Guideline No.E-12 (202511)

E-12

LOW-VOLTAGE SWITCHBOARD

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Foreword

CCS Product Inspection and Testing Guideline (hereinafter referred to as this Guideline) contains the technical requirements, inspection and testing criteria related to classification and statutory survey of marine products to be applied for CCS approval/inspection.

This Guideline frees the users to adopt other test methods and requirements which are equivalent to or are stricter than this Guideline.

This Guideline is published and updated by CCS, and is released at http://www.ccs.org.cn. Your comments or suggestions are welcomed and may be sent to our email addressed service@ccs.org.cn.

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Main changes :

1. Add the test requirements for AC daily distribution panels in DC integrated power systems.

2. Editorial amendments and corrigenda.

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LOW-VOLTAGE SWITCHBOARD

1 Application

1.1 The Guideline applies to the plan approval and inspection on the low-voltage switchboard and distribution apparatus, which are used in low-voltage AC power distribution systems installed on the marine ships.

1.2 The low-voltage switchboard consists of the main switchboard and emergency switchboard (including the battery charging and discharging panel).

1.3 In consideration of the variety of marine low-voltage switchboard and distribution apparatus, CCS does not require any works approval or type approval. The Guideline applies to the low-voltage power distribution equipment that is not subject to type approval. For such products in batch production, CCS encourage the marine product manufacturer conducts a type approval and test on the low-voltage power distribution equipment. For specific requirement, see the product standard described in Article 2 of the Guideline. The applicable requirement in the Guideline should be met at the same time.

1.4 It can be cited for the inspection on similar equipment used on the marine installations.

1.5 The Guideline does not apply to the approval and inspection on electrical/electronic equipment used on the above-mentioned equipment (such as the circuit breaker, fuse, and generator protection device).

2 Normative reference documents

2.1 CCS Rules for Classification of Sea-going Steel Ships;

2.2 IEC60092-302-2:2019 Electrical installations in Ships - Part 302: Low-voltage switchgear and controlgear assemblies – Marine power;

2.3 IEC60092-504:2016 Electrical installations in ships - Part 504: Special features - Control and instrumentation;

2.4 IEC60865-1:2011 Short-circuit currents – Calculation of effects – Part 1: Definitions and calculation methods;

2.5 IEC61439-1:2020 Low-voltage switchgear and controlgear assemblies – Part 1:General rules;

2.6 GB/T 7061-2016 Low-voltage switchgear and controlgear assemblies in ship.

3 Terms and definitions

The terms and definitions specified in the above-mentioned basis apply to the Guideline. To facilitate the compilation and use, the Guideline directly cites or supplements the following definitions.

3.1 *Steel Rules*

It means the CCS Rules for Classification of Sea-going Steel Ships.

3.2 Essential equipment

The equipment necessary for propulsion, steering and ship safety, as well as those special equipment with CCS class notations on the ship. They are divided into primary essential equipment (which should conduct continuous operation for propulsion and steering) and secondary essential equipment (which is not necessary to conduct continuous operation for propulsion and steering, but necessary for guaranteeing ship safety). For details, see 1.1.2.1 of Part Four of *Steel Rules*.

3.3 Switchgear and controlgear assemblies

Assemblies of one or more switching devices, the combination of control, measurement, signal, protection and adjustment equipment, and the internal electrical and mechanical connectors and structural members assembled by the manufacturer.

3.4 Main switchboard

The switchgear and controlgear assemblies used to control and distribute the power provided directly by the main power supply to various equipment on the ship.

3.5 Emergency switchboard

Emergency switchboard is a switchboard which, normally supplied by the main switchboard, in the event of failure of the main electrical power supply system is directly supplied by the emergency source of electrical power or the transitional source of emergency power and is intended to control and distribute electrical energy to switch gear and control gear assemblies of the ship’s emergency services.

3.6 Charge and discharge board

The distribution apparatus used to monitor, control, and protect the charge and discharge of the battery, excluding the battery charger (unit).

3.7 Low voltage system

The a.c. system operated at the rated frequency of 50Hz or 60Hz and the max. voltage between conductors of not more than 1000 V, or d.c. system with the max. transient voltage between conductors of not more than 1500 V under the rated operating conditions.

3.8 Partition

The parts made of steel plate or other flame retarding materials and used to separate a compartment with another.

3.9 Compartment

The structural unit that is separated with the distributing board and other spaces via the partition and that can be opened only in case of internal wiring, adjustment or ventilation.

3.10 Rated current

The rated current of certain circuit in the LV distributing board and distribution apparatus should be determined by the manufacturer based on the rated value, arrangement and application of the components and parts in the electrical equipment in the circuit of the device. To determine the rated current of the electrical device of the ship, the temperature rise of the device should not exceed the specified limit when temperature rising test is conducted according to 5.2.

3.11 Rated ultimate short-circuit breaking capacity (Icu)

The breaking capacity value of circuit breaker under the test conditions (the voltage, current and power factor) does not include the capability of the circuit-breaker to carry its rated current continuously.

3.12 Rated service short-circuit operation breaking capacity (Ics)

The breaking capacity value of circuit breaker under the test conditions (the voltage, current and power factor) includes the capability of the circuit-breaker to carry its rated current continuously.

