Guideline No.E-14 (201610)

E-14 Generator Protection Device and Automatic Power Station Control Device

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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:

1. “Guideline on Type Approval Test of Electrical and Electronic Products (GD01-2006) (2006)” is modified to “CCS GD 22-2015<Guidelines for Type Approval Test of Electric and Electronic Products> (current valid version)”. “GD01-2006” appearing in this guideline is modified to <Guidelines for Type Approval Test of Electric and Electronic Products> (current valid version) which is enter into force from Jan.1 2016.

CONTENTS

Generator Protection Device and Automatic Power Station Control Device

1 Application

1.1 The Guideline applies to the approval and inspection of the generator protection device and automatic power station control device installed in the LV AC system on the marine ship and offshore installations (hereinafter referred to as the ship).

1.2 According to the universality of the computer system definition in the regulations of CCS and recognized standards, the products involved in the above-mentioned devices can all be classified as the computer system (except for individual product) in spite of different complexity. It can be used as reference for non-computer-system products.

1.3 According to the requirement on the system classification specified in Article 1.4 of Annex of Chapter 2 in Part Seven of the *Rules for Classification of Sea-Going Steel Ships*, the equipment should be classified as the Type-III equipment, namely, such system failure will endanger immediately the personnel and ship safety as well as the environment.

1.4 The devices mentioned in the Guideline exclude such detecting elements as the voltage transformer and current transformer that are independent of the device and installed externally.

2 Basis for approval and inspection

2.1 CCS Rules for Classification of Sea-Going Steel Ships

2.2 IEC60092-504: 2001 Electrical Installations in Ships- Part 504: Special Features-Control and Instrumentation

2.3CCS GD22-2015 Guideline on Type Approval Test of Electric and Electronic Products (Current valid version)

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 LV AC system

The AC system operated with rated frequency of 50 Hz or 60 Hz and max. voltage between conductors of not more than 1000V.

3.3 Generator protection device

The electrical and electronic control device (or equipment) operated together with the generator circuit breaker, load switch or generator excitation device to perform the generator protection function specified in 2.5.6 and 2.5.7 of Section 5 in Chapter 2 of Part Four of the *Rules for Classification of Sea-Going Steel Ships*. It can replace the overload/short circuit protection unit (or module) of the generator circuit breaker or be used together with the protection unit of the generator circuit breaker, depending on different functions of the device.

3.4 Automatic power station control device

The electrical and electronic control device (or equipment) operated together with the ship power distribution device and generator set to perform (but not limited to) the power station function specified in Section 1 of Chapter 2 in Part Four and Section 4 of Chapter 3 in Part Seven of the *Rules for Classification of Sea-Going Steel Ships*.

3.5 Computer

A programmable electronic device used for such operations as data storage and processing as well as calculation or execution control. It involves the basic calculation unit, input and output equipment, control unit as well as program and data storage unit. It can be standalone or consist of several internally-connected units, as well as a programmable electronic system (PES) involving the mainframe, minicomputer and micro mechanism.

3.6 Computer system

The system consisting of one or more computers, relevant software, peripheral equipment and interfaces used to perform such functions as control, alarm, security and monitoring.

3.7 Fail-safe

A type of safety design principle that enables the output of any component to be adjusted automatically to the preset safety status in case of any failure. The preset safety status varies with specific applications, which refers to the lowest danger level generally. The system should enter the preset safety status when it is initially started or restarted due to any failure. The fail-safe principle should take into consideration not only the safety of the system-related machinery but also the safety of the whole device, and even the safety of the ship and personnel.

3.8 Redundancy design

The backup technical means taken in case of any system or equipment failure to enable relevant functions and keep the normal operation going on, or restore the original function to maintain the running status.

4 Plans and documents

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

4.1.1 System instructions (technical product conditions)

The system instructions (technical product conditions) should specify the general requirements on product performance and design, including at least the applicable part of the following contents:

－Requirement on product environment condition: The adaptability requirement on the working conditions (including the electromagnetic compatibility) of the product specified in the *Rules for Classification of Sea-Going Steel Ships*. －Details on product functions: including detailed description on system configuration, product application, product control and monitoring function and the realization method, detailed safety status of the function realized, features of the system under various operation conditions (including emergency or failure), as well as operation Guidelines under normal and abnormal status.

