vented cell.

1.4.7.2.2 *Valve regulated battery*

Cells which are closed but have a valve which allows the escape of gas if the internal pressure exceeds a predetermined value.

The lead-acid version is called the valve regulated lead-acid VRLA.

[IEC 60092-507:2008, Clause 3.5.8.3]

1.4.7.2.3 *Vented cell*

Cell which allows products of electrolysis and evaporation to escape freely from the cells to the atmosphere and can receive additions to the electrolyte.

[IEC 60092-507:2008, Clause 3.5.8.1]

1.4.7.3 *Cable trunking*

Trunk or trough for housing and protecting electrical cables and conductors.

[AS/NZS 3000]

1.4.7.4 *Captive-spade terminal*

Conductor terminal component which is maintained in connection to the screw or stud even when the threaded terminal fastener is loose.

1.4.7.5 *Certified safe for explosive gas atmospheres type equipment*

Equipment for use in areas with zone classification for hazardous areas and designed, constructed and marked to comply with the AS/NZS 60079 series of Standards.

1.4.7.6 *Galvanic isolator*

Device installed in series with the a.c. protective earthing conductor to block low-voltage d.c. galvanic current flow, but permit the passage of alternating current normally associated with the protective earthing conductor.

[ISO 13297]

1.4.7.7 *Generator*

Device which creates d.c. or a.c. (alternator) power for distribution to the electrical system on-board a boat.

NOTE: In its simplest form a generator may be an engine driven alternator with integral rectifier for recharging batteries in a boat's d.c. system. It may also be a solar panel, generator driven by wind or water mill or fuel cell.

1.4.7.8 *Ignition protection*

The design and construction of a device such that under design operating conditions—

- (a) it will not ignite a flammable hydrocarbon mixture surrounding the device when an ignition source causes an internal explosion;
- (b) it is incapable of releasing sufficient electrical or thermal energy to ignite a hydrocarbon mixture; or
- (c) the source of ignition is hermetically sealed.

1.4.7.9 *Shore power inlet*

Fitting designed for mounting on a boat, of a shrouded male type, to connect to the female connector on the boat end of the shore power connection, in order to make the electrical connection for transmission of electrical energy.

1.4.7.10 *Transformer*

Transformer with isolating separation between the input and output windings and the protective conductor.

1.4.8 Essential services

Services essential for the navigation, steering or manoeuvring of the boat, or for the safety of human life, or for special characteristics of the boat (special services).

NOTE: Examples of essential services are—

- (a) engine-starting systems;
- (b) fire extinguishing systems;
- (c) bilge pumps;
- (d) fuel pumps;
- (e) bilge level detection;
- (f) circulating and cooling water pumps;
- (g) fire detection and alarm systems;
- (h) fire pumps;
- (i) lubricating oil pumps;
- (j) navigation lights and special purpose lights where required by statutory regulations;
- (k) essential lighting systems for areas normally accessible to personnel and to passengers;
- (l) fuel and heating pumps;
- (m) steering gear;

- (n) engine and heating ventilation systems;
- (o) navigation and communication systems;
- (p) alarm systems;
- (q) sound signal appliances;
- (r) control and instrumentation systems; and
- (s) power sources for supplying the above services.

1.4.9 Live part

A conductor or conductive part intended to be energized in normal use, including a neutral conductor and conductive parts connected to a neutral conductor.

[AS/NZS 3000]

1.4.10 Neutral

The conductor of a three wire or multi-wire system that is maintained at an intermediate and approximately uniform potential in respect of the active or outer conductors, or the conductor of a two wire system that is connected to earth at its origin.

[AS/NZS 3000]

1.4.11 Protection

1.4.11.1 *Circuit-breaker*

A switch suitable for opening a circuit automatically, as a result of predetermined conditions, such as those of overcurrent or undervoltage, or by some form of external control.

[AS/NZS 3000]

1.4.11.2 *Equipotential bond*

Electrical connections intended to bring exposed conductive parts or extraneous conductive parts to the same or approximately the same potential, but not intended to carry current in normal service.

[AS/NZS 3000]

1.4.11.3 *Final subcircuit*

A circuit originating at a switchboard and to which only consuming devices or points will be connected. The origin of a final subcircuit is deemed to be at the connecting devices of the neutral bar or link or at the load terminals of the circuit protective devices provided within or on a switchboard specifically for the connection of the circuit. The termination of a final subcircuit is deemed to be at the supply terminals of consuming devices or points.

[AS/NZS 3000]

1.4.11.4 *Fuse*

A protective device that interrupts the circuit irreversibly when the current flow reaches a specified value for a specified time.

[ISO 13297, ISO 10133]

1.4.11.5 *Low-voltage switchgear and controlgear*

A combination of one or more low-voltage switching devices together with associated control, measuring, signalling, protective, regulating equipment etc. often contained within an enclosure or mounted on a panel.