3.13 Rated short-time withstand current (Icw)

The current value that the circuit or circuit breaker at the ON position can carry without damage in specific time under specified operation and performance conditions.

3.14 Rated short-circuit making capacity (Icm)

The short-circuit making capacity value of the circuit breaker under the rated operating voltage and rated frequency specified by the manufacturer, as well certain power factor (for a.c.) or time constant (for d.c.), which is expressed with the max. estimated peak current.

3.15 Main bus bar

The bus connecting one or several sub-bus bars and (or) the incoming & outgoing units.

3.16 Sub-bus bar

The bus bar connected with the main bus bar and used to supply power for the electrical load.

3.17 Switchboards of the same type in batch production

The switchboards produced by the same manufacturer with the same structure, same bus structure, size and material, as well as same generator line circuit breaker connection, and same rated current.

4 Plans and documents

4.1 Basic principle of review of plans and documents

For such key power distribution equipment as the main switchboard and emergency switchboard (including the emergency charge and discharge board), CCS makes product plan approval together with the ship plan approval. The ship plan approval is conducted by the ship plan approval unit of CCS. The product plan approval is conducted by the qualified product inspection unit (or the plan approval unit).

4.2 Ship plan approval

The ship plans mentioned below provide a basis for design of such key power distribution equipment as the main switchboard and emergency switchboard, which must be approved by the ship plan approval unit of CCS. The ship plans approved by CCS and the plan approval submissions should be submitted to the product inspection unit together with the product plans.

4.2.1 Short-circuit current calculation book (applicable to ships with total parallel-connection generator capacity of more than 250 kVA);

The short-circuit current should be calculated according to the methods specified in CCS regulations (see the annexes) or IEC61363-1;

4.2.2 Analysis on actuation coordination of electric protection equipment (applicable to ships with total parallel-connection generator capacity of more than 250 kVA). For detailed analysis method, see the requirements in relevant Guidelines of CCS;

4.2.3 Single line diagram of the main switchboard (if any);

4.2.4 Single line diagram of the emergency switchboard, charge and discharge board of the emergency battery (if any);

4.2.5 Diagram of electric power system;

4.2.6 Power load calculation book.

4.3 Product plan approval

4.3.1 The following plans and documents should be submitted to CCS for approval:

(1) General plan (including the outline plan, base plan, and structure plan);

(2) Panel arrangement plan;

(3) Technical conditions of product (which specify the applicable regulations, model and specifications, main technical requirements and test of the power switchboard) (it can be omitted if other plans and technical documents of the power switchboard cover the contents related);

(4) Electrical schematic diagram (indicating codes of each component and part, model/specification of each loop wire, material and specification of the bus bar, and the main equipment parameters);

(5) Other plans and documents required to be submitted for approval (if any). For example, software specification (including function description of software module and related hardware description, control/logic flow chart, software version number, software maintenance and update description).

4.3.2 The following plans and documents should be submitted to CCS for information:

(1) Specification list of supporting electrical appliances (indicating the name, model, specification, and quantity of the component and part, as well as its code in the plan);

(2) Product operation instructions (It can be omitted if other plans and technical documents of the power switchboard cover the contents of the instructions);

(3) External wiring diagram;

5 Design and technical requirements

5.1 Structure, assembly and components

5.1.1 The switchboard should be provided with the protective enclosure specified in Table 1.3.2.2 in Part Four of the *Steel Rules.* All protective enclosures should be made of flame-retarding and anti-corrosion materials (or with reliable protection layer), and provided with solid structure.

5.1.2 The top of the power switchboard should reach a grade of IP22, which can be IP 21 if it is installed in the control room meeting the requirement in 2.1.4.2 of Part Four of the *Steel Rules.* Protective means with grade of not less than IP 2X should be provided at both sides of the power switchboard. If the rated voltage is more than 500 V, the protective means with grade of not less than IP 2X should be provided in the rear of the power switchboard.

5.1.3 Measures should be taken at the cable incoming position of the power switchboard, so as to prevent water intrusion into it

5.1.4 If the voltage to earth or operating voltage is more than 50 V, the naked live part should not be installed on the panel;

5.1.5 If the total generator capacity exceeds 100 kVA (a.c.), each generator should be provided with independent generator panel, and steel plate or other flame-retarding materials should be set between generator panels as well as the generator panel and other adjacent panel for separation. Baffles should be set between the generator circuit breaker unit and the control function unit to avoid any electric arc effect.

5.1.6 The binding post used for systems with rated voltage of more than 500 V should be separated from that with low voltage, and provided with distinct mark.

5.1.7 Partitions should be provided between panels of the power switchboard. The switchgear of the power distribution system with different voltages should be set on different panels; when being set at the same panel, partitions should be provided for separation;

5.1.8 The control units of essential equipment should be set at their appropriate compartments as far as possible;

5.1.9 Measures should be taken on the power switchboard to prevent the free hot gas produced due to internal short circuit from escaping from the front of the power switchboard;

5.1.10 Each power switchboard should be provided with an insulated handrail installed on a fixed part, or an insulated handle installed properly in front of the power switchboard. If the rear of the power switchboard must be accessible for operation and maintenance, an insulated handrail or handle must also be provided in the rear. And horizontal insulated handrails are to be fitted on a fixed part of the switchboard.;

5.1.11 The structure as well as the internal electrical component, circuit and terminal arrangement of the power switchboard should be in line with the designed installation pattern. In any case, it should facilitate the operation and maintenance, and guarantee necessary safety class. The terminal (bar) should be kept at 0.2 m at least on the mounting base.

