Guideline No.E-30(202605)

E-30

Low-Voltage Converter

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Foreword

China Classification Society (hereinafter refferred to as 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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Low-Voltage DC Converter

1 Applicaion

This Guideline is applicable to the inspection and approval of low-voltage power electronic converters (including modular encapsulated converter BM or complete cabinet converter CM) installed and used on ships, with voltage not exceeding AC 1000 V / DC 1500 V. Other converters may refer to this Guideline.

2 Normative References

(1) China Classification Society Rules for Classification of Steel Ships (2025)

(2) China Classification Society Rules for Application of Power Batteries on Ships (2025)

(3) China Classification Society (GD 019-2024) Guideline for Type Approval Test of Electrical and Electronic Products,

(4) China Classification Society(GD 018-2023) Guideline for Survey of Marine DC Integrated Power Systems,

(5) China Classification Society(GD 028-2023) Guideline for Reliability Verification of Marine Equipment and Systems,

(6) GB/T 3783-2019 Basic requirements for marine low-voltage electrical apparatus

(7) GB/T 3797-2016 Electrical control equipment

(8) GB/T 3859.1-2013 Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements (IEC 60146-1-1:2009, MOD)

(9) GB/T 4208-2017 Degrees of protection provided by enclosure (IP code) (IEC 60529:2013)

(10) GB/T 14548-2025 General technical specification for marine semiconductor converters

(11) GB/T 4988-2016 Electrical products for ships and offshore installations – Rated frequency, rated voltage and rated current

(12) GB/T 6994-2006 Electrical installations in ships – Definitions and general requirements

(13) GB/T 7061-2016 Marine low-voltage switchgear and controlgear assemblies

(14) GB/T 12668.2-2002 Adjustable speed electrical power drive systems – Part 2: General requirements – Rating specifications for low-voltage adjustable frequency a.c. power drive systems (IEC 61800-2:1998, IDT)

(15) GB/T 13030-2009 Technical specification for marine electric propulsion systems

(16) GB/T 13384-2008 General specification for packaging of mechanical and electrical products

(17) GB/T 35701-2017 Marine variable frequency converter for electric propulsion

(18) GB/T 12668.501 (IEC 61800-5-1) Adjustable speed electrical power drive systems – Part 5: Safety requirements

(19) IEC 60146-1-3-1991 Semiconductor converters – General requirements and line commutated converters

(20) IEC 61439-1-2020 Low-voltage switchgear and controlgear assemblies

(21) IEC 60146-1-1:2024 Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements

(22) GB/T 30844.1-2024 General variable frequency drive equipment up to 1 kV – Part 1: Technical specifications

(23) GB/T 30844.2-2024 General variable frequency drive equipment up to 1 kV – Part 2: Test methods

(24) GB/T 30843.1-2024 General variable frequency drive equipment above 1 kV and not exceeding 35 kV – Part 1-3: Technical specifications

(25) GB/T 30843.2-2024 General variable frequency drive equipment above 1 kV and not exceeding 35 kV – Part 2: Test methods

(26) IEC 61800-2:2021 Adjustable speed electrical power drive systems – Part 2: General requirements – Rating specifications for low-voltage adjustable frequency a.c. power drive systems

(27) IEC 61800-5-1:2022 Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy

(28) IEC 61800-5-2:2016 Adjustable speed electrical power drive systems – Part 5-2: Safety requirements – Functional safety

(29) IEC 60950-1:2022 Information technology equipment – Safety – Part 1: General requirements

(30) IEC 62040-3:2021 Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

3 Terms and definitions

3.1 Definitions

(1) Guideline for Inspection of Marine DC Integrated Power Systems (2023) is hereinafter referred to as "this Guideline".

(2) The definitions given in GD 018-2023 Guideline for Inspection of Marine DC Integrated Power Systems apply to this Guideline.

(3) Converter – A power electronic functional device that changes the voltage, frequency, phase and other electrical characteristics of a power supply system for the purpose of power transmission. It is generally a module or cabinet composed of one or more power electronic switching devices and associated components, together with filters, controllers, protection and auxiliary devices, serving as a power conversion unit that changes one or more electrical characteristics.

