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E-15

UNINTERRUPTIBLE POWER SYSTEMS (UPS)

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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 mp@ccs.org.cn.

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Main changes:

1. Correct clerical mistakes;
2. Update the version of normative references;
3. Update the test items according to the latest version of normative references.

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UNINTERRUPTIBLE POWER SYSTEMS (UPS)

1 Application

1.1 The Guideline applies to the approval and inspection of the uninterruptible power system (UPS) installed on the marine ship and offshore installations.

1.2 Such equipment includes:

The power supply substituting the emergency power supply specified in Section 9 of Chapter 3 in Part Four of the *Rules for Classification of Sea-Going Steel Ships* or the temporary emergency power supply, supplying power to the load specified in Articles 2.2.2.1 (3) and 2.2.3.1 (4) of Chapter 2 in Part Four of the *Rules for Classification of Sea-Going Steel Ships*.

1.3 The following UPS, if requiring approval by CCS, should meet the applicable requirement of the Guideline:

1.3.1 The backup power supply for the automation system required in 2.1.6.1 of Chapter 2 in Part Seven of the *Rules for Classification of Sea-Going Steel Ships*, supplying power to the safety system, alarm system, and the control system (such as the automation system of the power station) that requires power supply in case of power loss of the power supply mentioned above.

2 Normative references

2.1 CCS Rules for Classification of Sea-Going Steel Ships and its Amendments;

2.2 IEC62040-1:2017 Uninterruptible Power Systems (UPS) – Part 1: Safety Requirements;

2.3 IEC62040-3:2011/COR1:2011 Uninterruptible Power Systems (UPS) – Part 3: Method of Specifying the Performance and Test Requirements;

2.4 CCS GD22-2015: Guideline for Type Approval Test of Electrical and Electronic Products (current valid version));

2.5 IEC 62477-1:2012 Safety requirements for power electronic converter systems and equipment - Part 1: General.

3 Terms and Definitions

The terms and definitions specified in the above-mentioned inspection bases 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 and its Amendments.

3.2 Uninterruptible power systems (UPS)

Combination of converters, switches and energy storage means, for example batteries, constituting a power system for maintaining continuity of load power in case of input power failure.

3.3 UPS unit

A complete UPS should consist of at least the following functional units: The UPS inverter, UPS rectifier and battery or other energy storage device. Such units should be operated together with other UPS units to form a parallel UPS or redundancy UPS.

3.4 Converter

Operative unit for electronic power conversion, comprising one or more electronic valve devices, transformers and filters if necessary and auxiliaries if any

3.5 DC energy storage system

System consisting of single or multiple devices (typically batteries) designed to provide the required cell.

3.6 DC link

Direct current power interconnection between the rectifier or rectifier/charger and the inverter functional unit.

3.7 Valve-regulated sealed battery

Secondary cell which is closed under normal conditions, but has an arrangement to allow gas to escape if the internal pressure exceeds a predetermined value. The battery cannot normally receive addition to the electrolyte.

3.8 Vented battery

Secondary cell having a cover provided with an opening through which gaseous products may escape.

3.9 UPS switch

UPS switch consisting of one or more switches used to transfer power from one source to another.

The term of the UPS switch applies to all the electrical switches acting as the functional UPS units (depending also on its application), including the circuit breaker, bypass switch, disconnecter, load changeover switch and interconnection switch. Such switches coordinate with other functional UPS units to maintain the load power continuity. Other switches or circuit breakers, such as the traditional main power supply distribution panel, rectifier input switch, battery switch, or other general circuit breaker or switch used for convenience, are not covered in the Guideline. For details, see Annex "C-UPS Switch" of IEC62040-3.

3.10 Bypass

Power path alternative to the indirect a.c. converter

3.11 Normal load

Load that in normal mode of operation, approximates as close as possible to the most severe conditions of normal use in accordance with the manufacturer's operating instructions

3.12 Normal mode of UPS operation

Stable mode of operation that the UPS finally attains when supplied under the following conditions:

3.12.1 The main power supply is available and in the prescribed deviation;

3.12.2 The battery has been charged or recharged in the given restored energy time;

3.12.3 It runs or may run continuously;

3.12.4 Phase locking is valid (if any);

3.12.5 The load is within the given range;

3.12.6 The output voltage is within the given tolerance;

3.12.7 The bypass is valid and in the specified deviation at places where the UPS applies.

3.13 Stored energy mode of UPS operation (generally called the "Battery operation")

Operation of the UPS when supplied under the following conditions:

