भारतीय मानक
Indian Standard

IS 16270 : 2023

सौर फोटोवोल्टीय अनुप्रयोग हेतु सैकेंडरी सैल एवं बैटरियाँ — सामान्य अपेक्षाएं और परीक्षण पद्धति

(पहला पुनरीक्षण)

Secondary Cells and Batteries for Solar Photovoltaic Application — General Requirements and Methods of Test

(First Revision)

ICS 27.160; 29.220.20

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

December 2023 **Price Group 7**

Secondary Cells and Batteries Sectional Committee, ETD 11

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Secondary Cells and Batteries Sectional Committee had been approved by the Electrotechnical Division Council.

This standard gives general information relating to the requirements of secondary cells and batteries used in photovoltaic energy systems (PVES) and to the typical methods of test used for the verification of the cell and battery performances. This standard does not include specific information relating to battery sizing, method of charge or PVES design.

This standard is applicable to all types of secondary cells and batteries presently being used in solar photovoltaic application.

This standard was first published in the year 2014. This revision has been taken up to incorporate new battery chemistries now being used in solar photovoltaic application as well as to incorporate experience gained during implementation of the previous version. The major changes from previous version are as below:

a) Maximum charge current: I_{10} (A) in **4.3.3 a)**;
b) Inclusion of lithium battery type and other electro chemistries in Table 1 and Table 2;
c) Inclusion of standards for lithium cells and batteries in **7.2**;
d) Inclusion of long duration capacity C_{120} in **8.1**; and
e) Inclusion of capacity requirement of the rated capacity in **8.1.1**.

Technical assistance has been taken from IEC 61427-1 : 2013 in the preparation of this standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis shallbe rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SECONDARY CELLS AND BATTERIES FOR SOLAR PHOTOVOLTAIC APPLICATION — GENERAL REQUIREMENTS AND METHODS OF TEST

(First Revision)

1 SCOPE

This standard specifies the requirements and tests for secondary cells and batteries for use in photovoltaic energy systems (PVES).

This standard does not include specific information relating to battery sizing, method of charge or PVES design.

This standard is applicable to all types of secondary cells and batteries used in solar photovoltaic applications.

2 REFERENCES

The standards listed in Annex A contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of these standards.

3 TERMS AND DEFINITIONS

For the purpose of this standard, the terms and definitions given in IS 1885 (Part 15) concerning secondary cells and batteries, and those given in IS 12834 concerning photovoltaic generator systems apply.

4 CONDITIONS OF USE

This clause specifies the particular operating conditions experienced by secondary cells and batteries in photovoltaic applications during their use.

4.1 Photovoltaic Energy System

The photovoltaic energy system with secondary batteries referred to in this standard can supply a constant, variable or intermittent energy to the connected equipment (pumps, refrigerators, lighting systems, communication systems etc).

4.2 Secondary Cells and Batteries

Secondary cells and batteries mainly used in photovoltaic energy systems are of the following types:

a) vented (flooded);
b) valve-regulated, including those with partial gas recombination; and
c) gastight sealed.

The cells and batteries are normally delivered in the following state of charge:

a) discharged and drained (vented nickel-cadmium batteries only);
b) charged and filled;
c) dry charged and unfilled (vented lead-acid batteries only); and
d) discharged and filled (nickel-cadmium batteries only).

For optimum service life, the battery manufacturer’s instructions for initial charge of the battery shall be followed.

Other secondary cells and batteries such as based on sodium or vanadium electrochemical systems can be potentially used for such an application. Due to the fact that they are in a phase of adaptation for a possible use in PV systems, it is recommended that their respective supplier be contacted for the necessary planning, test and operation details.

4.2.1 *Material and Construction*

All the materials used in the manufacture of secondary cells and batteries for photovoltaic system shall conform to the relevant Indian standard, if any.

4.3 General Operating Conditions

Batteries in a typical PV system operating under average site weather conditions may be subjected to the following conditions:

4.3.1 *Autonomy Time*

The battery is designed to supply energy under specified conditions for a period of time, typically from 3 days to 15 days, with or without solar radiation.

When calculating the required battery capacity, the following items should be considered, for example:

a) Required daily/seasonal cycle (there may be restrictions on the maximum depth of discharge, DOD shall be limited to 80 percent at the end of autonomy);
b) Time required to access the site;
c) Aging;
d) Operating temperature; and
e) Future expansion of the load.

4.3.2 *Typical Charge and Discharge Currents*

The typical charge and discharge currents are the following:

a) maximum charge current: I_{10} (A);
b) average charge current: I_{50} (A); and
c) average discharge current as determined by the load: I_{120} (A).

Depending on the system design, the charge and the discharge current may vary in a wider range.

In some systems the load current must be supplied at the same time as the battery charging current.

NOTE — The following abbreviations are used:

a) C_{rt} is the rated capacity declared by the manufacturer in ampere-hours (Ah);
b) t is the time base in hours (h) for which the rated capacity is declared;
c) $I_{rt} = C_{rt}/t$; and
d) for nickel-cadmium, nickel-metal hydride and lithium battery systems $I_{rt} = C_{rt}/$ 1 h in this document corresponds to $I_t = C_5/1$ h.

4.3.3 *Daily Cycle*

The battery is normally exposed to a daily cycle as follows:

a) Charging during daylight hours; and
b) Discharging during night-time hours.

A typical daily usage results in a discharge between 2 percent and 20 percent of the battery capacity.

