Guideline No.: E-06(201510)

E-06 STORAGE BATTERIES

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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 .

Historical versions and release date :

Main changes and effective date:

CONTENTS

1 General provisions

1.1 Application

This Chapter applies to permanently installed storage batteries.

1.2 Normative references

IEC 60092-101: 1980 Electrical installations in ships – Part 101: Definitions and general requirements;

IEC 60092-305: 1980 Electrical installations in ships – Part 305: Equipment- Accumulator (storage) batteries;

CCS Rules for Classification of Sea-going Steel Ships, 2006.

1.3 Terms and definitions

1.3.1 For definitions of terms such as products inspection, approval, type test, sample and unit/batch inspection, refer to 3.1.2 of Chapter 3, PART ONE of CCS Rules for Classification of Sea-going Steel Ships.

1.3.2 Batch means specifically the products of the same specification, made by the same manufacturer with the same production line and manufacturing processes.

2 Plans and documents

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

(1) General plans;

(2) Drawings of main parts, including enclosures and pole plates;

(3) Technical specifications of the products;

(4) Type test programme.

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

(1) List of raw materials;

(2) Essential manufacturing processes (such as paste mixing and smearing);

(3) Operation instructions for the products.

3 Deign and technical requirements

3.1 All pole plates are to be of rigid construction, and are to be designed to minimize the shedding of active material to a minimum. The cells are to be so constructed as to prevent spilling of electrolyte due to an inclination of 40 ° from the normal, and to prevent emission of acid or alkaline spray.

3.2 The cells are to be grouped in crates or trays of rigid construction and suitable material and equipped with means to facilitate handling. The weight of the assembled batteries is not to exceed 100 kg. The requirement does not apply to the cell impossible to be assembled in the above-mentioned crates or trays due to its weight.

3.3 The emergency storage battery is to be so designed and arranged as to ensure that they will function satisfactorily at full rated power when the ship is upright or when inclined at any angle up to 22.5 °, or when inclined up to 10 ° either way in the fore or aft direction, or in any combination of angles within the afore-said limits.

3.4 Technical plans of products are to be prepared according to related standards.

3.5 Marine storage batteries have conical and rectangular terminals.

3.6 Marine storage batteries are to be marked with clear and durable polar symbols, i.e. with “+” for positive terminal or “-“ or “N” for negative terminal.

3.7 Terminal posts of marine storage batteries and related material are to be of lead-coated copper or copper alloy.

3.8 Crates and covers of marine storage batteries are to be made of solid and corrosion-resistant material.

3.9 Each crate of marine storage batteries is to be provided with a securely attached durable nameplate, stating the following:

Marine starting (or lighting) lead-acid storage battery

(1) type;

(2) capacity (5 h, 10 h or 20 h rating recommended);

(3) voltage;

(4) product no. or batch no.;

(5) manufacturer;

(6) date of manufacture;

(7) mark of ship survey.

4 Selection of typical samples

Specifications of type test samples are at least to include the products with maximum capacity; six products are to be selected from each specification.

5 Type test

5.1 Type test of storage batteries are at least to include the following items:

(1) visual examination (including "external dimension examination" and "terminal examination");

(2) polarity test;

(3) gas-tightness test (if applicable);

(4) sealing agent;

(5) insulation resistance;

(6) capacity (starting capability and reserve capacity of starting storage batteries are to be checked) at an inclination of 22.5°;

(7) maximum discharge current proof (for communicating and lighting batteries);

(8) overcharging proof (for communicating and lighting batteries);

(9) seal reaction efficiency (for communicating and lighting batteries);

(10) overcharging life (for communicating and lighting batteries);

(11) starting capacity at low temperature (for starting storage batteries);

(12) charge acceptance (for starting storage batteries);

(13) cycle endurance (for starting storage batteries);

(14) charge retention;

(15) explosion proof;

(16) acid mist proof;

(17) inclination endurance;

(18) swing endurance;

(19) vibration endurance.

5.2 Test methods:

5.2.1 Measuring apparatus

(1) Electrical instrumentation

① Instrument ranges are to match voltage or current to be tested and readings of pointer instruments are to be within the last one third of the range.