－Details on transfer of control

－Details on redundancy setting and conversion mechanism

－Details on failure monitoring and recognition function (manually or automatically).

－Details on data security and user safety level (function access permission).

－List of control and inspection items: List of all system input/output signals (service description, instrument, system and signal type, range and limit setting range).

4.1.2 Hardware instructions

It should include at least the applicable part of the following contents:

－Details on main hardware configurations of the product.

－System block diagram: Describes the connection between main components of all systems (software/hardware unit and module) as well as the interface with other systems.

－Detailed data on input/output equipment.

－Detailed data on power supply unit.

4.1.3 Wiring diagram

It should include at least the applicable part of the following contents:

－Power supply arrangement: The power supply arrangement of the system as well as the connection between the system and the switch panel, battery, convertor or UPS.

－Circuit diagram of key hardware circuit involving emergency operation and interlock, details on input/output equipment, and power supply status of each circuit.

4.1.4 Software instructions

It should include at least the applicable part of the following contents:

－Descriptions on basic software installed on each hardware unit.

－Descriptions on communication software installed in the network node.

－Descriptions on application software: Information on guaranteeing mandatory function of the system module and dependency upon other systems, relationship between software modules for guaranteeing mandatory operation of each function, as well as the data flow and control flow between software modules.

－Software configuration, including priority scheme.

－Handoff mechanism between redundancy systems

4.1.5 UI instructions

It should include at least the applicable part of the following contents:

－Descriptions on function allocation of each workstation and operation station as well as the transfer of control between stations.

－Descriptions on the function specified for each input equipment

－Arrangement, size and necessary photo of the input/output equipment

－Descriptions on each user input interface and menu

4.1.6 Test procedures: It should describe the test configuration and analogy method. Each test should specify the initial status of the equipment/system, test method, test result analysis, acceptance criterion, normal mode and failure mode, as well as the power supply and communication failure mode.

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

4.2.1 Operation manual (including troubleshooting instructions);

It should include at least the system start-up, function recovery, maintenance and regular test, data security and backup, user permission, software re-installation and system recovery, failure positioning and troubleshooting, system updating, and other items to be noted by users.

4.2.2 Software quality control plan

It is compiled according to the software service cycle and should include the technical software requirement, data requirement, software function test (parameter test and effectiveness test), system development plan, software modification and version control.

4.2.3 Failure mode and effects analysis (FMEA): It should apply to the whole system (for type-III computer system).The analysis should cover all the main system components and include at least the following information: Key system components and function block diagram (including the interaction between them); all important failure modes; the most possible failure cause of each failure mode; transient impact of each failure on the ship; failure detection method; failure impact on other components of the system; analysis on possible common failure mode. The reliability and protection mechanism of the component in the system that is not backed up or cannot be backed up should be further analyzed.

The manufacturer can adopt other proper methods (such as the failure tree analysis, risk analysis and FMECA) for function failure analysis, and the analysis contents should meet the requirements mentioned above.

Note 1: The above-mentioned items provide the general requirements on contents to be covered in the documents submitted by the manufacturer, which vary with specific product features.

Note 2: The contents involved in each item mentioned above do not mean it should be submitted separately.

5 Design and technical requirements

5.1 Operating conditions

The equipment should work normally under the operating conditions specified in Section 1 of Chapter 2 in Part Seven of the *Rules for Classification of Sea-Going Steel Ships*. The operating conditions of the equipment are as follows, unless otherwise specified:

5.1.1 Environmental conditions

(1) Ambient air temperature: 0℃~55℃; For equipment that is required by the manufacturer to be installed in the location the ambient air temperature of which is to be controlled as per the requirement specified in 1.2.1.2 of Part Four in the *Rules for Classification of Sea-Going Steel Ships*, the max. ambient air temperature can be reduced from 55℃ to not less than 35℃, and relevant description should be added to corresponding certificate issued by CCS.

(2) Inclination and swinging: Heeling and rolling of 22.5 °and trimming and pitching of 22.5 °.

