SRI LANKA STANDARD 1126 PART 1: 2020
(IEC 60095-1: 2018)

SPECIFICATION FOR
LEAD-ACID STARTER BATTERIES
PART 1: GENERAL REQUIREMENTS AND METHODS OF TEST
(Third Revision)

SRI LANKA STANDARDS INSTITUTION

Sri Lanka Standard

SPECIFICATION FOR LEAD-ACID STARTER BATTERIES PART 1: GENERAL REQUIREMENTS AND METHODS OF TEST

(Third Revision)

SLS 1126 Part 1: 2020
(IEC 60095-1: 2018)

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This Standard does not purport to include all the necessary provisions of a contract

Sri Lanka Standard
SPECIFICATION FOR LEAD-ACID STARTER BATTERIES
Part 1: General requirements and methods of test
(Third Revision)

NATIONAL FOREWORD

This standard was approved by the Sectoral Committee on Electrical Appliances and Accessories and was authorized for adoption and publication as a Sri Lanka Standard by the Council of Sri Lanka Standards Institution on 2020-05-27.

This is the third revision of the **SLS 1126** Part**1:** 2020 and identical with **IEC 60095-1: 2018,** Edition 8.0 2018-11 Lead-Acid Starter Batteries Part 1: General requirements and methods of test published by the International Electrotechnical Commission (IEC).

Terminology and conventions

The text of the International Standard has been accepted as suitable for publication with additional information given in the **National Appendix**. However, certain terminology and conventions are not identical with those used in this Sri Lanka Standard; attention is therefore drawn to the following:

a) Wherever the words "International Standard" appear referring to this standard they should be interpreted as "Sri Lanka Standard".

b) Wherever the page numbers are quoted they are the page numbers of IEC standard.

c) The comma has been used as a decimal marker. In Sri Lanka Standards it is the current practice to use a full point on the base line as a decimal marker

CROSS REFERENCES

International Standard	**Corresponding Sri Lanka Standard**
IEC 60050-482: International Electrotechnical Vocabulary (IEV) Chapter 482: Primary and secondary cells and batteries	…….
IEC 60095–2: Lead acid starter batteries Part 2: Dimensions of batteries and dimensions and marking of terminals	SLS 1126: Specification for Lead- acid starter batteries Part 2: Dimensions of batteries and dimensions and marking of terminals
IEC 60095–4: Lead acid starter batteries Part 4: Dimensions of batteries for heavy trucks	SLS 1126: Lead acid starter batteries Part 3: Dimensions of batteries for heavy commercial vehicles

NATIONAL APPENDIX
AMENDMENTS TO THE TEXT OF IEC 60095-1

Clause 8.4.1 Batteries filled and charged

Replace the Note given under Clause 8.4.1a) with the following Note

NOTE: *Conformity of Capacity of batteries is determined, based on the results of Effective Capacity.*

IEC 60095-1

Edition 8.0 2018-11

INTERNATIONAL STANDARD

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Lead-acid starter batteries –
Part 1: General requirements and methods of test

IEC 60095-1:2018-11 (en)

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IEC 60095-1

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Lead-acid starter batteries –
Part 1: General requirements and methods of test

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FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 60095-1 has been prepared by IEC technical committee 21: Secondary cells and batteries.

This eighth edition cancels and replaces the seventh edition published in 2006. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) charge acceptance test;
b) cranking performance test;
c) charge retention test; and
d) endurance test added.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
21/974/FDIS	21/987/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60095 series, published under the general title *Lead-acid starter batteries*, can be found on the IEC website.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

LEAD-ACID STARTER BATTERIES –

Part 1: General requirements and methods of test

1 Scope

This part of IEC 60095 is applicable to lead-acid batteries with a nominal voltage of 12 V, used primarily as a power source for the starting of internal combustion engines, lighting, and for auxiliary equipment of internal combustion engine vehicles. These batteries are commonly called "starter batteries".

This document is applicable to batteries for the following purposes:

- batteries for passenger cars;
- batteries for commercial and industrial vehicles.

This document is not applicable to batteries for other purposes, such as the starting of railcar internal combustion engines or for motorcycles and other power sport vehicles.

This document defines many general properties of lead-acid batteries. Single sections can be referenced in other parts of the IEC 60095 series even if the application is excluded in the scope of this document.

This document specifies the:

- general requirements;
- essential functional characteristics, relevant test methods and results required,

for several classes of starter batteries:

- according to the general type of application;
- according to the type of product.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050-482, *International Electrotechnical Vocabulary – Chapter 482: Primary and secondary cells and batteries*

IEC 60095-2, *Lead-acid starter batteries – Part 2: Dimensions of batteries and dimensions and marking of terminals*

IEC 60095-4, *Lead-acid starter batteries – Part 4: Dimensions of batteries for heavy vehicles*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-482 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1
flooded battery
lead-acid battery having a cover provided with one or more openings through which gaseous products may escape

3.2
enhanced flooded battery
EFB battery
flooded lead-acid battery with additional special design features to significantly improve the cycling capability compared to standard flooded batteries

3.3
valve regulated lead-acid battery
VRLA battery
lead-acid battery which is closed under normal conditions but which has an arrangement that allows the escape of gas if the internal pressure exceeds a predetermined value

Note 1 to entry: The VRLA battery cannot receive addition to the electrolyte and after activation of dry-charged VRLA.