(4) BM (Modular encapsulated converter) – An electronic power converter and associated control components, whose control power supply requires external filtering and which itself requires an external cabinet to provide electromagnetic compatibility and protection. Its protection degree is normally IP00 or IP20.

(5) CM (Complete cabinet converter) – A converter consisting of, but not limited to, a BM and extended equipment, such as protection equipment, filtering equipment, resistors, transformers and other auxiliary equipment (excluding motors and other components mechanically coupled to the motor shaft). It is normally wall-mounted or floor-standing, and provides its own protection and electromagnetic compatibility.

(6) Series – For the purpose of this Guideline, a series means a family of products having the same operating principle. If there are differences in raw materials, manufacturing processes or optional components, the manufacturer shall clearly distinguish them in the enterprise standard and indicate such differences in the type designation.

3.2 Product classification

3.2.1 According to the mode of conversion, converters may be classified as rectifiers, inverters or frequency converters, AC converters, and DC converters.

3.2.2 According to the marine application scenario, converters may be classified as electric drive converters (for propulsion, motor loads, etc.), power supply converters (battery DC/DC, inverter DC/AC, energy storage PCS, AFE, etc.), switching converters, isolating converters, control converters, motor starting converters, and others.

4 Drawings and Documents

4.1 The following drawings and documents shall be submitted for approval:

(1) Product dimensional drawing;

(2) Panel schematic diagram;

(3) Electrical schematic diagram;

(4) Internal arrangement drawing;

(5) Type test programme;

(6) Product technical specification.

4.2 The following drawings and documents shall be available for reference:

(1) Product instruction manual;

(2) Component list;

(3) External interface drawing;

(4) Software instruction manual (if applicable);

(5) Risk assessment report (if applicable).

The product application scope, applicable standards and other contents described in the Product Instruction Manual shall be consistent with the application form and the relevant contents of this Section. The instructions for installation, use and operation of the product shall be correct and detailed, and shall be consistent with other submitted information for approval. The manual shall include at least the following descriptions:

(1) Intended application, purpose and operating modes;

(2) Description of the control system;

(3) Description of the integrated and advanced control system (if any);

(4) Description of cooling system redundancy (if any);

(5) Description of manual operation (if any);

(6) Description of protection, tripping and shutdown functions;

(7) Description of alarm functions.

5 Technical Requirements

5.1 The converter shall be capable of stable operation at 100% continuous load, and shall also be capable of overload operation for a specified period. The rated capacity shall include at least 100% continuous load and the necessary overload capability.

5.2 The materials of the converter shall comply with the requirements of Chapter 1, Section 1.3.1.5, Part 4 of the Rules for Classification of Steel Ships.

5.3 Converters for motor drive (including soft starters) shall be capable of two consecutive starts immediately after a long period of shutdown.

5.4 Creepage distances and clearances shall comply with the relevant product standards and the minimum values given in the relevant IEC standards. For semiconductor converters for power supply, the requirements are specified in IEC 60950-1, Annex G, Table G.2. For semiconductor converters for motor drive, the requirements are specified in IEC 61800-5-1, Table 8 and Table 10.

5.5 Capacitor discharge: Capacitors inside the converter shall be discharged to less than DC 60 V within 5 seconds (or a residual charge of less than 50 μC). If this requirement cannot be met, a warning sign shall be installed.

5.6 Cooling system: Air cooling, liquid cooling or combined air-liquid cooling is generally adopted. If forced cooling is provided, the unit shall be designed so that the converter cannot remain loaded unless effective cooling is provided or other effective means of protection against high temperature are provided. If the air supply contains particles that may reduce the cooling effect, air filtration

shall be provided to ensure proper operation of the air cooling system. The liquid cooling system shall be capable of online maintenance during normal operation to prevent scaling and corrosion.

5.7 The arrangement of cooling pipes shall have measures to prevent harmful effects caused by leakage, condensation or splashing, and shall be installed as far as possible at the lower part of the components.