3.13.1 The main power supply is interrupted or exceeds the given deviation;

3.13.2 The DC energy storage system starts running;

3.13.3 The load is within the given range;

3.13.4 The output voltage is within the given deviation;

3.14 Bypass mode of UPS operation

State the UPS attains when operating the load supplied via the bypass only

3.15 UPS double conversion (generally called the "online mode")

Any UPS operation, where continuity of load power is maintained by a UPS inverter, with energy from the d.c. link in normal mode of operation or from the energy storage system in stored energy mode of operation. The output voltage and frequency are independent of input voltage and frequency conditions

3.16 UPS double conversion with bypass

UPS operation as for UPS double conversion with the following addition. Under temporary or continuous output overload conditions, or in the case of UPS rectifier/inverter failure, the load is temporarily supplied with power via the alternative bypass path. Under bypass operation, the load may be affected by input supply voltage and frequency variations

3.17 UPS line interactive operation

Any UPS operation where, in normal mode of operation, the continuity of load power is maintained by the use of a UPS inverter or a power interface while conditioning primary power at the input supply frequency

When the a.c. input voltage and/or frequency is out of UPS preset variation limits, the UPS inverter and battery maintain continuity of load power in stored energy mode of operation within the stated output voltage/frequency tolerances

3.18 UPS line interactive operation with bypass

UPS operation as for UPS line interactive with the following addition. In the event of a UPS functional unit failure, the load may be transferred to an alternative bypass path fed from primary or standby power. In bypass mode of operation, the load may be affected by input supply voltage and frequency variations

3.19 UPS passive standby operation

Any UPS operation where, in normal mode of operation, the load is primarily supplied by primary power and is subject to input voltage and frequency variations within stated limits. When the a.c. input supply is outside UPS design load tolerances, the UPS inverter is activated from the battery, and maintains continuity of load power in stored energy mode of operation

3.20 Fixed equipment

Stationary equipment which is fastened or otherwise secured at a specific location

3.21 Service access area

Area, other than an operator access area, to which it is necessary for service personnel to have access even with the equipment switched on

3.21.1 Places that can be accessed only by maintenance personnel with special tool, lockset or keys.

3.21.2 Places with controlled access

3.22 Total harmonic distortion (THD)

Ratio in percent of the r.m.s. value of the harmonic content to the r.m.s. value of the fundamental component of the alternating quantity

3.23 Total distortion factor (TDF)

Ratio of the r.m.s. value of the harmonic content to the r.m.s. value of the alternating quantity

3.24 Cell

Minimum time during which the UPS will ensure continuity of load power, under specified service conditions when the primary power fails, starting with the energy storage means sufficiently charged

3.25 Recell

Maximum time required to recharge sufficiently the energy storage means of the UPS with the charging capacity installed to ensure another such discharge.

NOTE – This period is the time taken after a cell discharge to restore sufficient energy to repeat the cell discharge.

3.26 Total UPS transfer time

Time interval between the occurrence of an abnormality or out-of-tolerance condition and the instant when the output quantities have been transferred

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

- (1) General plan and UPS deployment diagram;
- (2) Electrical schematic diagram;
- (3) Technical product conditions (For details, see Article 5 of IEC62040-3 and Annex D)

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

- (1) External wiring diagram;
- (2) List of specifications of supporting electric equipment and main components
- (3) Product installation and operation instructions.

5 Technical requirements

5.1 Operating conditions

The equipment should work normally under the operating conditions specified in Section 2 of Chapter 1 in Part Four 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°C~55°C; 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°C to not less than 35°C, 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°. For marine equipment used for liquefied gas and chemicals, the heeling should reach 30°. When the UPS battery inclines by 40° at all directions, measures should be taken to avoid electrolyte spillover.
- (3) Vibration and shock: The general vibration condition specified in Article 2.7 of Guideline for Type Approval Test of Electrical and Electronic Products(current valid version).
- (4) Damp air: Temperature of +55°C and relative humidity of 95%.

5.1.2 Electrical operating conditions

(1) Voltage and frequency fluctuation

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

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

(2) Harmonic component

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

5.2 Equipment enclosure and enclosure protection level

5.2.1 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.

5.2.2 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*. For equipment installed inside the switchboard and console, the enclosure protection level should be at least IP20.

5.3 Temperature rise:

When the marine UPS operates in various working modes, the temperature rise should meet the requirement of IEC 62477-1, chapter 4.6.4.

5.4 Electrical clearance and creepage distance

The electrical clearance and creepage distance in the equipment and between components should meet the requirement of IEC62477-1, chapter 4.4.7.1, 4.4.7.5.

5.5 Dielectric strength

Under normal operating conditions, the high voltage test can be carried out between different circuits of the equipment, as well as all circuits and the ground for 1 min. without any breakdown or flashover. Before test, the electronic components of each circuit can be removed.