Note 2 to entry: In VRLA batteries the electrolyte is immobilized.

3.4
absorbent glass mat battery
AGM battery
VRLA battery in which the electrolyte is immobilized by absorption in a glass mat

3.5
gel battery
VRLA battery in which the electrolyte is immobilized by fixing as a gel

4 Designation of starter batteries – Electrolyte density and open circuit voltage

4.1 Designation according to type

Batteries are designated according to their type, as follows:

- flooded batteries (vented);
- enhanced flooded batteries, EFB;
- valve regulated lead-acid batteries, VRLA;
  - absorbent glass mat batteries, AGM;
  - gel batteries.

4.2 Dry-charged batteries

Lead-acid batteries may be supplied in a dry-charged state. Dry-charged batteries can be activated by filling with the defined electrolyte indicated by internal or external marks or according to the manufacturer's activation instructions. After activation, these batteries are ready to use.

4.3 Electrolyte density and open circuit voltage

The density of the electrolyte in all fully charged vented batteries shall be in the range of 1,27 kg/l to 1,30 kg/l at 25 °C unless otherwise specified by the manufacturer.

NOTE For valve-regulated batteries, the electrolyte is not accessible and, therefore, its density cannot be checked.

The open circuit voltage (OCV) at 25 °C, of fully charged batteries after a minimum 24 h stand on open circuit, shall be in the range of 12,70 V to 12,90 V for vented types and 12,80 V to 13,10 V for valve regulated types unless otherwise specified by the manufacturer.

The manufacturer shall specify the value and tolerance of the electrolyte density or OCV. If such information is not available, vented battery testing shall be carried out with a density of 1,28 kg/l ± 0,01 kg/l at 25 °C or an OCV of 12,76 V ± 0,06 V at 25 °C and valve regulated battery testing shall be carried out with a minimum OCV of 12,80 V.

5 Condition on delivery

New vented batteries may be supplied either:

- in a state ready for use, or
- in a dry-charged (or charge-conserved) state not filled with electrolyte. The density of the electrolyte to fill these batteries before use (unless otherwise recommended by the manufacturer) shall be:
  - 1,28 kg/l ± 0,01 kg/l at 25 °C;

Valve-regulated batteries are normally supplied in a state ready for use.

6 General requirements

6.1 Identification, labelling

6.1.1 General

Batteries complying with this document shall bear the following characteristics on at least the top or one of their four sides.

6.1.2 The identification of manufacturer or supplier

The name of the manufacturer or supplier shall be indicated.

6.1.3 Nominal voltage: 12 V

The nominal voltage of 12 V shall be indicated.

6.1.4 Capacity or reserve capacity (see 7.1.2) and nominal cranking current (see 7.1.1)

Three options are possible for the identification and labelling of capacity (or reserve capacity) and nominal cranking current:

Option 1:

- 20 h capacity C_{20} (Ah);
- with nominal cranking current I_{cc} (A) (see 7.1.1 and 9.3.1) defined at −18 °C with U_{10s} ≥ 7,5 V and U_{90s} ≥ 6,0 V (under I_{cc}/0,6).

Option 2:

- reserve capacity RC (minutes);
- with nominal cranking current I_{cc} (A) (see 7.1.1 and 9.3.1) defined at −18 °C with $U_{30\ s}$ ≥ 7,20 V.

Option 3:

- 20 h capacity C_{20} (Ah);
- with nominal cranking current I_{cc} (A) (see 7.1.1 and 9.3.1) defined at −18 °C with $U_{30\ s}$ > 7,20 V.

NOTE These three options are in accordance with the present use in the different areas in the world.

The preferred version is Option 1.

6.1.5 Production date code

Batteries shall be marked with the date of production. This can be part of a more complex code.

6.1.6 Safety labelling

If under national regulations, coloured safety symbols are required to be used, they should follow the design as set out in Annex C, Clause C.1.

However, to be in compliance with some national regulations, additional wording or special labelling can be used (for example, the safety label for North America area shown in Annex C, Clause C.2).

6.1.7 Recycling labelling

Batteries shall be marked for separate collection and recycling, if required by local area regulations.

6.1.8 Valve-regulated batteries

VRLA batteries shall be marked using the term "VRLA". In addition it is recommended that VRLA batteries shall bear special indication that the battery shall not be opened.