5.1.12 The effective space for wiring should guarantee the correct connection of the external conductor made of specific material and the multi-core cable with separated core wire. The conductor should not bear the stress affecting its service life.

5.1.13 Each panel of the power switchboard should be provided with reliable grounding device. Reliable grounding should be provided between the panel and structure installed with electrical component, and between the structure and the base. If the operating voltage of the power switchboard or electrical component is less than 50 V, and the a.c. voltage is obtained via non-autotransformer, grounding is not required, unless otherwise specified. The secondary winding of the voltage transformer and current transformer should be grounded reliably, and the grounding position should be provided with durable grounding mark; the grounding wire and

screw should not be shared by the protective grounding and working grounding. The sectional area of the grounding conductor fixed separately should meet the requirement in the table below:

Size of the earthing conductor (mm^2) **Table 5.1.13**

Cross-sectional area of relevant current-carrying conductor S mm^2	Min. cross-sectional area of copper earthing conductor Q mm^2
S≤2.5	Q=S, but not less than 1.5
2.5＜ S≤120	Q=S/2, but not less than 4
S＞120	Q＝70

5.2 Bus bar and bus bar sectioning

5.2.1 The bus bar should be made of aluminum alloy cladded by conductive cathode copper or copper, with the max. allowable temperature rise of 45 K(Ambient air temperature at 45 degree Celsius). Or meet the requirements of IEC60092-302-2.

5.2.2 The bus bar and its supporting components should bear thermal stress and mechanical stress generated during short circuit without any damage. For power distribution unit with rated short circuit current of more than 10 kA, the short-circuit strength of the bus bar and its supporting components should be calculated and reviewed according to IEC60865-1 or other standard accepted by CCS if necessary if somebody required.

5.2.3 The rated current-carrying capacity of the main bus bar (or part of it) is the carrying current (root-mean-square value) crossing the main bus bar at the max. load condition, whereas the rated current-carrying capacity of the sub bus bar is the total current of the branch circuit (with proper rated diversity factor), as shown in 5.4 and Anex E of IEC61439-1. The rated current-carrying capacity of the main bus bar should not be less than the current value crossing it at the max. load condition as specified in the CCS-approved power load calculation book.

5.2.4 The current-carrying capacity of the equalizer bus bar should not be less than 50% of the rated max. generator current at the power station.

5.2.5 The sectional area of the neutral bus bar in the a.c. three-phase four-wire system should not be less than 50% of that of corresponding bus bar.

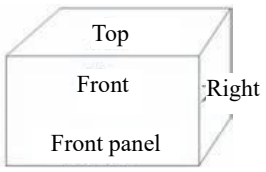
5.2.6 Proper measures should be taken on the bus bar (its supporting members and connection) to maintain its conductivity during long-term operation, and the nuts should be provided with locking device.

5.2.7 The connection between the main bus bar and equipment should be realized via the sub-bus bar. If any insulated cable is adopted for connection, the cable and its rating should meet the requirement specified in Section 12 of Chapter 2 in Part Four of the *Steel Rules,* and the flexible cable with the max. conductor working temperature of not less than 75℃ should be selected.

5.2.8 The bus bar phase sequence (a.c.) or polarity (d.c.) in the switchboard should be arranged according to the requirement in Table 5.2.8.

Installation arrangement of the phase sequence or polarity **Table 5.2.8**

Bus bar	Phase	Position of bus bars	Sketch

	sequence or polarity	Vertical	Horizontal	Downlead	
a.c.	Phase 1	Top	Front	Left	As viewed from the front of switchboard assembly 
	Phase 2	Middle	Middle	Middle	
	Phase 3	Bottom	Rear	Right	
d.c.	Positive pole	Top	Front	Left	
	Equalizer pole	Middle	Middle	Middle	
	Negative pole	Bottom	Back	Right	

5.2.9 The main bus bar of the main switchboard should be divided into at least two separate sections as per 2.1.1.1 (5) in Part Four of the *Steel Rules*, which are required to be connected with the circuit breaker, disconnector or other means accepted by CCS without any protective automatic trip mechanism such as overload or short-circuit protection. The generator and other double-set equipment should be connected to those sections in a uniform manner as far as possible. The main switchboard used on ships of less than 500 GT or domestic ships with total power station capacity of less than 500 kVA may not be sectioned, but should meet the requirement of the single line diagram of the approved switchboard. The circuit breaker or disconnector used in the section connection mentioned above should be produced according to the standard accepted by CCS (such as the IEC60947-2 and IEC60947-3). The rated current-carrying capacity of the connection device should be consistent with that of the main bus bar, and the rated short-time withstand current of the device should not be less than the expected symmetrical short circuit current (root-mean-square value) of its installation point.

5.3 Electrical clearance and creepage distance

5.3.1 The electrical clearance and creepage distance between live parts as well as the naked conductive part and live part in the switchboard should meet the requirement in Table 5.3.1.