NOTE: Examples of devices are circuit-breakers, fuses, switches, instruments and indicators.

1.4.11.6 *Neutral (neutral conductor or mid-wire)*

The conductor of a three-wire or multi-wire system that is maintained at an intermediate and approximately uniform potential in respect of the active or outer conductors, or the conductor of a two-wire system that is connected to earth at its origin.

[AS/NZS 3000]

1.4.11.7 *Overcurrent protection device*

Device, such as a fuse or circuit-breaker, designed to interrupt the circuit when the current flow exceeds a predetermined value for a predetermined time.

[IEC 60097-507]

1.4.11.8 *Protective earthing conductor*

A conductor, other than a main earthing conductor, connecting any portion of the earthing system to the portion of the electrical installation or electrical equipment required to be earthed, or to any other portion of the earthing system.

[AS/NZS 3000]

1.4.11.9 *Residual current device (RCD)*

A device intended to isolate supply to protected circuits, socket-outlets or electrical equipment in the event of a current flow to earth that exceeds a predetermined value.

[AS/NZS 3000]

1.4.11.10 *Sheath*

A uniform and continuous tubular covering of metallic or non-metallic material, generally extruded around one or more insulated conductors.

[ISO 10133]

1.4.12 Safety voltage

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

A voltage which does not exceed 50 V d.c. between conductors, or between any conductor and earth, in a circuit which is isolated from higher voltage circuits.

NOTES:

- 1 Consideration should be given to the reduction of the limit of 50 V under certain conditions, such as wet surroundings or exposure to heavy seas or where direct contact with live parts is involved.
- 2 The voltage limit should not be exceeded either at full load or no load, but it is assumed, for the purpose of this definition, that any transformer or converter is operated at its rated supply voltage.

1.4.13 Shall

Indicates that a statement is mandatory.

1.4.14 Should

Indicates a recommendation.

SECTION 2 GENERAL REQUIREMENTS

2.1 RATINGS

Conductors, switchgear and accessories shall be suitable for expected environmental and operational conditions and shall sustain anticipated overloads and transient current induced by motor start-up without damage, tripping or overheating.

2.2 AMBIENT AIR AND COOLING WATER TEMPERATURE

Electrical equipment shall be designed to operate satisfactorily under the various temperature parameters indicated in Table 1.

TABLE 1
DESIGN PARAMETERS—TEMPERATURE
(From IEC 60092-101)

Parameters		Unit value °C	Type of equipment
Relevant Standard	Clause		
High air temperature			
IEC 60092-201:1994	3.3	45	Cables
IEC 60092-301:1980	3.1 (Table A.1)	50	Generators and motors
IEC 60092-352:2005	3.3.4, 3.3.6	45	Cables
IEC 60092-502:1999	A.2.1.3, A.3.1.3, A3.2.3.3	50	Certified safe-type equipment
IEC 60092-504:2001	3.2	55	Control and instrumentation
Low air temperature			
		5	General
		−25	Open deck
High water temperature			
IEC 60092-301:1980	3.1 (Table A.1)	30	Generators and motors

2.3 INCLINATION OF BOAT

Electrical equipment shall be designed to continue to operate satisfactorily with the boat at the inclinations from normal indicated in Table 2.

TABLE 2
ANGULAR DEVIATION AND MOTION
(From IEC 60092-101)

Static condition	Angular deviation about fore-and-aft axis	
	General conditions*	$\pm 15^\circ$
	Emergency conditions	$\pm 22^\circ 30'$
	Angular deviation about athwartship axis (trim)	
Dynamic condition	Emergency conditions*	$\pm 10^\circ$
	Rotation about fore-and-aft axis (rolling)†	$\pm 22^\circ 30'$
	Rotation about athwartship axis (pitching)	$\pm 7^\circ 30'$
	For sailing boats only: maximum heel angles of 45° on either tack	

* The boat in any combination of angles within these limits.

† These motions may occur simultaneously.

2.4 VOLTAGE AND FREQUENCY VARIATIONS

2.4.1 General

Equipment shall function under the normal voltage and frequency variations and harmonic distortion which can occur in the distribution system in normal operation.

2.4.2 d.c. systems

The nominal d.c. voltage tolerance at the battery terminals over which all d.c. equipment shall operate is +25%, -12.5%.

The boat's essential services shall remain functional to the minimum voltage at the battery terminals.

NOTE: When battery chargers and battery combinations are used as d.c. power systems, adequate measures should be taken to keep the voltage within the specified limits during charging, quick charging and discharging of the battery.

2.4.3 a.c. systems

The system shall be designed to operate within the following limits:

- (a) Frequency: $\pm 5\%$
- (b) Voltage: $\pm 10\%$
- (c) Total harmonic distortion: to be acceptable for the on-board loads to be supplied

2.4.4 Adverse effects and its interference

Electrical equipment shall be selected so that, during normal operation, including switching, it will not cause harmful effects to other equipment.