EXAMPLE: "VRLA – Do not open"

6.2 Marking of the polarity

The terminals shall be identified according to the requirements of IEC 60095-2 or of IEC 60095-4.

6.3 Fastening of the battery

Where batteries are fastened to the vehicle by means of integral parts (for example, bottom ledges), these shall be in compliance with the requirements of IEC 60095-2 and of IEC 60095-4.

7 Functional characteristics

7.1 Electrical characteristics

7.1.1 The cranking performance is the discharge current I_{cc}, as indicated by the manufacturer according to the option chosen (Option 1 or Option 2), which a battery can supply according to 9.3.

7.1.2 The capacity of a starter battery is defined for a temperature of 25 °C ± 2 °C.

It may be indicated by the manufacturer as either:

- nominal 20 h capacity C_{20}, or
- nominal reserve capacity RC_n.

The nominal 20 h capacity C_n is the electric charge in ampere hours (Ah) that a battery can supply with a current:

$$I_n = C_n / 20\ h \quad (A)$$

until the terminal voltage falls to U_f = 10,50 V.

The effective 20 h capacity C_e shall be determined by discharging a battery with constant current I_n to U_f = 10,50 V (see 9.1). The resultant discharge time, in hours, is used for the verification of C_n.

The nominal reserve capacity RC_n is the period of time (in minutes) for which a battery can maintain a discharge current of 25 A to a cut-off voltage U_f = 10,50 V.

The effective reserve capacity RC_e shall be determined by discharging a battery with the constant current I = 25 A to U_f = 10,50 V (see 9.2). The resultant discharge time, in minutes, is used for the verification of RC_n.

NOTE For the correlation (relationship) of C_n and RC_n, see Annex A.

7.1.3 The charge acceptance is expressed as the current I_{ca} which a partially discharged battery accepts at 0 °C and a constant charging voltage of 14,40 V.

7.1.4 The charge retention is rated by the cold cranking performance of the charged and filled battery after storage on open circuit under defined conditions of temperature and time (see 9.5).

7.1.5 The endurance test consists of two parts:

- the corrosion test represents the ability of a battery to perform repeated overcharge/storage periods (see 9.6.1.1).
- the cycling test represents the ability of a battery to perform repeated discharge/recharge cycles and long rest periods on open circuit. This ability shall be tested by a series of cycles and rest periods under specified conditions after which the cold cranking or the capacity performances shall be determined (see 9.6.1.2 or 9.6.2).

7.1.6 The water consumption test checks if the battery can keep its performance under extended exposure to heat and overcharge conditions. It is measured as loss of weight during overcharge of a fully charged battery and is defined as g/Ah C_e (see 9.7).

7.2 Mechanical characteristics

7.2.1 Vibration resistance represents the ability of a battery to maintain service under periodic or irregular acceleration forces. Minimum requirements shall be verified by a test (see 9.8).

7.2.2 Electrolyte retention is the ability of a battery to retain the electrolyte under specified physical conditions (see 9.9).

8 General test conditions

8.1 Sampling of batteries

Samples shall be tested not later than:

- 45 days after the production date of the manufacturer in the case of filled batteries;
- 60 days after the production date of the manufacturer in the case of dry-charged batteries.

8.2 Charging method – Definition of a fully charged battery

Batteries shall be considered as fully charged if they have undergone the charging procedures. Prior to the first capacity test, the battery charge shall be limited to 16 h.

If not specified differently by the battery manufacturer, the batteries that will be tested according to this document shall be charged according to Table 1.

Table 1 – Charging method

Battery type	Voltage U_C	Current	Time	Remarks
Flooded batteries with size in accordance with IEC 60095-2	16,00 V ± 0,05 V	5 I_n	24 h (16 h)[a]	
Flooded batteries with size in accordance with IEC 60095-4	16,00 V ± 0,05 V	5 I_n	20 h (16 h)[a]	Step 1
	no limitation	I_n	4 h	Step 2
Valve-regulated batteries VRLA	14,80 V ± 0,05 V	5 I_n	24 h (16 h)[a]	
[a] A charging time of 16 h is sufficient after a cranking performance test and prior to the first capacity check.				

All charges shall be performed with batteries in a water bath at 25 °C ± 2 °C.

8.3 Test equipment

8.3.1 Measuring instruments

The range of instruments used shall be appropriate for the magnitude of the parameters to be measured. The minimum accuracy of test equipment is given in Table 2.

Table 2 – Accuracy of test equipment

Parameter	Accuracy of test equipment
Current for cold cranking tests	0,5 %
Current for other tests	1 % full-scale with a minimum accuracy of ±30 mA
Voltage	± 0,04 V
Temperature	± 1 °C
Time	± 1 s
Density of electrolyte	≤ 0,005 kg/l
Weight of battery	± 1 g below 30 kg ± 5 g above 30 kg

The instruments used for measuring time shall be graduated in hours, minutes and seconds.