Min. electrical clearance and creepage distance **Table 5.3.1**

Rated voltage V	Min. electrical clearance mm	Min. creepage distance mm
≤ 250	15	20
250＜ ≤ 690	20	25
＞ 690	25	35

5.3.2 The naked live conductor and terminal connected directly with the equipment (such as the bus, connection between electric appliances and cable joint) should have the electrical clearance and creepage distance at least meeting relevant requirement of the electrical apparatus element connected with them directly, with additional insulation measures (e.g. installation of insulating bush) taken if necessary.

5.4 Operation instruction and control

5.4.1 The main switchboard should be provided with automatic starting device for the main generating set according to 2.1.1.1 (4) in Part Four of the *Steel Rules*. Other automatic control devices (such as the automatic parallel operation switchgear and automatic generating system) should be provided as per the applicable requirement in Part Seven of the *Steel Rules*. The

automatic control device should be set in such a way that it will not hamper the manual operation in case of its failure.

5.4.2 Each main generating set should be provided with an automatic starting device. If the automatic starting device is shared by multiple generating sets, necessary redundancy should be provided. The automatic starting device should not be powered only via the main power supply.

5.4.3 The setting and power supply of other automatic control device should be based on the actual conditions, and meet the requirement of 5.4.2.

5.4.4 The generator control panel should be provided with a lamp to indicate the making/breaking of the generator circuit breaker. If the generator is provided with a space heater, an operating indicator for it should be provided on the generator control panel.

5.4.5 A facility should be provided on the control panel (or paralleling panel) of the a.c. generator with parallel operation to make remote regulation for the rotatory speed of the prime motor at ± 10% of the rated speed.

5.4.6 Interlocking apparatus should be provided between the main generator and emergency generator as well as between the main generator and the shore power, so as to avoid simultaneous power supply. Proper measure should be taken to avoid any maloperation during manual parallel connection.

5.4.7 For transformers designed not for parallel operation, proper interlocking measures should be provided.

5.4.8 Lamps indicating the main switchboard power supply status and charge power supply status should be provided on the charge and discharge board of the emergency power supply and temporary emergency power supply.

5.4.9 The battery charge equipment should meet the requirement in Section 11 of Chapter 2 in Part Four of the *Steel Rules*.

5.4.10 Indicators should be provided in proper position in the main switchboard or machine control room to indicate the operating status of the emergency power supply or temporary emergency power supply as well as the power supply status of the shore connection box (such as the power supply of the emergency generator and the discharge of the battery).

5.4.11 Insulation monitoring alarm should be provided on the main switchboard and emergency switchboard to monitor continuously the insulation resistance of the primary and secondary systems, and give an audio or visual alarm signal in case of low insulation resistance. That requirement should also be met if the main bus bar is provided with sectioning. That requirement may not be met for the control circuit powered via the power supply unit.

5.4.12 The colors of the indicating lamp, alarm lamp and button on the switchboard should meet the applicable requirement specified in Section 3 of Chapter 1 in Part Four of the *Steel Rules*.

5.5 Wiring and component mark

5.5.1 The wiring and mark in the switchboard should meet the requirement specified in Annex 1 "Technical requirement on the laying and connection of marine wire and cables".

5.5.2 The cable used in the power distribution unit should meet the requirement in Section 12 of Chapter 2 in Part Four of the *Steel Rules*. The type selection and laying of cables for such electronic equipment as the generator protection module and automatic generating unit should meet the manufacturer's relevant requirement.

5.5.3 For cables with diameter of more than 2.5 mm^2, the cable lug should be adopted instead of welding connection.

5.5.4 Durable nameplates marked with usage and operation position should be provided for such parts on the switchboard as the instrument, switch, indicating lamp, button, operating handle and handwheel.

5.5.5 Each circuit and its equipment (component) should be provided with durable mark. The overload protection device (component) should be provided with durable mark (label) indicating the rating or setting value at the place where it is installed. For fuse of over 500 V, special warning board should be provided if a fuse of low rated voltage can be inserted to the fuse holder, for example, "Caution! Only a 660 V fuse can be used.".

5.5.6 The cable of the main loop should be laid independently of the cable of the control loop.

5.6 Circuit breaker:

5.6.1 The circuit breaker should meet the requirement of the IEC60947-2 publication or other generally accepted standard accepted by CCS. The circuit breaker should be of free trip type.

5.6.2 The switch and circuit breaker, when being in the off position, should not be turned on due to unexpected movement.

5.6.3 The making/breaking capacity of the circuit breaker should be determined according to the short-circuit current calculation book approved, with the basic principles shown as below (for detailed requirement, see Section 5 of Chapter 2 in Part Four of the *Steel Rules*):

(1) The rated short circuit breaking capacity of a common circuit breaker should not be lower than the expected max. short circuit current necessary for breaking at the installation point. For the a.c. system, the rated short circuit breaking capacity should not be lower than the expected symmetrical short-circuit current at its installation point (root-mean-square value).

(2) The Ics of the circuit breaker used for essential equipment or emergency equipment circuit or installed on the main switchboard or emergency switchboard should not be lower than the expected max. short circuit current necessary for breaking at the installation point. For the a.c. system, the Ics should not be lower than the expected symmetrical short-circuit current at its installation point (root-mean-square value).