② Accuracy of voltmeters is not to be less than grade 0.5 and internal resistance is not to be less than 300 Ω/V.

③ Accuracy of ammeters is not to be less than grade 0.5.

(2) Thermometers

Thermometers are to have an appropriate range, with grade division being not more than 1℃ and nominal accuracy not less than 0.5℃.

(3) Density meters

Density meters are to have an appropriate range, with grade division being not more than 0.005 g/cm3 and nominal accuracy not less than 0.005 g/cm3.

(4) Time meters

Time meters are to be graduated in hours, minutes and seconds with an accuracy of not less than ±1 s/h.

(5) Weighing apparatus

Accuracy of weighing apparatus is not to be less than ±0.05%.

(6) Megohmmeters

Accuracy of megohmmeters is not to be less than grade 1.5, and voltage rating is not to be less than 250 V.

(7) Measuring devices

Accuracy of measuring devices is not to be less than 1 mm.

(8) Pressure meters

Accuracy of pressure meters is not to be less than grade 0.25.

5.2.2 Pretreatment of storage batteries for tests

(1) Storage batteries for tests are to be products manufactured within last three months and to be kept upright in testing.

(2) All storage batteries are to be fully charged before test. Dry-charged or wet-charged storage batteries are to be activated.

(3) Storage batteries are to be fully charged at 25℃±5℃, and the cells to be charged at the voltage of 2.35 V±0.05 V for not less than 24 h. At the initial stage of charging, the current is not to be more than 2 I10 (charging voltage may be reduced appropriately when charging current exceeds 2 I10). During the last 4 h, full charge of storage batteries may be confirmed when no obvious change occurs in charging current.

5.2.3 External dimensions

External dimensions of storage batteries are to be measured by required measuring devices. The results are to comply with requirements of approved plans.

5.2.4 External appearance

Storage batteries are to be visually examined and free from cracks, stains or obvious distortion.

5.2.5 Gas-tightness test

Storage batteries not filled with electrolyte are to be filled with or bled of air to reach a difference of 4 kPa (telecommunications or lighting batteries), or 20kPa(starter batteries) between their internal and external pressures, observing the readings of pressure meters. When such difference reaches 4 kPa (telecommunications or lighting batteries), or 20kPa(starter batteries), the readings of pressure meters are to be stable for at least 3 s.

5.2.6 Seal test

(1) Cold resistance test

Storage batteries not filled with electrolyte are to be put into a low-temperature cabinet or room and kept at the temperature of -30℃±1℃ for 6 h. When the temperature rises to -20℃ ±1℃, the batteries are to be taken out and their sealing agent is to be visually examined in 1 min. The sealing agent is to be free from cracks and not to be separated from grooves or covers of the batteries at the temperature of -30℃.

(2) Heat resistance test

After the cold resistance test, the storage batteries are to be kept at room temperature for 6 h and then put into a thermostat and kept at an inclination angle of 45℃ from the horizontal surface at the temperature of 65℃±1℃ for 6 h. Then taking out and visually examining the batteries, the sealing agent is not to overflow out at 65℃.

5.2.7 Insulation resistance test

The surface of the storage battery filled with electrolyte is to be cleaned at the ambient temperature of 15℃ to 35℃ and relative humidity of 25% to 75%. When dried, the battery is to be placed on a metal plate and one end of the megohmmeter connected to any terminal of the battery and the other end of the megohmmeter to the metal plate for measurement. The insulation resistance of the battery to earth is not to be less than 10 MΩ.

5.2.8 Capacity test

(1) During the entire test period, the storage batteries are be put in a water tank with the temperature of 25℃±2℃, with the upper edge of the batteries being not more than 25 mm above the water surface and the distance between the batteries and between batteries and the tank wall being not less than 25 mm.

(2) When the temperature of electrolyte of general storage batteries reduces to 25℃±5℃ within 1 h to 24 h after full charge, the current I10 being discharged into the cell for 10 h

capacity is to be cut off at an average voltage of 1.80 V; the current I1 being discharged into the cell for 1 h capacity is to be cut off at an average voltage of 1.75 V, and the discharging time is to be recorded.