8.3.2 Water bath

If a test needs to be carried out in a water bath, the following conditions shall be fulfilled. The terminal base of the battery shall be at least 15 mm but not more than 25 mm above the water surface level. If several batteries are in the same water bath then the distance between them and also the distance to the walls of the bath shall be at least 25 mm.

Minimum soak time for batteries in the water bath is 4 h.

If not stated differently in the individual test description, the tolerance for the temperature of the water bath is ±2 °C.

It is recommended to cover the surface of the water with floating elements using testing temperatures of 40 °C or more. This improves the thermal isolation against air and avoids evaporation of water.

8.3.3 Environmental chamber

If a test needs to be carried out in an environmental chamber, the batteries are placed in an air gaseous phase at the requested temperature and tolerance; the wind velocity near the battery shall not be more than 2,0 m/s.

Minimum time for batteries in the environmental chamber before the test beginning is 8 h.

8.4 Test sequence

8.4.1 Batteries filled and charged

a) Initially, the batteries are subjected to the following series of tests:
   - first C_e or RC_e check;
   - first cranking performance test;
   - second C_e or RC_e check;
   - second cranking performance test;
   - third C_e or RC_e check;
   - third cranking performance test.

   For C_e or RC_e and the cranking performance, the specified values shall be met in at least one of the relevant discharges above.

It is not necessary to complete the sequence if the specified values are achieved on the first or second test.

NOTE The choice between testing C_e or RC_e is the decision of the customer or user.

b) The tests according to Table 3 shall be carried out only if batteries have complied with the previous tests, and not later than one week after completion of the first part.

Table 3 – Test sequence

Step	Test	Reference	Battery					
			No. 1	No. 2	No. 3	No. 4	No. 5	No. 6
0	Cranking performance for dry charged batteries	8.4.2 and 9.10	✓	✓	✓	✓	✓	✓
1	Initial charge prior to test	8.2	✓	✓	✓	✓	✓	✓
2	First 20 h capacity or First reserve capacity	9.1 or 9.2	✓	✓	✓ C_{20}	✓	✓	✓
3	First cranking performance according to Option 1 or Option 2	9.3.1	✓	✓	✓	✓	✓	✓
4	Second 20 h capacity Second reserve capacity	9.1 or 9.2	(✓)	(✓)	✓ C_{20}	(✓)	(✓)	(✓)
5	Second cranking performance according to Option 1 or Option 2	9.3.1	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)
6	Third 20 h capacity Third reserve capacity	9.1 or 9.2	(✓)	(✓)	✓ C_{20}	(✓)	(✓)	(✓)
7	Third cranking performance according to Option 1 or Option 2	9.3.1	(✓)	(✓)	(✓)	(✓)	(✓)	(✓)
8	Cranking performance – very cold climate	9.3.2	✓					
9	Corrosion test	9.6.1.1	✓					
10	Endurance in cycle test	9.6.1.2 or 9.6.2		✓				
11	Charge retention	9.5				✓		
12	Charge acceptance	9.4			✓			
13	Electrolyte retention	9.9				✓		
14	Vibration resistance	9.8					✓	
15	Water consumption	9.7						✓

Key

– ✓: test to be fulfilled.

– (✓): test to be fulfilled only if the previous identical test carried out failed.

Battery no. 3 shall perform the full sequence of 3 tests with 20 h capacity before the charge acceptance test in 9.4.

8.4.2 Dry-charged or conserved-charge batteries

a) Initially, the batteries are subjected to:

– initial cranking performance after filling with electrolyte (see 9.10).

b) The tests according to Table 3 shall be carried out only if the batteries have complied with the test mentioned in a) and no more than one week after the said test.

9 Tests methods

9.1 20 h capacity check C_e

Throughout the duration of the tests, the battery shall be placed in a water bath at a temperature of 25 °C ± 2 °C, in accordance with 8.3.2.

The battery shall be discharged with the current I_n (calculated according to 7.1.2) kept constant at ±2 % of the nominal value until the terminal voltage falls to 10,50 V ± 0,05 V. The duration t (h) of the discharge shall be recorded. The beginning of the discharge shall take place between 1 h to 5 h after the completion of charging according to 8.2.

The battery temperature, measured in one of the middle cells, if applicable, shall be 25 °C ± 2 °C before the discharge begins.

The capacity C_e is as follows:

$$C_e = t \times I_n \quad \text{(Ah)}$$

9.2 Reserve capacity check RC_e

Throughout the duration of the tests, the battery shall be placed in a water bath at a temperature of 25 °C ± 2 °C, in accordance with 8.3.2.

The battery shall be discharged with a current (25 ± 0,25) A until the terminal voltage falls to 10,50 V ± 0,05 V. The duration t (in minutes) of the discharge shall be recorded. The beginning of the discharge shall take place between 1 h to 5 h after the completion of charging according to 8.2.