(3) The Icu of the circuit breaker used for the equipment and / or emergency circuit rather than those mentioned in (2) should not be lower than the expected max. short circuit current necessary for breaking at the installation point. For the a.c. system, the Icu should not be lower than the expected symmetrical short-circuit current at its installation point (root-mean-square value).

(4) The Icw of B-type circuit breaker (with short-time delay) should not be lower than the expected max. short circuit current measured when the contact is broken at its installation point. For the a.c. system, the Icw should not be lower than the expected symmetrical short-circuit current measured when the contact is broken at its installation point. (root-mean-square value).

(5) The Icm of the circuit breaker or switch turned on in case of short circuit should not be less than the maximum peak (Ip) of the expected short circuit current at its installation point.

(6) If any fuse or circuit breaker (rather than the generator circuit breaker) with necessary rated short circuit making/breaking capacity is provided at the generator side for backup, the circuit breaker with available rated short circuit breaking capacity and/or rated short circuit making capacity lower than the expected max. short circuit current at its installation point can be used.

(7) Manual operating mechanism must be provided for power-operated circuit breakers, so as to guarantee continuous operation in case of any power-operated mechanism failure. The generator circuit breaker should be capable of being operated in front of the panel without the need to open the door cover.

(8) The circuit breaker with a fuse should be so structured that the single phasing will not occur when the fuse blows. It should also facilitate the replacement without any risk of touching live part unexpectedly.

5.7 Contactor

The contactor should meet the requirement of the IEC60947-4-1 publication or other generally accepted standard accepted by CCS.

5.8 Fuse

5.8.1 The design, production and test of the fuse should meet the requirement of IEC60269 publication or other generally accepted standard.

5.8.2 The fuse should be of closed type and structured such that the enclosure will not be broken or burned out when the fuse blows. The molten metal flow or gas generated should not damage the adjacent insulation.

5.8.3 The fuse should be so designed that the replacement with spare one is easy without any risk of electric shock or burn-out when the fuse is removed or installed.

5.8.4 In case of a long-term operation at the rated current, the temperature of the cable connection end of the fuse should not exceed the max. allowable operating temperature of the cable connected.

5.9 System protection

5.9.1 The electric installation protection setting and electric protector selection should meet relevant requirement in Section 5 of Chapter 2 in Part Four of the *Steel Rules* as well as that specified in the approved calculation book.

5.9.2 The setting of the over-current tripping device of the generator circuit breaker should be adjustable. If not, it should be easy to be changed into different values.

5.9.3 The protective device of each generator should be independent (including power supply), and the failure of any protective device should not affect the operation of others.

5.9.4 The power of the main circuit breaker of the generator set as well as the independent generator protection module should be supplied by the generator set protected. Other power supply means should be approved by CCS.

5.9.5 Normally, the power of the emergency switchboard should be supplied by the main switchboard via the feeder connected between them. The feeder should be protected as required, and should be cut automatically at the emergency switchboard in case of main power supply failure. If the reverse power supply is allowed, short circuit protection for such feeder should be provided at least on the emergency switchboard (for specific requirements, see the ship plans approved by CCS).

5.10 Instrument of the a.c. generator

5.10.1 The precision level of the measuring meter should be selected according to the purpose, which should not be less than level 1.5.

5.10.2 The range and scale of the measuring meter should comply with the following provisions:

(1) The upper limit of the voltmeter should be 120% of the rated circuit voltage;

(2) The upper limit of the ammeter should be 130% of the rated circuit current;

(3) The upper limit of the wattmeter should be 120% of the rated circuit power; the d.c. generator ammeter and a.c. generator wattmeter for parallel operation should indicate 15% of the reverse current and reverse power respectively;

(4) The frequency meter should have the scale of ±10% of the rated frequency;

(5) A clear sign indicating the rated value must be available on the dials of the voltmeter, ammeter, and wattmeter.

(6) The control panel of the generator should be provided with a measuring meter according to 5.10.2 or a higher standard.

5.10.3 The secondary winding of the voltage transformer and current transformer should be grounded reliably. The accuracy of the transformer used for the measuring meter should be at least grade 1. The current transformer used for the protective device and control device should be consistent with the expected over-current range and meet relevant requirement of the manufacturer.

5.10.4 The battery charge/discharge board should be provided with at least the following measuring meters: voltmeter (used to measure the charge/discharge voltage), and ammeter (used to measure the charge/discharge voltage).

5.10.5 For the power system with harmonic filter, the requirements of article 1.3.7 of Chapter 4 of CCS *Steel Rules* shall also be met. Confirm that the equipment or interface of the equipment that can continuously monitor the harmonic of the main busbar has been installed.