(3) When the surface temperature of the terminal post of sealed storage batteries reaches 25℃ ±5 ℃ within 1 h to 24 h after full charge (within 1 h to 5 h for starting storage batteries), the discharge into the cell for 10 h capacity I10 is to be cut off at an average voltage of 1.80 V; the discharge into the cell for 1 h capacity I1 is to be cut off at an average voltage of 1.60 V, and the discharging time is to be recorded.

(4) Capacity is calculated by multiplying discharge current and the time from discharge to voltage cutoff.

(5) If the temperature is not the reference temperature of 25℃ when discharge begins, the measured capacity is to be converted into the reference capacity at the reference temperature of 25℃ according to formula (1).

$$Ce = \frac{Ct}{1 + K(t - 25)} \quad \text{.....(1)}$$

where: Ce – capacity of storage batteries at reference temperature of 25℃, in Ah;
Ct – measured capacity of storage batteries, in Ah;
K – temperature coefficient, K = 0.006/℃ for testing at 10 h capacity; K = 0.01/℃ for testing at 1h capacity;
T – temperature when discharge begins, in ℃.

(6) At least one out of five storage battery capacity tests at 10 h rate and 1 h rate is not to be less than 95% of the rated capacity.

5.2.9 Maximum discharge current proof test

When the temperature of electrolyte of general storage batteries (the surface temperature of the terminal post of sealed storage battery) reaches 25℃±5℃ within 1 h to 24 h after full charge, current 30I1 is to be discharged for 5 s or current 15I10 discharged for 1 min and then the poles are to be examined visually. When current 30I1 is discharged for 5 s or current 15I10 discharged for 1 min, the conducting parts of the battery are not to blow out and to be free from any obvious distortion.

5.2.10 Overcharging proof test

(1) The 10 h capacity of the storage batteries for overcharging proof test is to comply with the

requirement of "at least one out of five storage battery capacity tests at 10 h rate and 1 h rate is to be carried out with a capacity not less than 95% of the rated capacity" and the batteries are to be fully charged.

(2) Charge with current 0.3I10 is to be continuous for 160 h at the temperature of 25℃±5℃, subsequently kept still for 1 h and then the storage batteries are to be examined visually.

(3) When charging with current 0.3I10 continuously for 160 h, the storage batteries are to be free from fluid leakage and any obvious distortion.

5.2.11 Charge retention test

(1) The 10 h capacity of the accumulator batteries for charge retention test is to comply with the requirement of "at least one out of five storage battery capacity tests at 10 h rate and 1 h rate is to be carried out with a capacity not less than 95% of the rated capacity" and the batteries are to be fully charged.

(2) After being kept for 28 days at the temperature of 25℃±5 ℃ in the open circuit, the storage batteries are to be tested and the 10 h capacity is to be calculated according to 6.5.2.8, without recharging.

(3) Charge retention capacity of storage batteries is to be calculated according to formula (2).

$$R = \frac{C_b}{C_{10}} \times 100 \quad \text{.....(2)}$$

where: R – charge retention capacity;

C_b –10 h capacity after retention, in Ah;

C_{10}–10 h rated capacity, in Ah.

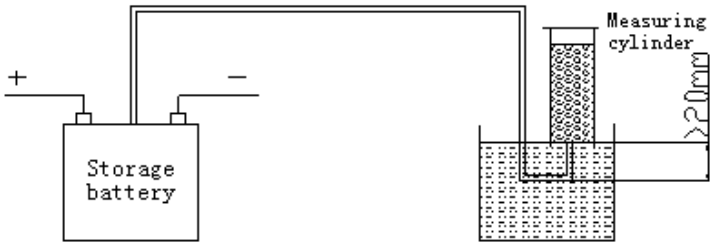
(4) Test results are to comply with the requirement of "the charge retention capacity of storage batteries is not to be less than 95%".

5.2.12 Seal reaction efficiency test

(1) The 10 h capacity of the storage batteries for seal reaction efficiency test is to comply with the requirements as specified in 4.10 and the batteries are to be fully charged.

(2) Charge with current 0.1I10 is to be continuous for 96 h at the temperature of 25℃±5℃. For storage batteries which have been subjected to overcharging proof test as specified in 6.5.2.10, the charging process may be omitted.

(3) After charging with current 0.05I10 continuously for 1 h and then gas is to be collected for 1 h. Charging is to continue during the gas collection. The gas collection is shown in Figure 1.