(3) Vibration and shock: The general vibration condition specified in Article 2.7 of *Guideline on Type Approval Test of Electric and Electronic Products*(Current valid version).

(4) Damp air: Temperature of +55℃ and relative humidity of 95%.

5.1.2 Electrical operating conditions

(1) Voltage and frequency fluctuation

AC:

Voltage: Steady state change of +6~-10%, transient state change of ±20%, and recover time of 1.5 s.

Frequency: Steady state change of ±5%, transient state change of ±10%, and recover time of 5 s.

DC:

Rectifier power supply: Steady-state voltage fluctuation of ±10%, cyclical voltage fluctuation of 5%, and ripple voltage of 10%.

Battery power supply: Connect to the battery during charge Voltage: +30%~-25%

Battery power supply: Do not connect to the battery during charge Voltage: +20%~-25%

(2) Harmonic distortion

The AC electrical equipment should run normally when the voltage harmonic distortion of the power supply is not more than 5%.

5.2 General requirements

5.2.1 The requirements specified in Part Seven of the *Rules for Classification of Sea-Going Steel Ships* apply to the Guideline, with the following supplements.

5.2.2 Equipment enclosure and enclosure protection level

(1) The equipment enclosure should be made of durable, flame-retarding and humidity-resistance materials, in which the metal part should be made of materials with sound corrosion resistance and provided with reliable protective layer.

(2) The enclosure protection level should meet relevant requirement specified in Table 1.3.2.2 of Section 3 in Chapter 1 of Part Four of the *Rules for Classification of Sea-Going Steel Ships*.

5.2.3 Hardware and interior wiring

(1) The device structure and internal module arrangement should be in line with the maintenance method specified by the manufacturer. The repairable and replaceable components should be accessible. The replaceable components should be designed structurally to facilitate the replacement. Each replaceable component structure should be

designed to guarantee safe operation. The plug-in module and connector (including electrical connections) should be provided with identification marks, and should be designed to avoid mis-plugging. It should also guarantee that no damage or system malfunction will occur in case of any mis-plugging.

(2) The circuit design should guarantee that there is no direct connection between the system/equipment and the main ship electric network, for example, to supply power via an isolated transformer. The equipment frame should not be part of the circuit, except for the functional grounding circuit.

(3) If necessary, the equipment should be arranged in such a way as to facilitate the adjustment. The set value should be recognized easily and prevented from being modified via proper measures.

(4) The control circuit should be separated from the signal and indicating circuit, and the indicating circuit failure should not affect the control circuit adversely, and vice versa.

(5) If any plug/socket is adopted, the contact point should not bear any other mechanical load even when components are pulled out and replaced except for maintaining necessary contact force. Wiring slot used for the needle joint, circuit board slot or other multi-point connector should be provided with fixing devices to avoid any looseness due to vibration/impact.

(6) The internal cable and insulated conductor should be of flame-retarding type. Any mechanical damage to the cable due to vibration should be avoided.

(7) The control equipment (including the convertor) should be provided with sufficient space for wiring, so as to guarantee satisfactory cable connection, and it is suggested to connect one connection terminal with one conductor. All connection terminals should be marked clearly. The cable shielding layer should be provided with proper connection terminal.

5.2.4 Software and data

(1) The software should be of confidentiality and encapsulation.

(2) If necessary, the software should be subject to system tests and documentation. These tests should involve all software functions, key function combination, operating features, relevance and operation requirement in various operating modes (including operations under emergency or in case of failure).In case of any software modification, the test should be changed accordingly. For software test method, refer to IEC61506, and get approval from CCS at the same time.

(3) Such data as the program, characteristic curve (characteristic value), and setting (limit value) should be stored with the permanent storage component, so as to guarantee that the program applied will not be lost or fail due to power interruption. If necessary, such data cannot be modified unless with special equipment or special operational command;

(4) The software should be designed in such a way that the operator cannot modify the program or fixed data related to the ship equipment.

(5) To guarantee the normal data exchange between systems, it is suggested that the interface design can meet the international standard.