Measuring meters on the generator control panel **Table 5.10.2**

Generator type	Operating status	Meter type	Quantity
DC	Standalone operation	Ammeter	Each generator 1 set (connected to the positive pole)
		Voltmeter	Each generator 1 set
	Parallel operation	Ammeter	Each generator 1 set (connected to the positive pole)
		Voltmeter	2 sets (1 for measuring the bus bar voltage, and 1 for measuring the voltage of each generator)
AC	Standalone operation	Ammeter	Each generator 1 set (used to measure the current of each phase [line])
		Voltmeter	Each generator 1 set (used to measure the voltage of each phase [line])
		Wattmeter	Each generator 1 set (excluding those with capacity of less than 50kW (kVA))
		Frequency meter	Each generator 1 set
		Excitation ammeter	Each generator 1 set (if necessary)
	Parallel operation	Ammeter	Each generator 1 set (used to measure the current of each phase [line])
		Voltmeter	2 sets (1 for measuring the voltage of each generator phase [line], and 1 for measuring the bus bar voltage) or 1 set (used to measure each generator phase [line] voltage and back flow bus voltage via the conversion device)
		Wattmeter	Each generator 1 set
		Frequency meter	2 sets (1 for measuring the bus bar frequency, and 1 for measuring each generator frequency) or 1 set (used to measure each generator frequency and back flow bus frequency via the conversion device)
		Synchronoscope	Shared by all generators 1 pc
		Excitation ammeter	Each generator 1 set (if necessary)

5.11 Function test of automatic power station (if applicable)

5.11.1 Remote starting and stopping test

Remotely start and stop each generating set, and inspect the control performance of each remote governor.

5.11.2 Shut down test

Simulate the signal for shut down of each prime motor, the generators are to shut down. At the same time, inspect the alarm system for alarm in centralized control station and group alarm in bridge control station.

5.11.3 Automatic starting and stopping test

(1) Bus-bars abnormality test

Simulate the voltage and frequency of bus-bars higher or lower than the operating value (exceeding set range) respectively, after a time delay, the standby generating set is to automatically start and switch on after the automatic switch off of the generating set in case of failure.

(2) Power failure test

Inspect the standby generating set is to start and be switched on automatically in a simulated condition of failure and stopping of the generating set in operation. Where the starting of the first standby generating set fails, the second standby generating set is to continue to start and be switched on. Where the emergency generating set supplies power before the standby set, the emergency set is to be capable of being switched off automatically before the standby set is switched on.

(3) Inspect the first standby generating set is to start in a simulated condition of short circuit of bus-bars and tripping of the generating set in operation. Where the standby set fails to be switched on, the second standby generating set is to start and is not to be switched on automatically.

(4) Overload test

Increase the load to set value (e.g. 85% of rated output), the standby generating set is to start automatically and switch in the electric network after a time delay (e.g. thirty seconds).

Increase the load to set value (e.g. 105% of rated output), the non-essential services are to be shed automatically after a time delay (e.g. five seconds).

Duplicated generating sets operate in parallel, decrease the load to set value (e.g. 20% of the rated output of the duplicated sets), then after a time delay (e.g. 60 seconds), the load is to be transferred automatically. The standby set is to be switched off and stop after some time of race rotation (e.g. 60 seconds).

(5) Heavy load interlocking test

Push the application button for starting heavy load such as athwartship thruster, hoisting appliances, fire pump, ballast pump, bilge pump, the switchboard is to give signal for starting if the load capacity of the power station permits, otherwise, the standby generating set is to start automatically and connect the network, and the switchboard is to give signal for starting.

5.12 Short circuit test of AC daily power distribution board (if applicable)

5.12.1 This article applies only to ships equipped with a DC integrated power system and meeting the requirements of the AC daily power distribution system in Chapter 3 of the 《Guidelines for inspection of DC integrated power systems for ships》.

5.12.2 Three-phase short circuit of AC busbar in AC daily power distribution system

In the event of a fault, the bus tie protection device (if applicable) connected to the faulty AC busbar section, along with the AC power supply unit, will either shut down or trigger protective devices in its distribution circuit. For non-faulty AC busbar sections powered by the power supply unit, power restoration and equipment operation can be automatically initiated immediately after the bus tie protection device activates. Neither the power supply unit nor the load equipment will sustain any damage.

5.12.3 Three-phase short circuit at the output end of the power supply device in the AC daily power distribution system

In the event of a fault,the power distribution branch protector of the fault power supply device should be activated; the corresponding AC busbar of the fault power supply device should be able to restore power supply within 45s (if power failure occurs); the power supply device and load device should not be damaged.

5.12.4 Three-phase short circuit at the load input end of the daily distribution system

In the event of a fault, the protective appliances of the faulty load branch should be operated, the power supply of the AC bus and other loads is not affected; the power supply device and load device are not damaged;

5.12.5 If the above test cannot be completed due to equipment supporting reasons before the installation on board, it is allowed to be carried out in the mooring test.

6 Raw materials and components

The raw materials and components of the products shall be controlled according to the relevant requirements of current CCS rules and guidelines.

7 Type test

Considering the diversity of product specifications of marine low-voltage distribution panels and distribution appliances, CCS does not require work approval or type approval for such products.

Therefore, this guide is applicable to low-voltage distribution equipment without type test. For such products produced in batches, CCS encourages manufacturers of marine products to carry out type approval and testing of low-voltage distribution equipment. Specific requirements may be based on the standards specified in chapter 2 of this Guide, such as GB/T7061, and shall also meet the applicable requirements in this Guide.

8 Unit/batch Inspection

8.1 Genaral

The factory test program should be confirmed by suveryor and manufacturer ,if feasible also with shipowner and shipbuilder.

