Guideline No.: E-07(201705)

E-07 TRANSFORMERS

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Foreword:

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

This Guide 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. IEC 60076-10(2001-05) update for IEC 60076-10:(2016-03).

2. IEC 60076-10-1(2005-10) update for IEC 60076-10-1:(2016-03).

3. IEC 60905(1987-12) was replaced by IEC 60076-12:(2008-11).

4. According to IEC 60076-1 (2011-04) requirements of the original determination of sound levels by the special test for type test.

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1 Application

1.1 This Chapter applies to approval and inspection of transformers for power and lighting (including single phase transformers rated at 1 kVA or more and three-phase transformers rated at 5 kVA or more) installed and used on ships and offshore installations.

2 Normative references

2.1 The approval and inspection of transformers in this Chapter are to be based on the following documents:

(1) IEC 60092-303(1980-1) Electrical installations in ships – Part 303: Equipment - Transformers for power and lighting

(2) IEC 60092-303-am1 (1997-9) Amendment 1-Electrical installations in ships – Part 303: Equipment - Transformers for power and lighting

(3) IEC 60076-1(2011-04) Power transformers – Part 1: General

(4) IEC 60076-2(2011-02) Power transformers – Part 2: Temperature rise

(5) IEC 60076-3(2013-07) Power transformers – Part 3: Insulation levels, dielectric tests and external clearances in air

(6) IEC 60076-4(2002-06) Power transformers – Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors

(7) IEC 60076-5(2006-02) Power transformers – Part 5: Ability to withstand short circuit

(8) IEC 60076-10: (2016-03) Power transformers – Part 10: Determination of sound levels

(9) IEC 60076-10-1: (2016-03) Power transformers – Part 10-1: Determination of sound levels - Application guide

(10) IEC 60076-11(2004-05) Power transformers – Part 11: Dry-type transformers

(11) IEC 60076-12: (2008-11) Loading guide for dry-type power transformers

(12) IEC 60529 (2013-08) Degrees of protection provided by enclosures (IP Code)

(13) IEC 60068-2-30(2005-08) testing – Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)

(14) IEC 60068-2-11(1981-01) Environmental testing – Part 2: Tests - Test Ka: Salt mist

(15) CCS Rules for Classification of Sea-going Steel Ships

(16) Guideline on Type Approval Test of Electrical and Electronic Products (current valid version)

3 Definitions

3.1 The terms and definitions used in this Chapter are consistent with those of IEC 60076.

4 Plans and documents

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

(1) General plans;

(2) Drawings of main parts including frame, coils, iron cores, terminal boxes, enclosures (if applicable);

(3) Technical specifications of the products;

(4) Type test programme.

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

(1) Operation instructions for the products;

(2) Process flow diagram indicating quality control points;

(3) Documents of manufacturing procedures, covering winding, sheet metal processing, painting (if applicable), lamination, insertion, vacuum dipping coating (if applicable), drying (if applicable), welding, polyester casting (if applicable) and various calculation sheets (tables);

(4) List of types (trade marks) and suppliers of main raw materials (e.g. magnetic wires, silicon steel sheets, insulation paper and insulating paints);

(5) Drawing of external wiring.

5 Design and technical requirements

5.1 Marine transformers rated at 5 kVA or more are to be subject to type approval by CCS.

5.2 Marine transformers are to comply with IEC 60092-303 and in addition, the following requirements:

5.2.1 All transformers, except those used for motor starting, are to be double wound or have multiple windings, with no electrical connections between primary and secondary windings.

5.2.2 In general, transformers are to be of dry, air-cooled type. Proposals for the use of liquid-immersed transformers are to comply with the following requirements:

(1) Cooling fluids are to be non-toxic and of low flammability. Liquid-immersed transformers are to be provided with a pressure release device with alarms and there is to be a suitable means provided to contain any liquid which may leak from the system due to the release of alarms or breakage of transformers;

(2) Where forced cooling is used, there is to be temperature monitoring of the heated cooling medium and coils with an alarm being given when the temperature exceeds a preset value which can be recovered by reducing load.

5.2.3 The voltage drop (voltage regulation) in the secondary voltage between no load and rated load, under resistive load, is not to exceed the following:

(1) 2.5% for single phase transformers rated more than 5 kVA or 3-phase transformers rated more than 15 kVA;

(2) 5% for single phase transformers rated up to 5 kVA or 3-phase transformers rated up to 15 kVA.