The battery temperature, measured in one of the middle cells, if applicable, shall be 25 °C ± 2 °C before the discharge begins.

$$RC_e = t \text{ (min)}$$

9.3 Cranking performance test

9.3.1 Cranking performance test – Standard temperature (−18 °C)

Option 1:

After a rest period of 24 h up to 72 h after preparation according to 8.2, the battery shall be placed in a cooling environmental chamber with (forced) air circulation at a temperature of −18 °C ± 1 °C until the temperature of the middle cells has reached −18 °C ± 1 °C.

It is generally accepted that the required temperature will be achieved after a minimum period of 24 h in the cooling environmental chamber.

The battery shall then be discharged, either within or outside the cooling chamber, within 2 min after the end of the cooling period with a current I_{cc} (see 7.1.1). This current shall be kept constant to within ± 0,5 % during the discharge.

After 10 s discharge, the terminal voltage U_f shall be recorded and the current shall be cut off.

The voltage U_f shall be not less than 7,50 V.

After a rest period of 10 s ± 1 s, the test shall be continued as follows:

The battery shall then be discharged at 0,6 I_{cc}. The current shall be kept constant to within ± 0,5 % during the discharge. The discharge time ($t'_{6\ V}$) at 0,6 I_{cc} to 6 V shall be recorded in seconds. $t_{6\ V}$ is defined as the duration of the second stage ($t'_{6\ V}$) plus the equivalent duration of the first stage discharge if run at 0,6 I_{cc}, i.e. it is given, in seconds, by the following equation:

$$t_{6\ V} = t'_{6\ V} + \frac{10\ s}{0{,}6} = t'_{6\ V} + 17\ s$$

Requirements: the battery shall comply with the following requirement: $t_{6\ V} \geq 90$ s.

Option 2:

After a rest period of 24 h up to 72 h after preparation according to 8.2, the battery shall be placed in a cooling environmental chamber with (forced) air circulation at a temperature of −18 °C ± 1 °C until the temperature in one of the middle cells has reached −18 °C ± 1 °C.

It is generally accepted that the required temperature will be achieved after a minimum period of 24 h in the cooling chamber.

The battery shall then be discharged, either within or outside the cooling environmental chamber, within 2 min after the end of the cooling period with a current I_{cc} (see 7.1.1). This current shall be kept constant to within ± 0,5 % during the discharge.

After 30 s discharge, the terminal voltage $U_{f30\ s}$ shall also be recorded and the current shall be cut off.

Requirements: the battery shall comply with the following requirement: $U_{f30\ s} \geq 7{,}2$ V.

9.3.2 Cranking performance test – Very cold climates

This test shall be performed only if the battery is specified for very cold climate application by the manufacturer.

The test method is the same as defined above in Option 2 for standard temperatures with:

- cooling environmental chamber temperature = −29 °C ± 1 °C;
- I_{cc} for very cold climate specified by the manufacturer.

9.3.3 High current discharge test at low temperature

After a rest period of up to 72 h, the battery shall be placed in a cooling environmental chamber with (forced) air circulation at a temperature of −18 °C ± 1 °C until the temperature of the middle cells has reached −18 °C ± 1 °C.

It is generally accepted that the required temperature will be achieved after a minimum period of 24 h in the cooling environmental chamber.

The battery shall then be discharged, either within or outside the cooling environmental chamber within 2 min after the end of the cooling period with a current 0,6 I_{cc} (see I_{cc} definition in 7.1.1, Option 1). This current shall be kept constant to within ±0,5 % during the discharge.

After 30 s discharge, the terminal voltage $U_{30\ s}$ shall be recorded and the current shall be cut off.

Requirements: if not stated differently in the previous test, the voltage $U_{30\ s}$ shall be not less than 7,20 V.

9.4 Charge acceptance test

The test shall be carried out on batteries which have been charged in accordance with 8.2.

The battery shall be placed in a water bath at a temperature of 25 °C ± 2 °C, according to 8.3.2.

The battery shall be discharged at a current I_0:

$$I_0 = C_{e20} / 10\ h\ (A)\ for\ 5\ h.$$

The value C_e shall be taken as the maximum value C_e of the three previous discharges in accordance with 9.1.

Immediately after the discharge, the battery shall be cooled at a temperature of 0 °C ± 1 °C for a minimum of 20 h or until the temperature of one of the middle cells has reached 0 ºC ± 1 ºC.

At this temperature of 0 °C ± 1 °C, the battery shall be charged at a constant voltage of 14,40 V ± 0,10 V.

After 10 min, the charging current I_{ca} shall be recorded.

9.5 Charge retention test

A fully charged battery (according to 8.2), with its vent plugs firmly in place and a clean dry surface, shall be stored at 40 °C ± 2 °C on open circuit for 21 days. No connecting clamps or cables shall be attached to the terminals.

After this storage period, the battery shall be submitted, without recharge, to a cranking performance test at −18 °C and a current I = 0,6 I_{cc}.The voltage after 30 s ($U_{30\ s}$) shall be recorded.