The switchboard should be subject to the following tests in the factory according to the comfirmed factory test program, but for products of the same type in batch production, only the first article is subject to temperature rise test. If some factory test items specified in 6.5 and 6.8 (such as the power station automatic control device function test and main generator circuit breaker protection test) cannot be conducted during the factory test due to lack of test condition or special test equipment, they should be noted in the remark column of the product certificate, indicating that they must be confirmed by the CCS Surveyor at site during the HAT (or SAT) after product installation.

8.2 Temperature rise test: The temperature rise test shall be carried out on the main busbar of the main switchboard, and the current should be the value which is mentioned in 5.2 rated carrying capacity.. For test method, see 10.10 of IEC61439-1 for reference.

8.3 High voltage test: The switchboard should be subject to high voltage test as per 6.3 at the test voltage frequency range of 25~100Hz, which should last for 1 min. without breakdown. For high voltage test, the semiconductor devices can be removed, and such accessories as the measuring meter, capacitor and indicating lamp may not be subject to test. The high voltage test should be carried out between all live parts and the enclosure and between poles (phases).

Voltage of high voltage test **Table 6.3**

Rated voltage (V)	Test voltage (V)
$Un \leq 60$	1000
$60 < Un \leq 300$	2000
$300 < Un \leq 690$	2500
$690 < Un \leq 800$	3000
$800 < Un \leq 1000$	3500
$1000 < Un \leq 1500$ ①	3500

Note: ① Only for d.c.

8.4 Insulation resistance measurement: After the high voltage test, a d.c. megger of at least 500 V should be used to measure the insulation resistance of all current-carrying parts to the ground as well as that between poles and phases, which should not be less than 1 MΩ.

8.5 Electrical function test: Check for control, interlocking, alarm and indication, display instrument indication, and emergent air and oil cut-off of the switchboard. The function test on the automatic control device should be carried out as far as practicable.

8.6 Structure and wiring inspection: It should be carried out as per the requirements of 5.1 and 5.5, and the enclosure protection level test should be carried out if necessary.

8.7 Inspection of electrical clearance and creepage distance: as per 5.3 of the Guideline.

8.8 Inspection and test on the system protection function should be carried out as per 5.9 of the Guideline as far as practicable. Automatic power plant functional test (if applicable) should be carried out as per 5.11 of the Guideline as far as praticable.

8.9 Short circuit test of AC daily power distribution board (if applicable): It should be assessed whether the relevant requirements of Section 3.4.4, Chapter 3, section 4 of the 《Guidelines for inspection of DC integrated power systems for ships》.And should be carried out in accordance with the requirements of 5.12 of this Guide as far as praticable.

Appendix 1 Technical requirements for laying and connecting marine cables and cables

1. Scope

This requirement specifies the technical requirements for the laying and connection of electrical wires and cables in marine machinery and electrical equipment. It is applicable to the internal wiring of marine electrical equipment, such as the main switchboard, the distribution box, the electromagnetic starter, the charging panel, the wheel house console, the engine room console, and the wiring of wire and cable in the marine machinery equipment such as diesel engine.

2. Technical requirements for laying and connecting wires and cables in electrical assembled equipment.

2.1 The electric wires and cables which meet requirements should be selected. The voltage level of wires and cables shall be applied to the rated voltage of electrical equipment. Conductors of wires and cables shall be twisted by multiple wires of copper and shall meet the requirements of class 5 of conductors stipulated by IEC60228. Wires and cables for power distribution loop and control loop should be separately laid as far as possible.

2.2 The connection between the two connection points should be complete, and no spliced or welded wires should be used.

2.3 Both ends of the wire should be reliably connected with the terminals of the electrical components or the special connection terminals. 2~3 joints can be connected to the same terminal. The joints of small section wires should be placed on the upper side of large section wire connectors. Connecting pieces should be used when small size joints are connected to larger ones.

2.4 It is suggested that the connection mode of cold-swaged joint is adopted. It is recommended to use "O" or "U" type cold-swaged joint. If the "C" type cold-swaged joint is selected, the fastening side should ensure that the notched side should be in line with the tightening direction of the nut. The needle type cold-swaged joint and the corresponding terminal are not recommended in general, unless a sufficient needle type cold-swaged joint, a special cold-swaged tool and a special fastening tool are provided to the ship. Single point welding is not allowed, unless proper

2.5 The material for cold-swaged joint should be silver plated copper, nickel plated copper or tinned copper.

2.6 The joint between the cold-swaged joint terminal and the wire& cable should be connected with the special stripping and pressing tools, and ensure the reliable contact between the

cold-swaged joint terminal and the wire core, and there should be no visible gap in the cross section. No conductor should be exposed between the ends of the cold-swaged joint terminal and the insulation layer of the wire, nor insulation material should be pressed between the wire conductor and the cold-swaged joint terminal. The connection between the wire and the cold-swaged joint terminal should be covered with insulating sleeves. All conductive parts must not be exposed except for the effective electrical connection part.

2.7 The specifications of the cold-swaged joint should be consistent with that of the wire. It is not allowed to press 2 or more wire conductors in a cold-swaged joint.