5.8 The coolant piping of a liquid-cooled converter shall be tested at 1.5 times the design pressure or 0.4 MPa, whichever is the greater, and shall show no leakage after 30 minutes.

5.9 Cooling requirement: If the heat generated by the equipment may affect its normal operation, a temperature regulation device shall be provided. The heat exchange capacity of the temperature regulation device shall be designed according to the demand of the equipment. In the event of cooling failure, an alarm or protection measure shall be given.

5.10 Converters used for main propulsion of ships shall have protection functions to limit speed and limit torque/current/power to prevent damage to the propulsion motor.

5.11 Converters for the ship's daily service switchboard:

5.11.1 The output voltage and frequency shall comply with the requirements of the Rules for Classification of Steel Ships.

5.11.2 Converters (or rectifiers) used as a power source or as a power supply unit for a DC or AC distribution system shall be capable of withstanding a short circuit on the distribution busbar without any damage. If the converter can be rapidly latched upon short-circuit protection, this is also considered to comply with this requirement.

5.12 When an inverter is used as the sole power supply for the AC daily service distribution system, it shall be capable of sustaining output short-circuit current under AC short-circuit conditions without internal damage. The maximum output short-circuit current and its duration shall be provided as the basis for selection for selective protection analysis of the ship's AC power grid, and shall comply with the requirements of Clause 3.3.1.2 of the Guideline.

5.13 Converters used as a shipboard power source shall comply with the requirements of Clauses 3.2.1.5, 3.3.1.1, 3.3.1.2, 3.3.1.3 and 3.3.1.4 of the Guideline, for the purpose of ensuring the continuity and safety of the ship's power supply.

5.14 Converters directly connected to the DC busbar, including generator rectifiers, energy storage device interface converters, frequency converters (for propulsion or operation) and inverters (for daily service), shall comply with the requirements of Clauses 2.2.5.2 to 2.2.5.7 of the Guideline.

5.15 Monitoring and protection

The converter module shall be provided with safety measures such as overvoltage, overcurrent, overtemperature, undervoltage, overload, phase loss, communication fault, insulation monitoring (if applicable) and cooling fault monitoring (if applicable), including but not limited to the following:

(1) An alarm shall be given in the event of a power supply fault or trip.

(2) An earth fault alarm shall be provided for the distribution system (insulated neutral system) (except for a dedicated power supply system for a single piece of equipment; for a non-isolated converter, such as an AFE propulsion converter, the earth fault alarm may be indicated by an earth fault alarm device of other equipment, such as a switchboard).

(3) For cooling media where the coolant is in direct contact with live parts, a high conductivity alarm shall be provided.

(4) For converters installed in a DC switchboard, the relevant monitoring and alarm requirements shall comply with Section 4.1.2, Chapter 4 of the Guideline.

5.16 For converters fitted with batteries (e.g. UPS):

(1) Alarm on battery charging failure;

(2) Alarm when the online UPS unit is put into operation;

(3) Alarm on operation of the battery protection device (when the battery is not connected).

The above alarm points shall be alarmed to a manned control station.

5.17 Starting and emergency stopping

After a power failure and upon restoration of power, the frequency converter shall be able to restart in a normal manner without the need for local resetting/restarting of the device. Inverters used as the power supply for the AC daily service distribution system and propulsion frequency converters shall be provided with an emergency stop button.

5.18 Enclosure Protection

The converter shall be adequately protected against mechanical damage. Its enclosure shall meet the required degree of protection (IP code) as specified in the Rules.

5.19 The cyber security of the converter shall comply with the requirements of the CCS Guidelines for Marine Cyber Security .

5.20 Key equipment—converters (inverters, frequency converters, choppers, etc.)—for marine power systems (including battery systems, distribution systems and propulsion systems) to which the Rules for Marine Application of Power Batteries apply shall be subject to reliability verification at the product type approval stage and shall hold a CCS Certificate of Compliance for Reliability. Reliability verification shall be carried out in accordance with the requirements of the CCS guidance document Guideline for Reliability Verification of Marine Equipment and Systems (GD 028-2023). If equivalent verification means are used, they shall be approved by CCS; otherwise, restrictions shall be stated in the certificate.