5.2.4 Transformers arranged for parallel operation are to comply with the following requirements:

(1) their winding connections are to be compatible;

(2) their rated voltage ratios are to be equal (with tolerances within permissible limits);

(3) their short-circuit impedance values are to be equal (if expressed in percentage, a ratio within 0.9 to 1.1 may be allowed);

(4) when transformers are intended for operation in parallel, the rated output of the smallest transformer in the group is not be less than 50% of the rated output of the largest transformer in the group.

5.2.5 The temperature rise of transformers at any part is not to exceed the values given in Table 5.2.5 during continuous operation at rated output, where the ambient air temperature is based on 45℃.

Limit of Temperature Rise **Table 5.2.5**

Transformer type	Temperature rise limit of windings (K)		Method of measurement
Dry type air cooled	Class A insulation	50	Resistance method
	Class E insulation	65	
	Class B insulation	75	
	Class F insulation	95	
	Class H insulation	120	
Oil-immersed	Defined as ON or OF in IEC60092-303	65	Thermometer or thermocouple method
	Defined as OD in IEC60092-303	70	

5.2.6 All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any windings for 2 s.

5.2.7 Transformers are to be subjected to high voltage test by applying a test voltage between primary and secondary windings and between windings and the frame. The test is to be made according to Table 5.2.7 and maintained for 1 min without breakdown and flashover.

Voltage of High Voltage Test **Table 5.2.7**

Maximum voltage (root mean square value) kV	Rated short-time withstand voltage (root mean square value) kV
≤ 1.1	3
3.6	10
7.2	20
12.0	28
17.5	38
24.0	50
36.0	70

5.2.8 Transformers are to withstand an induced high voltage test with a voltage twice the rated voltage and the duration of the test is to be 1 min for a frequency less than or equal to twice the

rated frequency, or t (t = 60 × 2 × rated frequency/test frequency (s)), but not less than 15 s for an increased frequency greater than twice the rated frequency. For transformers subject to temperature rise test, the induced high voltage test is to be carried out immediately after the temperature rise test.

Proper terminals and clear marks should be provided for outside wirings. The terminals should be protected and isolated from each other to avoid accidental grounding, short circuit or being touched.

Transformers should have a grounding terminal for protection use. All the metal parts which are not electrically charged should have structural method to be connected to the grounding terminal.

5.3 Marine transformers with metal enclosures are to comply with the above-mentioned standards an in addition, the following requirements.

5.3.1 Metal enclosures are to be of sufficient mechanical strength for mechanical protection, normal operation and safe handling of transformers.

5.3.2 Metal enclosures are to have sufficient space to maintain enough air clearance and creepage distance between conducting parts and between conducting parts and non-conducting parts of transformers inside metal enclosures. When a transformer mounted in the metal enclosure is in normal operation, the temperature rise is to comply with the requirements of Table 5.2.5 for Classification of Sea-going Steel Ships.

5.3.3 Degree of protection provided by metal enclosures is to be appropriate to the ambient conditions of the location where transformers are installed.

5.4 For transformers with voltage rating higher than 1kV, following requirements are to be complied with:

5.4.1 The enclosure protection class should be at least IP23. If installed in locations which can be accessed by unprofessional personnel, the enclosure protection class should be at least IP4X, the installation should comply with CCS Rules Part Four 2.14.7.1.

5.4.2 Dry-type transformers should comply with acceptable standards (See IEC60076-11 Dry-type transformers or other equivalent standards), oil-immersed transformers should also comply with acceptable standards (See IEC60076 power transformers or other equivalent standards).

5.4.3 Oil-immersed transformers should have following alarms and protections:

(1) Low oil level – alarm;

(2) High oil temperature – alarm;

(3) Low oil level – tripping or load decrease;

(4) High oil temperature - tripping or load decrease;

(5) High air pressure relay – tripping.

6 Type test

Marine transformers are to be subjected to type test according to the following requirements.

6.1 Unless otherwise specified, all tests are to be carried out under the following ambient conditions:

(1) ambient temperature: 15℃ to 40℃, cooling water temperature should be no higher than 25 ℃ if applicable;

(2) relative humidity: 30%RH to 90％RH;

(3) air pressure: 86 to 106 kPa.