Factors that may need to be considered include the following:

- (a) Power factor.
- (b) Excessive voltage fluctuations.
- (c) Severe distortion of current waveforms.
- (d) Electromagnetic emissions.

NOTE: IEC 60945 and IEC 60950-1 or AS/NZS 60950.1 should be referred to for equipment that could cause electromagnetic disturbance.

2.5 ELECTRICAL POWER SOURCES

2.5.1 General

The boat's electrical power may be supplied by one or more generators or battery banks or combinations of generators, batteries and battery charging systems having sufficient capacity to supply the essential services.

2.5.2 d.c. systems supplied from batteries

Where dual-battery systems are installed, one battery or battery group shall be reserved for engine starting service, the other for supplying the boat's electrical services. It shall be possible to temporarily connect the engine to the service battery in an emergency to assist engine starting. Special charge splitting arrangements may also be fitted if required to enable two or more batteries to be recharged by a single charging source.

Each main battery bank shall be capable of being isolated from the d.c. system that is supplied, normally by a switch in each non-earthed conductor from each battery or group of batteries. The battery switches or control shall be fitted in a readily accessible location, as close as practical to the battery or group of batteries.

Isolation switches shall be placed on the exterior of battery compartments or containers. Remotely operated battery switches shall incorporate a means to clearly indicate the state of the switch and a local manual override control.

However, the following systems may be connected between the isolation switch and the battery as close as practical to the battery terminal:

- (a) Electronic devices with protected memory and essential services such as bilge pumps and alarms, if individually protected by a fuse or circuit-breaker.
- (b) Ventilation exhaust blower of engine/fuel tank compartment if separately protected by a fuse or circuit-breaker.
- (c) Charging devices that are intended to be used when the boat is unattended (e.g. solar panels, wind generators) if individually protected by a fuse or circuit-breaker.

The minimum continuous rating of the battery isolation switch shall be at least equal to the maximum current for which the main protective device is rated and also the intermittent load of the starter motor circuit, or the current rating of the feeder conductor, whichever is less. A separate battery disconnect switch may be installed for the engine-cranking motor circuit.

2.5.3 d.c. generator

Where the generator is the only charging source, it shall be capable of supplying the maximum demand of the boat and simultaneously be capable of charging the main battery bank to 80% charge within 10 h.

Wind driven d.c. generators, towed impeller driven generators and photovoltaic systems shall be fitted with charge regulators set so that the battery manufacturer's maximum charging voltage is not exceeded.

NOTE: These are generally alternators with integral rectifiers and regulators fitted to the propulsion machinery which charge accumulator batteries supplying the boat's electrical equipment and essential services.

2.5.4 a.c. systems

2.5.4.1 Power source

Power may be provided by one or a combination of the following to supply the maximum demand of the boat:

- (a) One or more shore power connections per boat, and associated power inlets, wiring and components with a capacity to supply the maximum demand of the boat.
- (b) Inverter supplying a.c. power from the boat's d.c. system.
- (c) On-board a.c. generator(s) supplying the required system load.
- (d) Combination of shore power connection(s) and on-board generator(s) used simultaneously if the boat's circuitry is arranged such that the load connected to each source is isolated from the other or supplies are combined in accordance with Clause 2.5.4.2 [from ISO 13297:2012 Cl.14.1(e)].

Individual circuits shall not be capable of being energized by more than one source of electrical power at a time except as provided in Clause 2.5.4.2. Two or more generators, when properly synchronized, shall be treated as one source. Each shore power inlet, generator or inverter shall be considered a separate source of a.c. electrical power. The transfer from one power source circuit to another shall be made by a means which opens all current-carrying conductors before closing the other source circuit, prevents arc-over between contacts and is interlocked by mechanical or electromechanical means. All current-carrying conductors shall be broken simultaneously when changing power sources.

2.5.4.2 Restrictions on combining power sources

Multiple independent power sources may be combined and transferred as follows:

- (a) *Shore power paralleling and combining devices* (also see Clause 3.5)
Devices capable of combining multiple independent shore power sources shall—
 - (i) achieve compatibility of phase relationships; and
 - (ii) preclude backfeeding of any source that is not intended to be energized or is inadvertently disconnected.
- (b) *Seamless transfer*
The following applies:
 - (i) a.c. power sources shall be synchronized before seamless transfer.
 - (ii) During seamless transfers between shore power and an on-board source, sources shall be paralleled for no more than 1 s to facilitate load transfer and be provided with backfeed protection.
- (c) Backfeed protection shall meet the requirements of AS 62040.1.1 or IEC 62040-1-1:2002.