6 Materials and Components

6.1 The raw materials and components of the product shall be controlled in accordance with the relevant requirements of the Society’s applicable current rules.

6.2 The manufacturer may make selection according to actual demands. In general, CM type approval may be adopted for general-purpose converters, and BM type approval may be adopted

for customized converters.

7 Type Test

7.1 The model and specification of type test samples shall cover the scope of products for which approval is applied and be technically representative, so as to verify the manufacturer's capability to manufacture approved products complying with CCS requirements through type test.

One specification product shall be selected as the test sample for each product series. Among samples of different series, at least one specification shall be no less than 80% of the maximum power applied for approval. Two units of each selected specification may be provided for testing.

7.2 For converters of different series supplied by the same manufacturer, sample selection shall be based on the representativeness of topology and configuration, power rating, voltage class, number of levels, cooling type/mode and manufacturing process.

7.3 For CM type approval, tests shall be conducted in accordance with Table 7.1. For BM type approval, tests may be carried out after cabinet integration in accordance with Table 7.1.

Type Test **Table 7.1**

No.	Test Item	Technical Requirement	Reference Test Method	Remarks
1	Visual Inspection	GD 019-2024 2.1	GD 019-2024 2.1	
2	Performance Test			
2.1	Input Voltage and Frequency Endurance Test	As specified by manufacturer	IEC62040-3 6.4.1.X	Applicable to power supply type
2.2	Light Load / Functional Test	As specified by manufacturer	IEC60146-1-1 7.3.1	Applicable to drive type
		As specified by manufacturer	IEC62040-3 6.2.2.3	Applicable to power supply type
2.3	Rated Current / Full Load Test	As specified by manufacturer	IEC60146-1-1 7.3.2	Applicable to drive type
		As specified by manufacturer	IEC62040-3 6.4.1.4, 6.2.2.5	Applicable to power supply type
2.4	Temperature Rise Test	IEC61800-5-1 4.6.5	IEC61800-5-1 5.2.3.10	Applicable to drive type
			IEC60146-1-1 7.4.2	Applicable to power supply type
2.5	Capacitor Discharge Test	IEC61800-5-1 4.4.9, 4.5.2.2, 4.11.7	IEC61800-5-1 5.2.3.8	
2.6	Impulse Voltage Test	IEC61800-5-1 4.4.3.2, 4.4.7	IEC61800-5-1 5.2.3.2	Applicable to drive type

Table 7.3 (Continued)