(4) Seal reaction efficiency is to be calculated according to formula (3) and formula (4).

$$V = \frac{P}{P_0} \times \frac{298}{(t+273)} \times \frac{v}{Q} \quad \text{.....(3)}$$

where: V – gas displacement of the accumulator battery, in m*l*/Ah, at the ambient temperature of 25℃, atmospheric pressure of one standard atmosphere and charged capacity of 1Ah,;

P – atmospheric pressure for gas collection, in kPa;

P_0 – standard atmosphere of 101.3 kPa;

t – ambient temperature surrounding the measuring cylinder, in ℃;

v – collected gas from the storage battery, in m*l*;

Q – battery–charging capacity for other collection, in Ah.

$$\eta = (1 - \frac{v}{684}) \times 100 \quad \text{.....(4)}$$

where: η – seal reaction efficiency, in %;

684 – theoretical gas displacement of the storage battery, in m*l*/Ah, at the ambient temperature of 25℃, atmospheric pressure of one standard atmosphere and charged capacity of 1Ah.

(5) Test results are to comply with the requirement of "for the fully charged accumulator battery, charge with current 0.1I10 is to be continuous for 96 h and then charge with current 0.05I10 is to be continuous for 1 h, the seal reaction efficiency is not to be less than 90%".

5.2.13 Exhaust valve action test

Exhaust valve action test is for valve components only. Air pressure is to be increased gradually on the exhaust valve and the pressure measured when the valve opens. The pressure is to be reduced in a natural condition and measured when the valve closes. Test results are to comply with the requirement of "the opening pressure of the storage battery exhaust valve is to be less than 49 kPa and the closing pressure is to be more than 1 kPa".

5.2.14 Overcharging life test

(1) The 1 h capacity of the storage batteries for overcharging life test is to comply with capacity test requirements and the batteries are to be fully charged.

(2) Charge with current 0.2I10 is to be continuous at the temperature of 25℃±5℃, and the test for 1 h capacity is to be carried out every 30 days as specified in 6.5.2.8. When the capacity is confirmed to be less than 80% of the 1 h rated capacity, the service life of the battery terminates.

(3) The total days of charging the storage battery are to be calculated, and the results are to comply with the requirement of "the storage battery is to be continuously charged with current 0.2I10, with every 30 days as a cycle. The overcharging life of sealed storage batteries is not to be less than 240 days; that of general storage batteries is not to be less than 360 days".

5.2.15 Explosion-proof test

The fully charged storage battery is to be charged with current 0.15I10 for 1 h and then sparks are to be produced near exhaust position twice by blowing out the 1A fuse with 24V DC power supply, and test results are to comply with the requirement of "the body of storage batteries is not to explode if sparks occur near exhaust position".

5.2.16 Acid mist proof test

The fully charged storage battery is to be charged with current I10 until gas strongly escapes from the electrolyte. A piece of PH test paper wetted with water used for the storage battery is to be hung 5 mm away from escaping gas for 2 h, observing whether the test paper turns red. The results are to comply with the requirement of "the fully charged accumulator battery is charged with current I10 and no acid mist escapes from the battery".

5.2.17 Inclination endurance test

(1) The fully charged storage battery is to be placed in open circuit for 4 h.

(2) The storage battery is to be fixed on the test bed and discharged with current I10 continuously. The discharge current deviation is to be within ±1% of required value. The battery is to be inclined from the front, back, left, right sides according to the following conditions:

a. The battery inclines from vertical position to an angle of 40 °within 1 s;
b. The battery is kept at an inclination angle of 40 °for 15 min;

c. The battery returns to vertical position within 1 s.

(3) Test results are to comply with the requirement of "the storage battery is inclined to an angle of 40 ° from the front, back, left, right sides for 15 min respectively, with discharge current being stable and voltage normal, without leakage or splash of electrolyte".

5.2.18 Swing endurance test

(1) The fully charged storage battery is to be placed in open circuit for 4 h.

(2) The storage battery is to be fixed on the test bed and discharged with current I10 continuously. The discharge current deviation is to be within ±1% of required value. The battery is to be swung to an angle of ±22°30' in horizontally axial direction from front to back and from right to left with a period of 10 s for 10 min respectively.