List of voltages for high voltage test

Table 5.5

Rated operating voltage U_n (V)	Test voltage (AC 50/60Hz)
Less than 65	$2U_n + 500$
66~250	1500
251~500	2000
501~690	2500

5.6 UPS input features

The manufacturer should specify the product input features according to the requirement of Article 5.2 of IEC62040-3. The UPS should work reliably under the electrical operating conditions specified in 5.1.2 of the Guideline.

5.7 UPS output features

In any operation mode, the marine UPS should meet the requirement of the connected load on the power supply.

5.7.1 The AC output of the marine UPS should have the type-I or type-II dynamic output performance specified in Article 5.2 of IEC62040-3, and the upper limit value of the steady-state voltage should not exceed +6%. For type-II dynamic output features, the manufacturer should specify the max. dynamic voltage.

5.7.2 Generally, the marine UPS should provide sine output voltage, and the harmonic component of the AC voltage should not exceed 5% in loaded conditions. Other output waveforms should be handled separately.

5.7.3 The DC output voltage of the marine UPS should meet the following requirement at least:

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

5.8 The marine UPS should be provided with bypass operation mode.

5.9 Stored energy time and restored energy time of the marine UPS

5.9.1 Under various design loads, the stored energy time of the marine UPS should comply with the specific application.

5.9.2 The restored energy time of the marine UPS: While the UPS equipment is supplying power to the design load, the UPS charging equipment should charge the battery set to the rated capacity (or the status specified by the UPS manufacturer, which is the initial status of the battery when test during stored energy power supply) within 10 h starting from the fully discharged status of the battery set (or the discharged status of the battery set specified by the UPS manufacturer) when the main power supply is in operation.

5.9.3 For valve-regulated sealed battery set, the UPS charger should limit the charging parameters, so as to prevent the discharged flammable gas from exceeding the manufacturer's design value. Such limitation should be independent of the charging equipment or charging circuit.

5.10 Marine UPS battery

5.10.1 The battery should be manufactured according to the standard accepted by CCS, and approved by CCS. Batteries with charging power of less than 0.2 kW (the value of the nominal voltage of the battery set multiplied by max. charging current value) may be treated separately.

5.10.2 After the marine UPS passes the approval test, the battery (the manufacturer and product mode) provided should not be changed generally.

5.11 Installation and test of the marine UPS battery

5.11.1 The installation of the external UPS battery should meet relevant requirement specified in Section 11 of Chapter 2 of Part Four of the Rules for Classification of Sea-Going Steel Ships.

5.11.2 For built-in batteries, the manufacturer should submit the calculation book of ventilation quantity that is used to prevent flammable gas from gathering. The ventilation rate test should be conducted if necessary (Annex CC of IEC62040-1).

5.11.3 The built-in battery should be separated physically from other electrical part, so as to avoid any adverse effect of the gas escaped from the battery on the electrical element. The gassing pressure reducing valve of the lead-acid battery should be installed upward.

5.12 Alarm and signal

The UPS device should be monitored, and proper measures should be taken to send the following audible and visual alarms to the generally-attended places:

- (1) Load power supply failure (voltage and frequency);
- (2) UPS grounding failure;
- (3) Operation of battery protection equipment;
- (4) Battery discharge;
- (5) Operation of online UPS bypass.

5.13 Electromagnetic compatibility

The marine UPS equipment should meet the test requirement specified in Table 3.1.2 (product category: converter) of Chapter 3 of CCS Guideline for Type Approval Test of Electrical and Electronic Products (current version).

6 Materials and components

Materials and components should be controlled by the relevant requirements of CCS current rules.

7 Type test

7.1 The marine UPS equipment should be subject to the type approval of 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*.

7.1 Selection of Typical Sample

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

For products with same structure and electrical design, products with maximum rated output power or maximum stored energy supply time 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.

7.2 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.

73 Type approval test items and requirements

(1) Environmental test and EMC test

It should be conducted according to the requirement of CCS Guideline for Type Approval Test of Electrical and Electronic Products (current version). The applicable environmental condition classification (Table 1.3.2 of Guideline for Type Approval Test of Electrical and Electronic Products (current version)) is Class B, and the equipment type (Table 1.3.3b of Guideline for Type Approval Test of Electrical and Electronic Products(current version)) is "all the equipment, computers and other electronic equipment used for control, protection, safety and internal communication". The test items related to the electrical performance can be carried out together with the items specified in (2) below.

EMC tests should be carried out according to Table 3.1.2 (product category: converter) of Chapter 3 of CCS Guideline for Type Approval Test of Electrical and Electronic Products (current version).

(2) Electrical performance test

For type approval test items of the marine UPS, see Table 7.3. The test items of No. 10~14 of Table 7.3 with additional requirements in the Guideline must be conducted during type approval, and for those without additional requirement, recent test report can be accepted by CCS based on special considerations.