5.2.5 Fail-safe and redundancy setting

(1) The generator protection device and automatic power station control device should be designed according to the fail-safe principle.

(2) The failure and restarting of the device will not cause the protected (controlled) equipment to enter the undefined or danger state. The device should be designed in such a way that single failure will not cause the failure of multiple functions.

(3) Redundancy design (if necessary) should be adopted for the automatic power station control device according to the equipment operating requirement and system configuration.

(4) The device failure should not affect the normal manual operation.

5.2.6 Alarm and indication

(1) The device should indicate the operating status of itself and the equipment controlled, and give an alarm in case of any abnormality. The alarm and indicating items should be in line with the control (protection) function.

(2) The device should monitor the operation, and give or output an alarm signal in case of any abnormality (including power supply failure or device failure).

5.3 Functional requirement

5.3.1 The generator protection device is operated together with the generator circuit breaker, load switch or generator excitation device, and should perform one or more functions specified in 2.5.6 and 2.5.7 of Section 5 in Chapter 2 of Part Four of the *Rules for Classification of Sea-Going Steel Ships*.

5.3.2 The automatic power station device can be used to perform one or more of the following functions:

(1) Automatic generator startup

①It should give automatic startup command in the following circumstances:

Power loss of the grid (main bus bar power loss, and the same below), long-time LV, long-time LF, overload (machinery or generator), load increase demand, demand of starting high power motor, operating unit failure, and remote manual command.

② Avoiding false start-up

The dynamic process of the power station in the allowed range should not cause the automatic startup of the generator set. Delayed startup can be adopted.

③ Conversion of startup command

The automatic sequence or that selected manually should be adopted for startup. In case of any starting failure, the startup command transfers automatically to another set allowed for startup.

④ Startup conditions

Measures should be taken to guarantee that the generator set will not be started automatically if the normal startup and operation condition (such as the starting are, fuel or cooling water) is not available.

⑤ Backup indication

Backup indication should be provided on the control panel (board) and local control position.

⑥ Startup interlocking

Each generator set should be provided with an interlocking device to guarantee maintenance and repairing safety and avoid false startup. An alarm should be given in case of any insufficient startup conditions for the generator set.

⑦ Startup indication and limitation

Indication should be provided when the set is automatically started or operated; in case of any startup failure, the time and duration of the automatic startup should be limited; in case of any generator set startup failure, a sound-light alarm should be given.

(2) Automatic connection in case of power loss of grid

① Sufficient HV should be guaranteed for the switched-on generator, and measures should be taken to limit the load switched in automatically after power restoration or the method of switching-in in sequence should be adopted, so as to prevent the initial load from exceeding the generator set capacity.

②Two or more generator sets should be prevented from being connected to the main bus bar at the same time.

③ Measures should be taken to prevent the main switch of the generator from being switched on automatically in case of any detection part (component) startup failure (for example, the voltage detection relay failure).

④ In case of any short circuit failure, the backup generator set should be prevented from being switched on to the bus bar (or section of the bus bar) with failure, which should be restored manually. In case of any short circuit failure, the main switch of the generator can only be turned on once.

⑤The backup generator set is started up due to long-time LV (or LF) of the operating generator unit. If the backup generator set meets the switch-on condition, the generator set with failure should be switched off before the backup generator set is switched on.

Note: Switch-on: The main switch of the generator is turned on, and the generator is connected with the main bus bar.

Switch-off: The main switch of the generator is turned off, and the generator is disconnected from the main bus bar.

Paralleling: The generator enters the parallel operation status.

Splitting: The generator exits the parallel operation status.

Startup failure: The generator set fails to reach the specified frequency and voltage in specific time after the device gives the startup command.

(3) Automatic load management

For systems with automatic load allocation function, the system failure should not cause power loss of the whole ship.

(4) Automatic shutdown

①The generator set should be automatically switched off and shut down in case that any failure may endanger the generator set safety (for example, over-speed or low oil pressure).

② Pre-alarm: To avoid any unexpected shutdown, detection alarm should be provided to remind operators of troubleshooting before any danger may occur.

③For system with automatic splitting mechanism in case of low load, proper time delay should be provided before splitting. If necessary (or required), the generator set splitted should run in no-load condition for some time before shutdown.