6.2 Type test of marine transformers is at least to be in accordance with Table 6.2.

Type Test Items **Table 6.2**

No.	Test item	Technical requirements	Test method
1.	Exterior inspection		Visual inspection
2.	Measurement of winding resistance	IEC 60076-1 para. 11.2	IEC 60076-1 para. 11.2
3.	Measurement of voltage ratio and check of phase displacement	IEC 60076-1 para. 11.3	IEC 60076-1 para. 11.3
4.	Measurement of no-load loss and current	IEC 60076-1 para. 11.5	IEC 60076-1 para. 11.5
5.	Measurement of short-circuit impedance and load loss	IEC 60076-1 para. 11.4	IEC 60076-1 para. 11.4

Continued Table 6.2

6.	Voltage withstand	3.6.6.3, Chapter 3, PART FOUR of CCS	IEC 60076-3 para. 11

		Rules	
7.	Induced voltage withstand	3.6.6.4, Chapter 3, PART FOUR of CCS Rules	IEC 60076-3 para. 12.2.1
8.	Insulation resistance test	3.6.7.5, Chapter 3, PART FOUR of CCS Rules	3.6.7.5, Chapter 3, PART FOUR of CCS Rules
9.	Lightning impulse test (applicable for rated voltage higher than 1kV)	IEC 60076-11 para. 21	IEC 60076-3 para. 13
10.	Partial discharge measurement (applicable for Um> 3.6 kV dry-type)	IEC 60076-11 para. 22	IEC60270, IEC60076-3Appendix A
11.	Measurement of zero-sequence impedance(s) on three-phase transformers	IEC 60076-1 para. 11.6	IEC 60076-1 para. 11.6
12	Sound level measurement	IEC 60076-10	IEC 60076-10
13	Voltage regulation test	3.6.3.1, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships	3.6.7.6, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships
14	Short-circuit test (when necessary)	3.6.6.7, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships	IEC 60076-5
15	Temperature rise	3.6.6.2, Chapter 3, PART FOUR of CCS Rules	IEC60076-2(for oil-immersed), IEC60076-11 para.23(for dry-type)
16	Damp heat test	CCS Guidelines for Type Approval Test of Electric and Electronic Products (current valid version) 2.10, 6 period	IEC 60068-2-30
17	Degree of protection (for transformers with enclosures)	IP××	IEC 60529
18	Salt mist test (for open deck)	Ka	IEC 60068-2-11
19	Function test of components (If applicable, PT100, cooling fans, protection devices, etc.)		

6.3 Selection of typical samples

6.3.1 Type test samples are to be taken from qualified products by CCS Surveyor at the manufacturer.

6.3.2 At least one marine transformer is to be taken as test sample (more may be taken if necessary), if the capacity of the product applying for approval is not larger than 200kVA, the capacity of which is to be the maximum in the products to be approved. If the capacity of the product applying for approval is larger than 200kVA, then the test sample can be chose between range 50%~100%, but it is needed to confirm that the manufacturer has the ability to produce the maximum capacity. Where different insulation levels and constructions are to be covered by approval, related products are to be sampled respectively.

6.3.4 If environmental tests are restricted by test equipment (such as damp heat test), a smaller transformer of the same type may be taken as test sample.

6.4 Test organization

6.4.1 The initial type test is to be carried out by a competent test organization holding CCS Product Inspection and Test Organization Approval Certificate.

6.4.2 For renewal of the type approval certificate, type test may be carried out at the manufacturer's laboratory in the presence of CCS Surveyor, subject to agreement of CCS and provided that the manufacturer has required test environment and equipment as well as competent inspection and test personnel.

7 Unit/batch inspection

7.1 The manufacturers holding a CCS Type Approval B Certificate are still to carry out unit/batch inspection for all transformers and submit relevant certification documents and test reports.

7.2 The number of transformers to be inspected by CCS is to be 10% of the total number of submitted ones, but not less than 2 sets, unless the inspection is requested for one transformer only .Unit/batch inspection items are at least to include items:

(1) visual examination and processing examination (visual);

(2) measurement of winding resistance (IEC60076-1 para.11.2);

(3) measurement of voltage ratio and check of phase displacement (if applicable) (IEC 60076-1 para. 11.3);

(4) measurement of short-circuit impedance and load loss (IEC 60076-1 para. 11.4);

(5) measurement of no-load loss and no-load current (IEC 60076-1 para. 11.5);

(6) withstand voltage test (IEC 60076-3 para. 11);

(7) induced withstand voltage test (IEC 60076-3 para. 12.2.1);

(8) measurement of insulation resistance (3.6.6.5, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships);

(9) partial discharge test (for Um ≥ 3.6 kV dry-type) (IEC60076-11 para. 22);

(10) voltage regulation test (may be omitted when impractical at the manufacturer, subject to agreement of CCS) (3.6.6.6, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships);

(11) temperature rise test (may be required only for the first product of batch products of the same type) (3.6.6.1~3.6.6.2, Chapter 3, PART FOUR of CCS Rules for Classification of Sea-going Steel Ships).

(12) function test of components(If applicable, PT100, cooling fans, protection devices, etc.).