Requirements:

- normal batteries (N) and low water loss batteries (L): $U_{30\ s}$ ≥ 8 V;
- very low water loss batteries (VL): $U_{30\ s}$ ≥ 8,5 V.

9.6 Endurance test for batteries

9.6.1 Corrosion test

9.6.1.1 General

The corrosion test unit is as follows.

- The test shall be carried out on fully charged batteries in accordance with 8.2.
- The battery shall be placed in a water bath maintained at a temperature of 60 °C ± 2 °C, according to the installation described in 8.3.2.
- The battery, maintained at 60 °C ± 2 °C, shall be charged at a constant voltage of 14,00 V ± 0,10 V, for a period of 13 days.
- The battery shall be stored on open circuit, still at 60 °C ± 2 °C, for a period of 13 days. No connecting clamps or cables shall be attached to the terminals.

- The battery shall be cooled to 25 °C ± 2 °C. Purified water shall be added, if possible, to maintain the electrolyte level in accordance with the manufacturer's recommendations (this does not apply to VRLA batteries).
- The battery shall then be recharged in accordance with 8.2 for 6 h.
- The battery, maintained at 25 °C ± 2 °C, shall be stored for a rest period of 20 h.
- The battery shall be discharged with a current of 0,6 I_{cc} at 25 °C ± 2 °C for 30 s. The 30 s voltage shall be recorded.

This corrosion test unit shall be repeated and the test shall be terminated when the battery voltage reaches less than 7,2 V at 30 s with a current of 0,6 I_{cc} in cranking test at 25 °C ± 2 °C.

The number of corrosion test units to apply is mentioned in Table 6.

9.6.1.2 Endurance in cycle test

The tests shall be carried out on fully charged batteries in accordance with 8.2.

Table 4 – Parameters cycle test

Battery size according to:	Test temperature	Charging voltage U	Constant current I	Charging ratio CR
IEC 60095-2	+40 °C ± 2 °C	14,4 V for VRLA 15,6 V for flooded	I_n	1,08
IEC 60095-4	+25 °C ± 2 °C	15,6 V	2,5 I_n	1,10

The battery shall be placed in a water bath as defined in 8.3.2 and maintained at a temperature as stated in Table 4.

The charging voltage U and charging ratio CR defined as:

$$CR = \frac{2C_{rch}}{C_n}$$

stated in Table 4 shall be used if not otherwise specified by the manufacturer of the battery to be tested.

Only for batteries having a normal water loss requirement, purified water shall be added to the battery as necessary during the test to maintain the electrolyte level in accordance with the manufacturer's recommendations.

The batteries shall be connected to a test device where they undergo a series of cycles. Each cycle consists of the following steps.

Step 1: discharge the battery for 2 h with a constant current of I = 5 I_n. The cut-off criterion for this test is the voltage during the discharge. If it drops below 10,5 V the test shall be terminated.

Step 2: recharge the battery for maximum 5 h with a constant voltage and a current limitation of 5 I_n. Record the recharged capacity C_{rch} (Ah) during the charging.

Once the charging ratio CR reaches the specified value of Table 4, stop the charging.

Step 3: if the charging ratio CR is lower than specified in Table 4 after completion of Step 2, continue to recharge the battery in a second step with a constant current as specified in Table 4 until the charging ratio CR reaches the required value or until the maximum duration of 1 h for this step is reached.

Perform Steps 1 to 3 as long as the voltage during discharge is above the limit or until the number of cycles of the requirement level is reached as defined in Table 6.

A following high current discharge test in accordance with 9.3.3 shall be performed without any preceding recharge of the battery.

The number of cycles to apply is mentioned in Table 6.

The requirement for the capacity test (with a preceding charging according to 8.2) is:

$$C_e \geq 0{,}5\ C_{20}$$

9.6.2 Optional endurance cycle test for passenger car batteries – Maximum capacity 100 Ah

The test shall be carried out on batteries that have been charged in accordance with 8.2.

Throughout the whole test period, the battery shall be placed in a water bath according to 8.3.2 at a temperature of 40 °C ± 2 °C.

Purified water should be added to the electrolyte as required during the cycling portion of the test with the exception of those batteries described as "low water loss", "very low water loss", or VRLA.

The batteries shall be connected to a device where they undergo a continuous series of cycles, with each cycle comprising:

a) a discharge for 240 s ± 1 s at 25 A ± 0,1 A;

b) followed, within 10 s, by a charge for 600 s ± 1 s at the maximum charge current of 25 A ± 0,1 A with a maximum charge voltage of 14,80 V ± 0,03 V;

with the interval between the charge and the discharge periods not exceeding 10 s, for 100 h $^{+12}_{0}$ h.

The battery, maintained at the temperature of 40 °C, shall be stored on open circuit for between 65 h to 70 h.