No.	Test Item	Technical Requirement	Reference Test Method	Remarks
2.7	Cooling Fault Test	Clause 5.9 of this Guideline	IEC61800-5-1 5.2.4.13	
2.8	Coolant Pipeline Pressure Test	Clause 5.8 of this Guideline	As specified by manufacturer	Applicable to liquid-cooled type
2.9	Monitoring and Protection Test	Clause 5.12 of this Guideline	As specified by manufacturer	
3	Insulation Resistance Measurement	GD 019-2024 2.3.1, 2.3.2	GD 019-2024 2.3.3	
4	Voltage Withstand Test	GD 019-2024 2.14.2	GD 019-2024 2.14.3	
5	Enclosure Protection Test	GD 019-2024 2.15	GD 019-2024 2.15	
6	Power Supply Fluctuation Test	GD 019-2024 2.4.1, 2.4.2	GD 019-2024 2.4.3	
7	Power Supply Fault Test	GD 019-2024 2.5.1, 2.5.2	GD 019-2024 2.5.2	
8	Inclination and Swaying Test ①	GD 019-2024 2.6.1, 2.6.2	GD 019-2024 2.6.4	Applicable to equipment with moving parts and free liquid level
9	Vibration Test	GD 019-2024 2.7.1, 2.7.3	GD 019-2024 2.7.4	
10	High Temperature Test	GD 019-2024 2.8.1, 2.8.3	GD 019-2024 2.8.3, 2.8.4	
11	Low Temperature Test	GD 019-2024 2.9.2, 2.9.3	GD 019-2024 2.9.4	
12	Alternating Damp Heat Test	GD 019-2024 2.10.1, 2.10.2	GD 019-2024 2.10.3, 2.10.4(1)	
13	Constant Damp Heat Test	GD 019-2024 2.11.1, 2.11.2	GD 019-2024 2.11.3, 2.11.4	Applicable to Class A environment
14	Salt Spray Test Kb ②	GD 019-2024 2.12	GD 019-2024 2.12	Applicable to open deck installation
15	Flame Retardant Test	GD 019-2024 2.16.2	GD 019-2024 2.16.3, 2.16.4	
16	EMC Test			
16.1	Conducted Emission Test	GD 019-2024 3.2.1, 3.2.2	GD 019-2024 3.2.3, 3.2.4	
16.2	Enclosure Port Radiated Emission Test	GD 019-2024 3.3.1, 3.3.2, UR E10	GD 019-2024 3.3.3, 3.3.4, UR E10	
16.3	ESD Immunity Test	GD 019-2024 3.4.1, 3.4.2	GD 019-2024 3.4.3, 3.4.4	
16.4	Radiated RF Field Immunity Test	GD 019-2024 3.5.1, 3.5.2, UR E10	GD 019-2024 3.5.3, 3.5.4, UR E10	
16.5	Electrical Fast Transient Burst Immunity Test	GD 019-2024 3.6.1, 3.6.2	GD 019-2024 3.6.3, 3.6.4	
16.6	Surge Immunity Test	GD 019-2024 3.7.1, 3.7.2	GD 019-2024 3.7.3, 3.7.4	
16.7	Low Frequency Conducted Immunity Test	GD 019-2024 3.8.1, 3.8.2	GD 019-2024 3.8.3, 3.8.4	
16.8	RF Field Induced Conducted Disturbance Test	GD 019-2024 3.9.1, 3.9.2	GD 019-2024 3.9.3, 3.9.4	

① The inclination test may be exempted provided that lubrication, cooling and free liquid level will not be affected.

② Products exempted from salt spray test shall be marked "Not suitable for installation on open deck" in the approval certificate and product certificate.

7.4 All international standards cited in this Guideline shall apply in their latest version.

7.5 For cited test method standards, other equivalent or recognized standards may be adopted where appropriate.

8 Unit/batch inspection (Factory Inspection)

8.1 After obtaining the CCS Type Approval Certificate B, the manufacturer shall conduct individual/batch inspection on every converter, and submit equivalent supporting documents and test reports. The individual/batch inspection report shall include test results, manufacturer's serial number of the unit and the type approval certificate number of the relevant model.

8.2 After type approval, the individual/batch inspection items shall at least follow the contents specified in Table 8.1. With the consent of CCS, destructive tests may be omitted during factory testing, provided that the manufacturer shall provide calculation reports based on type test records to prove compliance with rule requirements.

Table 8.1 Factory Test

No.	Test Item	Technical Requirement	Reference Test Method	Remarks
1	Visual Inspection	GD 019-2024 2.1	GD 019-2024 2.1	
2	Performance Test			
2.1	Light Load / Functional Test	As specified by manufacturer	IEC60146-1-1 7.3.1	Applicable to drive type
		As specified by manufacturer	IEC62040-3 6.2.2.3	Applicable to power supply type
2.3	Cooling Fault Test	Clause 5.9 of this Guideline	61800-5-1 5.2.4.13	
2.4	Coolant Pipeline Pressure Test	Clause 5.8 of this Guideline	As specified by manufacturer	Applicable to liquid-cooled type
2.5	Monitoring and Protection Tes	Clause 5.12 of this Guideline	As specified by manufacturer	
3	Insulation Resistance Measurementt	GD 019-2024 2.3.1,2.3.2	GD 019-2024 2.3.3	
4	Voltage Withstand Test	GD 019-2024 2.14.2	GD 019-2024 2.14.3	

8.3 The surveyor may add additional test items if deemed necessary.

8.4 The sampling rate for CCS inspection is 5% of the applied quantity, but not less than 2 units (except when only one unit is applied for inspection).