2.8 Use the steel screws coated with anticorrosive metal layer to reliably fasten the cold-swaged joints to the electrical components and the wiring terminals. Fasteners should be prevented from loosening due to vibration. For example, the spring washer and disc washer should be installed on the general washer.

2.9 The welding of wire and cable conductor should be rosin flux or neutral flux. Corrosive flux should not be used. The solder joints should be clean, smooth, burr free and not false welding.

2.10 The wires and cables used for power distribution should be marked with different colors, and the ends of the wires shall have a clear and durable number consistent with the drawings.

2.11 The connecting wires between the electrical components should be moderate in length, leaving a certain allowance for repair and replacement of connectors. Electrical wires, cables and electrical components connected should not be subjected to additional stress.

2.12 The laying of wires and cables should be as smooth, vertical, neat and beautiful as possible. In addition to meeting the special requirements of EMC, avoid crossing and winding wires as far as possible. The bending radius of wire and cable should not be less than 4 times of its outer diameter. The bending radius of wires and cables with a diameter larger than 25mm should be no less than 6 times of its outer diameter.

2.13 The wires and cables which are laying inside the equipment should be reliably fixed to avoid scraping between wires, cables and the prominent parts equipment shells or structures (components). According to the actual situation, should choose cable trunking, wire fixed bracket / plate, tie band, tie wire and so on. No plastic adhesive wire fixator should be used.

2.14 When using cable trunking, safety, beauty and convenience should be considered. The space occupied by the wire should not exceed 2/3 of the cable trunking depth. The cable trunking should

be reliably fixed on the mounting plate.

2.15 The position which is not big enough to use cable trunking may use the nylon tie band or wire to fasten the wire and cable firmly on the installation bar (plate) which is pre welded on the equipment shell or the mounting plate. The size of the tie band should be selected according to the outer diameter of the bundled wiring harness. The spacing of the bundling should be as uniform as possible.

2.16 Wire bundles laid on the panel, or door, box cover and the connection of the box or skeleton, should be reliably coated with materials such as artificial leather cloth or nylon net to prevent damage to the wire. The degree of tightness of bandage can be easily adjusted with the bundling line. When door is closed, other components and appliances should not be touched; and when the door is opened, it should not be jammed.

2.17 When wires and cables pass through partitions, the openings on the clapboards should be smooth, without sharp edges and burrs. At the edge of the opening, rubber rings should be fixed or covered with insulating materials to avoid cutting or wearing wires and cables.

2.18 The grounding terminals of all electrical components are connected reliably to the special earthing bolts by using yellow and green two-color wiring wires. Ensure that the connection between the grounding element and the ground wire has good contact and electrical conductivity. It is advised to clean before installation, such as remove paint and protective film, and ensure that there is enough contact area between ground bolts and ground wire joints. After the completion of the connection, proper anticorrosion measures should be taken.

2.19 According to the rated current of the electrical components, the appropriate electrical intercepting area of the grounding wire should be selected, and the relevant requirements of the CCS "Rules for the Classification of Sea-going Steel Ships" (hereinafter referred to as "Rules") should be fulfilled, but the minimum is 2.5mm2. The grounding bolts should be made of good conductive materials, such as silver plating, nickel plating or tinned brassed copper, and have large enough conductive cross section to meet the requirements of "Rules". The grounding signs which are clear, strong and durable ,should be placed next to the grounding bolts. If an electrical component with a voltage greater than 50V is installed on the door or box cover, there should be a reliable connection between the door or the box cover and the special earthing bolt.

2.20 It is forbidden that using the same earthing screws for grounding of different properties.

2.21 Electrical equipment such as control box and switchboard should be equipped with special

access holes or stuffing box. The edge of the entry hole should be smooth, without sharp projections and sharp edges. There should be a special support for fixing wires and cables near the entry hole.

2.22 The terminals used for external wiring should be arranged near the entry hole or stuffing box (GLAND), and as far as possible, enough space can be provided for wiring operation.

3. Technical requirements for laying wires and cables on mechanical equipment.

3.1 Cable with metal armour and outer sheath should be choosed and installed on mechanical equipment as far as possible.

3.2 The cable with high temperature resistance and oil resistance shall be installed on mechanical equipment as far as possible. Such as mineral insulated cables, silicone rubber cables, neoprene rubber sheathed cables, etc are good choice. Do not choose PVC or other thermoplastic insulated or sheathed wires and cables as far as possible.

3.3 Cable should be laid at a lower temperature place as far as possible, and should not be laid near the parts of the hot components, such as the exhaust pipe of the internal combustion engine, which may produce high temperature (more than 90 degree Celsius) when working.

3.4 The wires and cables laid on the surface or inside of the mechanical equipment should be reliably fixed on the equipment, and the length should not be too long.

3.5 Wires and cables should be avoided as far as possible to lay on or near the moving parts of mechanical equipment so as to avoid wear or fatigue damage. If unavoidable, IEC60228 class 5 or 6 conductor wires and cables should be chosen. At the time of laying, it should be ensured that the wires and cables do not contact and friction directly with the mechanical parts of the activities, and there is enough length in the active position so that the minimum bend of the cable is not less than 8 times the outer diameter of the cable, and the wires and cables in other positions should be reliably fixed.

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