(3) Test results are to comply with the requirement of "storage batteries are to have stable discharge current and normal voltage, and electrolyte is not to leak or splash".

5.2.19 Vibration endurance test

(1) The fully charged storage battery is to be placed in open circuit for 4 h.

(2) The storage battery is to be fixed on the test bed and discharged with current I10 continuously. The discharge current deviation is to be within ±1% of required value. The battery is to be vertically vibrated with a frequency of 30 Hz to 34 Hz and an acceleration of 30 ms-2. The vibration is to be in a form close to sine wave.

(3) Test results are to comply with the requirement of "the storage battery is to have stable discharge current, normal voltage without any mechanical injury and electrolyte is not to leak or splash".

5.2.20 Charge acceptance test

(1) The fully charged storage battery is to be discharged with current I0 for 5 h at the temperature of 0℃ to 30℃.

(2) Current I0 is to be calculated according to formula (5).

$$I_0 = C_{10}/10 \quad \text{.....(5)}$$

where: C_{10} – the maximum capacity in three capacity tests.

(3) After completion of discharge, the battery is to be placed into a low-temperature cabinet or

room with the temperature of 0℃ ±1℃ for 20 h to 25 h.

(4) Within 1 min after being taken out of the low-temperature cabinet or room, 6 V storage batteries are to be charge at constant voltage of 7.20 V±0.02 V, and 12 V storage batteries are to be charged at constant voltage of 14.40 V±0.05 V. After 10 min, the charging current ICC is to be measured and recorded. ICC is not to be less than 2I20.

5.2.21 Starting capacity test at low temperature

Within 1 h to 5 h after the storage battery is fully charged, the battery is to be put into a low-temperature cabinet or room with the temperature of -18℃ ±1℃ for at least 20 h, or until the electrolyte temperature of the middle cell reaches -18℃ ±1℃. Within 1 min after being taken out of the low-temperature cabinet or room, the battery is to be discharged with starting current IS for 60 s. Discharge current deviation is to be within 1% of required value during discharging and the terminal voltage of the battery is to be measured and recorded. The results are to comply with the requirement of "cell voltage is to be higher than 1.4 V in at least one of three consecutive discharge tests".

5.2.22 Cycle endurance test

(1) Except starting capacity test at low temperature, storage batteries are to be placed in water bath with a temperature of 40℃ ±2℃ as specified in 6.5.2.8.1 and then connected to the continuous cycling test apparatus during testing.

(2) The fully charged storage battery is to be discharged with current 2I20 for 1 h and then immediately charged with current 2I20 for 5 h, constituting a cycle. After 36 such continuous cycles, the battery it to be kept still in open circuit for 96 h as specified in 6.5.2.22.1 and then discharged with starting current Is until the average voltage of the cells is reduced to 1.33 V. After completion of discharge, the battery is to be fully charged immediately and the density and level of electrolyte adjusted.

(3) The above-mentioned process constitutes a cycle endurance test unit.

(4) Starting from the third cycle endurance test unit, the storage battery is to be subjected to starting capacity test at low temperature as specified in 6.5.2.21 without recharging after 36 cycles and being placed still in open circuit for 96 h. Discharge is to last for 60 s and the terminal voltage of the battery is to be measured and recorded. Then the battery is to be fully charge and the density and level of electrolyte adjusted for the nest test unit. After low temperature starting discharge for 60 s, the average voltage of the cells is to be less than 1.00 V. When the test is completed, the unit is not counted as a cycle endurance test unit. At

least, storage batteries are to withstand three cycle units.

6 Unit/batch inspection

6.1 Upon Type Approval B, the unit/batch inspection is to be carried out after completion of installation and routine tests at the manufacturer.

6.2 The routine inspection reports are to be submitted together with an application for inspection to CCS.

6.3 Based on 100% routine tests by the manufacturer, the Surveyor is to sample at least 1% of each batch, but not less than 2 batteries; where the batch is unknown, 10% for each specification, but not less than 1 battery, is to be inspected.

6.4 Unit/batch inspection items are to include:

(1) external dimensions;

(2) visual examination;

(3) polarity;

(4) gas-tightness test.