With the battery at the temperature selected 40 °C, discharge at I_{cc} cranking amps for 30 s. The terminal voltage at 30 s ($U_{30\ s}$) shall be recorded together with the number of cycles described.

The battery should be replaced on the cycling test without a separate charge, starting on the "charge" portion "b)" of the cycle.

The cycling test should be considered complete when the terminal voltage at 30 s ($U_{30\ s}$) of the cranking test falls to below 7,20 V. The number of cycles shall be determined by plotting the 30 s ($U_{30\ s}$) voltage values versus the cycle values. The point where the line crosses 7,20 V shall be the cycle reported for that battery.

The number of cycles to apply is mentioned in Table 6.

9.7 Water consumption test

This test applies only to vented batteries.

The battery, after being charged according to 8.2, shall be cleaned, dried and weighed to an accuracy of ± 0,05 % (W1).

The battery shall be placed in a water bath maintained at a temperature of 40 °C ± 2 °C according to the provisions of 8.3.2.

The battery shall be charged at a constant voltage of 14,40 V ± 0,05 V (measured across the battery terminals) for a period of 500 h.

Immediately after this overcharge period, the battery shall be weighed under the same conditions as initially, with the same scales (W2).

The ratio (W1-W2)/C_{20} shall be calculated and compared against the requirements listed in Table 6.

NOTE It is possible to carry out this test with a different temperature than 40 °C (for example 60 °C); see the correlation formula between temperatures in Annex B.

9.8 Vibration resistance test

After charging according to 8.2, the battery shall be stored for 24 h at a temperature of 25 °C ± 2 °C.

The battery shall be fastened rigidly to the table of the vibration tester. The fastening shall be of the same type as that used on a vehicle and secured by either:

- the bottom hold-downs or ledges on the lower part of the container and suitable hold-down clamps and bolts with M8 thread, tightened to a torque of between 15 Nm and 25 Nm, or
- an angle-iron frame covering the upper edges of the battery case/cover assembly for a minimum width of 15 mm for batteries according to IEC 60095-2 and of 33 mm for batteries according to IEC 60095-4, connected to the vibration table by four screwed rods with M8 thread, tightened to a torque of between 8 Nm and 12 Nm.

The battery shall be subjected for a period of T (h) (see Table 5) to a vertical vibration of a frequency of 30 Hz ± 2 Hz, these vibrations being as nearly sinusoidal as possible.

The maximum acceleration on the battery shall reach the value Z (see Table 5).

The battery temperature throughout the vibration shall be between 20 °C and 30 °C.

After a maximum of 4 h after the end of the vibration, the battery shall be subjected, without recharge, to a discharge at a temperature of 25 °C ± 2 °C with a current $I = I_{cc}$.

The terminal voltage after 30 s ($U_{30\ s}$) discharge shall be recorded. The discharge shall then be terminated.

Table 5 – Vibration resistance – Levels V1 to V3

Parameter	Requirement level		
	V1	V2	V3
Period of vibration, T	2 h	2 h	20 h
Maximum acceleration on the battery, Z	30 ms^{-2}	60 ms^{-2}	60 ms^{-2}

The requirement level V1 to V3 should be chosen according to customer application needs; however V3 is limited to applications that need extremely high vibration resistance.

9.9 Electrolyte retention test

After charging according to 8.2, the battery shall be stored for 4 h on open circuit at a temperature of 25 °C ± 2 °C.

If necessary, the electrolyte level of each cell shall be adjusted to the maximum with purified water. The external surfaces of the battery shall be cleaned and dried.

The battery shall then be tilted in each of the four directions at intervals of not less than 30 s between each tilting as follows:

a) the battery shall be tilted through 45° from the vertical in a maximum period of 1 s;

b) the battery shall be maintained in this position for 3 s;

c) the battery shall be returned to the vertical position in a maximum period of 1 s.

Throughout the tests described above, the battery shall be examined for any sign of electrolyte leaking from the battery. The observations shall be recorded.

9.10 Cranking performance for dry-charged (or conserved-charge) batteries after activation

The dry-charged battery and a sufficient amount of electrolyte supplied by the manufacturer, or according to the manufacturer's specifications, shall be stored at 25 °C ± 2 °C for at least 12 h (before filling).

The battery shall be filled with its electrolyte up to the level indicated by the manufacturer. After a rest period of 20 min at the same ambient temperature, the battery shall be discharged at a current $I = I_{cc}$ for 30 s.

The voltage after a discharge period of 30 s ($U_{30\ s}$) shall be recorded. The discharge shall then be terminated.

10 Requirements

The requirements applicable to essential functional characteristics are summarized in Table 6.

