Guideline No.E-12 (201705)

E-12 Low-voltage Switchboard

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Foreword

This Guideline is a part of CCS Rules, which contains technical requirements, inspection and testing criteria related to classification and statutory survey of marine products.

This Guideline is published and updated by CCS and can be found through http://www.ccs.org.cn. Comments or suggestions can be sent by email to ps@ccs.org.cn.

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Main changes and effective date:

There is one change in normative reference file. The file “IEC60092-504:2001” is updated to “IEC60092-504:2016”..

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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 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 Given the specification variety of marine low-voltage switchboard and distribution apparatus, CCS does not require any works approval or type approval. As a result, the Guideline applies to the low-voltage power distribution equipment that is not subject to type approval. For such products in batch production, CCS hopes 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 Basis for approval and inspection

2.1 CCS Rules for Classification of Sea-going Steel Ships

2.2 IEC60092-302:1997 Electrical Installations in Ships - Part 302: Low-voltage Switchgear and Controlgear Assemblies

2.3 IEC61439-1:2011 Low-voltage Switchgear and Controlgear Assemblies. Part 1: General Rules

2.4 IEC60092-504:~~2001~~ 2016 Electrical Installations in Ships - Part 504: Special Features - Control and Instrumentation

3 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 Rules for Classification of Sea-going Steel Ships

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 1.1.1.2 of Part Four of *Rules for Classification of Sea-going Steel Ships*.

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 AC system operated at the rated frequency of 50Hz or 60Hz and the max. voltage between conductors of not more than 1000 V, or DC 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 capacity

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 borne in the circuit or circuit breaker at the ON position 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 AC) or time constant (for DC), 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 capacity.

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 (or the charge and discharge board of the emergency battery).

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 of the instructions);

(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.

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;

4.4 Materials and components

The materials and components of the product should be controlled as per relevant requirements of current regulations of CCS.

5 Design and technical requirements

5.1 Structure, assembly and components

5.1.1 The main switchboard and sub switchboard should be provided with the protective enclosure specified in Table 1.3.2.2 in Part Four of the *Rules for Classification of Sea-going Steel Ships.* 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 *Rules for Classification of Sea-going Steel Ships.* 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) or 100 kW (d.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;

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. If the rear of the power switchboard is kept open, the insulated handrail in the rear should be installed horizontally;

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 AC 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:

ctional area of the grounding conductor (mm^2) **Table 5.1.13**

Sectional area of relevant current-carrying conductor S	Min. sectional area of copper grounding conductor Q
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.

5.2.2 The bus bar and its supporting members 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 members should be calculated and reviewed according to IEC60865-1 or other standard accepted by CCS if necessary.

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 diversity factor), as shown in Table 1 of IEC60439-1. 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.

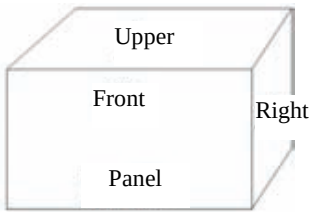
5.2.5 The sectional area of the neutral bus bar in the AC three-phase four-wire system should not be less than 50% of that of corresponding bus bar.

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 *Rules for Classification of Sea-going Steel Ships*, 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 (AC) or polarity (DC) 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 sequence or polarity	Relevant location for bus bar installation			Figure
		Vertical arrangement	Horizontal arrangement	Downlead	
AC	Phase 1	Top	Front	Left	Front view of the switchboard 
	Phase 2	Middle	Middle	Middle	
	Phase 3	Bottom	Rear	Right	
DC	Anode	Top	Front	Left	
	Voltage-sharing pole	Middle	Middle	Middle	
	Cathode	Bottom	Rear	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 *Rules for Classification of Sea-going Steel Ships*, 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
TTA equipment	8	16

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 *Rules for Classification of Sea-going Steel Ships*. 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 *Rules for Classification of Sea-going Steel Ships*. 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 The voltage-regulating equipment should be provided on the DC generator control panel as per the requirement in Section 2 of Chapter 3 in Part Four of the *Rules for Classification of Sea-going Steel Ships*.

5.4.6 A facility should be provided on the control panel (or paralleling panel) of the AC generator with parallel operation to make remote regulation for the rotatory speed of the prime motor at -20%~+10% of the rated speed.

5.4.7 The magnetization equipment of the generator should be provided on the control panel of the DC generator.

5.4.8 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.

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

5.4.10 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.

5.4.11 The battery charge equipment should meet the requirement in Section 11 of Chapter 2 in Part Four of the *Rules for Classification of Sea-going Steel Ships*.

5.4.12 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).

5.4.13 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.

5.4.14 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 *Rules for Classification of Sea-going Steel Ships*.

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 *Rules for Classification of Sea-going Steel Ships* and be approved by CCS. 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.

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.

5.5.4 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.".

5.5.5 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, and pass the type approval of 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 *Rules for Classification of Sea-going Steel Ships*):

(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 AC 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 AC 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 AC 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 AC 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 manual operation should be conducted in front of the panel.

(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.

5.6.4 Measures should be taken to isolate the circuit breaker of the generator, so as to conduct safe maintenance in case of any live main bus bar. It is also applicable for the power supply of other key load.

5.7 Contactor

The contactor should meet the requirement of the IEC60947-4-1 publication or other generally accepted standard accepted by CCS, and pass the type approval of 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. The fuse used in the power and distribution system should pass the CCS type approval.

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 *Rules for Classification of Sea-going Steel Ships* 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 AC 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 DC generator ammeter and AC generator wattmeter for parallel operation should indicate 15% of the reverse current and reverse power respectively;

(4) The cymometer 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).

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 anode)
		Voltmeter	Each generator 1 set
	Parallel operation	Ammeter	Each generator 1 set (connected to the anode)
		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))
		Cymometer	Each generator 1 set
		Excitation ammeter	Each generator 1 set (if necessary)

Continued Table 5.10.2

	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
		Cymometer	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

5.11.3.1 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.

5.11.3.2 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.

5.11.3.3 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.

5.11.4 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).

5.11.5 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.

6 Unit/batch Inspection

The switchboard should be subject to the following tests in the factory according to the approved 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 mooring test (or navigation test) after product installation.

6.1 Temperature rise test: The switchboard should be subject to temperature rise test with the rated carrying capacity specified in 5.2. For test method, see 8.2.1 of IEC60439-1.

6.2 High voltage test: The switchboard should be subject to high voltage test as per 6.2 at the test voltage frequency range of 25~100Hz, which should last for 1 min. without breakdown.

Voltage of high voltage test **Table 6.2**

Rated voltage (V)	Test voltage	Other provisions
$Un \leq 60$	1000 V	① Only DC ② 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. ③ The high voltage test should be carried out between all live parts and the enclosure and between poles (phases).
$60 < Un \leq 300$	2000 V	
$300 < Un \leq 690$	2500	
$690 < Un \leq 800$	3000 V	
$800 < Un \leq 1000$	3500	
$1000 < Un \leq 1500$ ①	3500	

6.3 Insulation resistance measurement: After the high voltage test, a DC 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.

6.4 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.

6.5 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.

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

6.7 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.