(d) *Parallel operation of power sources*

The following requirements shall be met:

- (i) a.c. power sources shall be synchronized before paralleling.
- (ii) Power source output neutrals shall be in accordance with Clause 3.2.2(b).
- (iii) The output of on-board power sources intended to be operated in parallel shall be provided with—
 - (A) under/over voltage protection; and
 - (B) under/over frequency protection.

(iv) *Additional requirements for generators*

- (A) Provisions shall be made to load share paralleled generators during steady state operation.
- (B) Reverse power protection shall be provided.

NOTE: See manufacturer's information for best guidance.

(v) *Additional requirements for inverters*

- (A) Inverters intended to be used in parallel with other power sources shall be provided with backfeed protection.
- (B) Provisions shall be made to load share the output of paralleled inverters.

(vi) *Additional requirements for shore power converters*

Provision shall be made to—

- (A) prevent backfeeding on to the distribution system when any other source is inadvertently disconnected; and
- (B) load share the output of paralleled shore power converters.

NOTE: Authorization from the electricity distributor may be required to operate on-board a.c. supplies in parallel with shore power.

2.5.5 a.c. generator

An a.c. generator may be driven by its own prime mover or be powered from propulsion machinery, or be a shaft generator. Electrical machines, including shaft generators and/or static converters/inverters, shall comply with the relevant requirements of IEC 60092-301 and IEC 60092-304.

Where an a.c. system is provided as a main source of electric power and consists of a single generator, it shall be possible to supply the generator start circuits from an alternative source.

The power-feeder conductors from a generator shall be adequate for the thermal capacity of the generator and shall be protected at the generator with overcurrent protection devices in accordance with the requirements of IEC 60092-202.

The continuity of supply should not be impaired by load-produced harmonic distortion or high load changes.

The combined prime mover, transmission system and generator shall be designed to withstand without damage the effects of the most onerous short-circuit condition at the generator terminals when running at rated voltage and speed.

Where synchronization and parallel operation of several generators is required, the requirements of Clause 2.5.4.2 shall apply.

2.5.6 Measuring instruments

2.5.6.1 General

Normal full load values shall be marked in red on the instrument scale for all indicating instruments, and appropriate labels shall be fixed to digital instruments when employed.

2.5.6.2 Instruments for batteries

Service battery banks shall be provided with at least one voltmeter switchable between each group, and an ammeter. Alternatively, proprietary battery condition monitoring devices may be fitted to monitor and display the state of the battery(s).

Each start battery shall be provided with a voltmeter.

2.5.6.3 Instruments for d.c. generators

A d.c. generator of 5.5 kW output or more, which is not operated in parallel, shall be provided with at least one voltmeter and one ammeter.

Generators for parallel operation shall be provided with one voltmeter for each generator (or one voltmeter and a changeover for its connection to each generator), one ammeter for each generator and one voltmeter for each section of busbar.

For compound-wound generators fitted with equalizer connections, the ammeter shall be connected to the pole opposite to that connected to the series winding of the generator.

2.5.6.4 Instruments for a.c. generators

An a.c. generator not operated in parallel, except single-phase generators smaller than 2 kVA, shall be provided with at least one voltmeter and an ammeter in each phase (or one ammeter with a selector switch which enables it to measure the current in each phase). Generators greater than 15 kVA shall be provided with a frequency meter.

NOTE: When an a.c. generator is installed a frequency meter should be used.

Generators for parallel operation shall be provided with a wattmeter and an ammeter in each phase conductor (or one ammeter with a selector switch to permit the measurement of current in each phase). Wattmeters shall be capable of indicating reverse power up to 15% of the rated full load of the generator. Two voltmeters, two frequency meters and a synchronizing device comprising either a synchroscope and lamps, or an equivalent arrangement, shall be provided for paralleling purposes. One voltmeter and one frequency meter shall be connected to the busbars; the other voltmeter and frequency meter shall have a selector switch to permit measurement of the voltage and frequency of any generator.

NOTE: When generators are run in parallel in installations with the neutral earthed, it is necessary to ensure that the equalizing current caused by harmonics does not exceed harmful values. Reference is to be made to guidance from the generator manufacturer.

2.6 EQUIPMENT

2.6.1 Transformers

Wire wound transformers used for power, lighting and as static converters, starting transformers, static balancers, saturable reactors and transducers, single-phase transformers and three-phase transformers shall comply with the AS/NZS 61558 series of Standards.

Transformers shall be installed in well-ventilated locations. Their connections should be protected against such mechanical damage, condensation and corrosion as may be reasonably expected.

Switched mode transformers shall meet the safety requirements of IEC 60950 or AS/NZS 60950.1, and the environmental and EMI/EMC requirements of IEC 60945.

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NOTE: Attention is drawn to the individual Australian state regulations and the New Zealand Electricity Regulations that have specific requirements for safety of electrical equipment.