Table 6 – Summary of requirements

Functional characteristics	See paragraph	Requirements	Comments
20 h capacity	9.1	$C_e \geq C_{20}$	For batteries rated in Ah
Reserve capacity	9.2	$RC_e \geq RC_n$	For batteries rated in reserve capacity
Cranking performance test −18 °C	9.3.1	Option 1 (for batteries rated in Ah) $U_{10\ s} \geq 7{,}50$ V $t_{6\ V} \geq 90$ s Option 2 (for batteries rated in reserve capacity) $U_{30\ s} \geq 7{,}20$ V	
Cranking performance test −29 °C	9.3.2	$U_{30\ s} \geq 7{,}20$ V	Optional
Charge acceptance	9.4	$I_{ca} \geq 2I_0$	
Charge retention Normal batteries (N) and Low water loss batteries (L)	9.5	$U_{30\ s} \geq 8{,}0$ V	
Charge retention Very low water loss batteries (VL)	9.5	$U_{30\ s} \geq 8{,}5$ V	
Corrosion test	9.6.1.1	Number of units ≥ 4	
Endurance in cycle test	9.6.1.2	Flooded (vented) ≥ 60 cycles VRLA ≥ 250 cycles	
Optional endurance in cycle test	9.6.2	Number of cycles = $34 \times RC_n - 581$	Optional
Water consumption Normal batteries (N)	9.7	No requirement	
Water consumption Low water loss batteries (L)	9.7	Maximum 4 g/Ah	
Water consumption Very low water loss batteries (VL)	9.7	Maximum 1 g/Ah	
Vibration	9.8	$U_{30\ s} \geq 7{,}2$ V	
Electrolyte retention	9.9	No evidence of liquid on the vent plugs (or from the single point vent outlet)	
Cranking performance after activation	9.10	$U_{30\ s} \geq 7{,}2$ V	
For both C_e or RC_e and the cranking performance, the specified values shall be met in at least one of the three relevant discharges above (see 9.1, 9.2, and 9.3).			

Annex A
(normative)

Correlation between C_n and RC_n

The value of RC_n (in minutes) may be estimated from C_n (in ampere hours) using the following equation:

$$RC_n = \beta\,(C_n)^{\alpha}$$

where

α = 1,182 8 for flooded batteries, or 1,120 1 for valve-regulated batteries;

β = 0,773 2 for flooded batteries, or 1,133 9 for valve-regulated batteries.

Reciprocal equation:

$$C_n = \delta\,(RC_n)\gamma$$

where

γ = 0,845 5 for flooded batteries, and 0,892 8 for valve-regulated batteries;

δ = 1,242 9 for flooded batteries, and 0,893 9 for valve-regulated batteries.

Annex B
(informative)

Water consumption test – Conversion of test temperatures and test durations

B.1 General

This document recommends that the water consumption test be performed according to 9.7 at 40 °C. Other regional standards request a test temperature of 60 °C. If the same charging voltage of 14,4 V is used it is possible to convert the results from the 60 °C test to 40 °C conditions following Arrhenius law and a compensation reflecting possible differences in test duration.

B.2 Conversion formula

$$WL_{40} = \frac{500\,\text{h}}{d} \times \frac{1}{4} \times WL_{60}$$

where

WL_{40} is the water loss result according to IEC 60095-1 after 500 h charging with 14,4 V at 40 °C;

WL_{60} is the water loss result according to regional standard after d hours charging with 14,4 V at 60 °C;

d is the duration of 60 °C test procedure in hours.

Annex C
(informative)

Safety labelling

C.1 Definition of the six coloured symbols

If coloured safety symbols are required to be used by national regulations, they should refer to the designs in accordance with ISO 7010.

Table C.1 – Definition of safety symbols according to ISO 7010

Reference	Description	Graphical symbol
ISO 7010 P003:2011-05	No open flame; Fire, open ignition source and smoking prohibited	
ISO 7010 M004:2011-05	Wear eye protection	
ISO 7010 P036:2012-06	No children allowed	
ISO 7010 W023:2011-05	Warning; Corrosive substance	
ISO 7010 M002:2011-05	Refer to instruction manual/booklet	
ISO 7010 W002:2011-05	Warning; Explosive material	

The individual symbols shall have common dimensions, as shown in Figure C.1, with minimum dimensions of 10 mm.

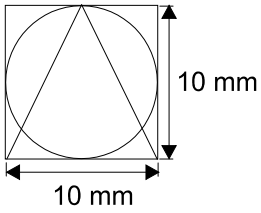

Figure C.1 – Symbol dimensions

C.2 Safety labelling – Label for North America area

For information, specific safety labelling is used in North America: see Figures C.2 and C.3.

Figure C.2 – Safety labelling – Label for North America area, former version (still valid)

Figure C.3 – Safety labelling – Label for North America area, new version

Bibliography

ISO 7010, *Graphical symbols – Safety colours and safety signs – Registered safety signs*

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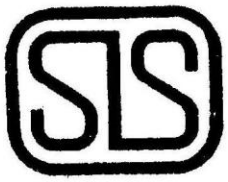

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