(3) Special arrangement:

For each functional unit existing in the form of separate product and forming a complete UPS equipment after interconnection, separate test can be carried out on indecent functional unit to replace the type test specified in (1) of this chapter after being approved by CCS. For specific test items and arrangement, see Article 6.3 of IEC62040-3.

Electrical performance test items**Table 7.3**

No.	Test items	General requirements of IEC62040-3	Additional requirements
1	Cable and interconnection check	6.2.2.2	-
2	Light load and functional test	6.2.2.3	-
3	No load	6.2.2.4	-
4	Full load	6.2.2.5	-
5	Synchronization	6.2.2.6	-
6	AC input failure	6.2.2.7	-
7	AC input return	6.2.2.8	-
8	Parallel redundant UPS fault	6.4.2.12	-
9	Transfer test to bypass	6.2.2.9	-
10	Input supply compatibility		
10.1	Steady-state input voltage tolerance	6.4.1.1	5.1.2
10.2	Input frequency tolerance	6.4.1.2	5.1.2
10.3	Input inrush current	6.4.1.3	-
10.4	Harmonic distortion of input current	6.4.1.4	-
10.5	Power factor	6.4.1.5	-
10.6	Efficiency	6.4.1.6	-
10.7	Stand-by generator compatibility	6.4.1.9	-
11	Output – Linear load		
11.1	Normal mode – No load	6.4.2.1	5.7
11.2	Normal mode – Full load	6.4.2.2	5.7
11.3	Stored energy mode – No load	6.4.2.3	5.7
11.4	Stored energy mode – Full load	6.4.2.4	5.7
11.5	3-phase voltage unbalance	6.4.2.5	-
11.6	DC voltage component	6.4.2.6	-
11.7	Current division across paralleled UPS	6.4.2.7	-
11.8	Output overvoltage test	6.4.2.8	-
11.9	Periodic output voltage variation test (modulation)	6.4.2.9	-
11.10	Overload – Normal mode	6.4.2.10.1	-
11.11	Overload – Stored energy mode	6.4.2.10.2	-
11.12	Fault clearing capability – Normal mode	6.4.2.10.3	-
11.13	Fault clearing capability – Stored energy mode	6.4.2.10.4	-
11.14	Dynamic performance – Normal to stored energy mode	6.4.2.11.1	5.7
11.15	Dynamic performance – Stored energy to normal mode	6.4.2.11.2	5.7

Continued Table 7.3

No.	Test items	General requirements of IEC62040-3	Additional requirements
11.16	Dynamic performance – Normal to bypass mode - overload	6.4.2.11.3	5.8
11.17	Dynamic performance – Step load – Normal mode	6.4.2.11.4	-
11.18	Dynamic performance – Step load – Stored energy mode	6.4.2.11.5	-
12	Output – Non-linear load		
12.1	Normal mode – Full load	6.4.3.1	-
12.2	Stored energy mode – Full load	6.4.3.2	-
12.3	Dynamic performance – Normal to stored energy mode	6.4.3.3.1	-
12.4	Dynamic performance – Stored energy to normal mode	6.4.3.3.2	-
12.5	Dynamic performance – Step load – Normal mode	6.4.3.3.3	-
13	Stored and restored energy times		
13.1	Stored energy time	6.4.4.1	5.9
13.2	Restored energy time	6.4.4.2	5.9
13.3	Battery ripple current	6.4.4.3	-
13.4	Restart test	6.4.4.4	-
14	Safety tests	IEC 62040-1	
14.1	Temperature rise test	IEC 62040-1 4.6.4	-
14.2	Backfeed protection test	IEC 62040-1 4.8.102	-
14.3	Ventilation rate test	IEC 62040-1 4.102.6	5.11

8 Unit/batch inspection

8.1 General requirement

After passing the Type Approval, the factory should conduct the following factory tests on each marine UPS equipment, and issue factory test report. The UPS with rated power of 50 kVA or higher should be inspected by the CCS Surveyor during its manufacturing and test. For other products, the Surveyor can conduct sampling inspection with sampling proportion of 10% and at least 2 sets.

The CCS Surveyor can increase the test items if necessary.

8.2 Factory test items

- (1) Main components (parts) data verification

- (2) Appearance and interior wiring inspection
- (3) Insulation resistance measurement
- (4) High voltage test
- (5) Performance test (for specific test method and requirement, see Item No. 2,3,4,5,6,7,9 of Table 7.3): light load and functional test, no load test, full load test, Synchronization, AC input failure test, AC input return test, transfer test to bypass
- (6) Alarm test

8.3 CCS will issue Marine Product Certificate after the product passes the factory tests specified above.