④ In case of automatic shutdown due to failure, sound-light alarm should be given, and measures taken to avoid any automatic startup.

(5) The processing accuracy for the electrical signal of each automatic power station device should not be lower than that specified in 3.3.4 of Section 3 in Chapter 3 of Part Four of the *Rules for Classification of Sea-Going Steel Ships*.

5.4 Electromagnetic compatibility

The facility should meet the test requirement specified in Table 3.1.2 (product category: Switchgear and control system - and electronic control unit) of Chapter 3 of the *Guideline on Type Approval Test of Electric and Electronic Products*(Current valid version).

6 Type approval and unit/batch test

6.1 The automatic generator protection device and power station automation device should be approved by CCS. The issuing, maintaining, modification, replacement, and cancellation of the type approval certificate should be conducted according to Chapter 3 in Part One of the *Rules for Classification of Sea-Going Steel Ships*.

6.1.1 Selection of typical sample

(1) The model and specification of the test sample should be typical in technology, and cover the scope of products applied for type approval.

(2) For products with same structure and electrical design, products with comprehensive functions can be selected for type approval test. One set of test sample can be selected for the specific model. The test sample should be selected by the CCS Surveyor at the factory.

(3) If the main components of the facility are produced by different manufacturer, CCS can select samples separately for approval test according to the above-mentioned principle.

6.1.2 Test agency

Test agencies accepted by CCS or the authoritative and impartial ones have the priority for type approval test. For some functional test items, the test can be conducted at the factory provided that the factory meets the test requirement and the test is approved and supervised by the CCS Surveyor.

6.1.3 Type approval test item and requirement

(1) Environmental condition test

It should be conducted according to the requirement in the *Guideline on Type Approval Test of Electric and Electronic Products*(Current valid version). The applicable environmental condition classification (Table 1.3.2 of *Guideline on Type Approval Test of Electric and Electronic Products*(Current valid version)) is Class B, and the equipment type (Table 1.3.3b of *Guideline on Type Approval Test of Electric and Electronic Products*(Current valid version)) is "all the equipment, computers and other electronic equipment used for control,

protection, safety and internal communication". The performance test can be carried out together with the items specified in (2) below.

(2) Electromagnetic compatibility test

It should be conducted according to Article 5.4 of the Guideline.

(3) Functional test

① Functional test of the generator protection device

(a) Test arrangement:

For initial approval, the generator protection device together with its voltage/current conversion device is tested with actual current.

(b) Test item, method and result

It should be carried out according to the requirements of IEC60947-2: 8.3.3.1 as well as those specified in 5.3.1 of the Guideline.

(c) For some products, CCS can specify the test items and test method according to the product feature and recognized standards.

② Functional test of the power station automation device

(a) Test arrangement

For initial approval, the power station automation device should be tested together with the generator and its prime motor.

(b) Test item, method and result

It should be conducted based on the test procedure approved by CCS. The test procedure should be prepared as per the applicable requirements in both 5.3.2 of the Guideline and Annex "Guideline on Marine Computer Application and Inspection" in Part Seven of the *Rules for Classification of Sea-Going Steel Ships*, as well as the features of specific products, which covers the test method and test result criterion for each function to be verified and such contents as the system self-inspection, system failure simulation test, software test (if applicable), and redundant equipment conversion(if any).

6.2 Unit/batch Inspection

6.2.1 General requirement

After passing the type approval, the factory should conduct the following factory tests on each marine product, and issue factory test report. The CCS Surveyor can conduct product delivery inspection by sampling inspection with sampling ratio of 10% and at least 2 sets. The CCS Surveyor can increase the test items and sampling quantities if necessary.

6.2.2 Factory test items

(1) Main components (parts) data verification

(2) Appearance and interior wiring inspection

(3) Insulation resistance measurement

(4) High voltage test

(5) Functional test

It should be carried out according to the approved factory test program. For specific items, see the applicable part in 5.3 of the Guideline. The function test can be carried out via simulation test.

6.2.3 CCS will issue the certificate of marine product after the product passes the factory tests specified above.