4.3.4 *Seasonal Cycle*

The battery may be exposed to a seasonal cycle of state of charge. This arises from varying average-charging conditions as follows:

a) Periods with low solar irradiation, for instance during rainy season/monsoon season/winter causing low energy production. The state of charge of the battery (available capacity) can go down to 20 percent of the rated capacity or less; and
b) Periods with high solar irradiation, for example in summer, which will bring the battery up to the fully charged condition, with the possibility that the battery could be overcharged.

4.3.5 *Period of High State of Charge*

During summer for example, the battery will be operated at a high state of charge (SOC), typically between 80 percent and 100 percent of rated capacity.

A voltage regulator system normally limits the maximum battery voltage during the recharge period. When generation voltage exceeds beyond the limits, the controller should trip-off and reconnect back as soon as the generation voltage comes to normal range to avoid any delay in charge cycle. Charge and controller should be sized accordingly to keep the battery and load always safe and getting charged.

NOTE — In a "self-regulated" PV system, the battery voltage is not limited by a charge controller but by the characteristics of the PV generator.

The system designer normally chooses the maximum charge voltage of the battery as a compromise allowing to recover to a maximum state of charge (SOC) as early as possible in the summer season but without substantially overcharging the battery.

The overcharge increases the gas production resulting in water consumption in vented cells. In valve-regulated lead-acid cells, the overcharge will cause less water consumption and gas emission but more heat generation.

Typically, the maximum charge voltage is 2.4 V per cell for lead-acid batteries and 1.55 V per cell for vented nickel-cadmium batteries at the reference temperature specified by the manufacturer. Some regulators allow the battery voltage to exceed these values for a short period as an equalizing or boost charge. For the other batteries, the battery manufacturers shall give the most adapted charge voltage values. Charge voltage compensation shall be used according to the battery manufacturer instructions if the battery operating temperature deviates significantly from the reference temperature.

The expected lifetime of a battery in a PV system, even kept regularly at a high state of charge, may be considerably less than the published life of the battery used under continuous float charge conditions.

4.3.6 *Period of Sustained Low State of Charge*

During periods of low solar radiation, the energy produced by the photovoltaic array may not be sufficient to fully recharge the battery. The state of charge will then decrease and cycling will take place at a low state of charge. The low solar irradiation on the PV array may be a result of the geographical location combined with the monsoon, snow periods, heavy clouds, rains or accumulation of dust on photovoltaic array.

4.3.7 *Electrolyte Stratification*

Electrolyte stratification may occur in lead-acid batteries. In vented lead acid batteries, electrolyte stratification can be avoided by electrolyte agitation/ recirculation or periodic overcharge whilst in service. In valve regulated lead-acid (VRLA) batteries, electrolyte stratification can be avoided by design or by operating them according to the manufacturer's instructions.

4.3.7.1 *Specific gravity*

The specific gravity of electrolyte for flooded lead-acid battery shall be 1.240 ± 0.005. This is specific requirement for cells/batteries for SPV application and shall override all other requirements specified in any other standard.

4.3.8 *Storage*

Manufacturer's recommendations for storage shall be observed. In the absence of such information, the storage period may be estimated according to the climatic conditions as shown in the Table 1.

The exact limits of storage conditions are to be verified with the manufacturer.

Lead-acid or nickel-cadmium batteries with electrolyte shall be stored starting from a state at full charge.

A loss of capacity may result from exposure of a battery to high temperature and humidity during storage.

The temperature of a battery stored in a shipping container in direct sunlight, can rise to + 60 °C or more in daytime. Choice of a shaded location or cooling should avoid this risk.

4.3.9 *Operating Temperature*

The temperature range during operation experienced by the battery at the site is an important factor for the battery selection and the expected lifetime.

Manufacturers' recommendations for operating temperatures and humidity shall be observed. In the absence of such information, operating temperatures and humidity may be those shown in Table 2.

Table 1 Limit Values for Storage Conditions of Batteries for Photovoltaic Applications

(*Clause* 4.3.8)

Sl No.	**Battery Type**	**Temperature Range** °C	**Humidity Percent**	**Storage Period for Batteries**	
				With Electrolyte	Without Electrolyte
(1)	(2)	(3)	(4)	(5)	(6)
i)	Lead-acid	− 20 to + 50	< 95	Up to 12 months (depending of the design)	1 year to 2 years (dry charged)
ii)	Nickel- cadmium	− 20 to + 50 (standard electrolyte) − 40 to + 50 (high density electrolyte)	< 95	Up to 6 months	1 year to 3 years (fully discharged, drained and sealed)
iii)	Nickel-metal hydride	− 40 to + 50	< 95	Up to 6 months	N/A
iv)	Lithium-ion	− 20 to + 50	< 95	Up to 12 months	N/A

Table 2 Limit Values for Operating Conditions of Batteries for Photovoltaic Applications

(*Clause* 4.3.9)

Sl No.	Battery Type	Temperature Range °C	Humidity Percent
(1)	(2)	(3)	(4)
i)	Lead-acid	− 15 to + 50	< 95
ii)	Nickel-cadmium (standard electrolyte)	− 20 to + 50	< 95
iii)	Nickel-cadmium (high density electrolyte)	− 40 to + 50	< 95
iv)	Nickel-metal hydride	− 20 to + 50	< 95
v)	Lithium-ion and other electrochemistries	To be verified with the battery manufacturer	To be verified with the battery manufacturer

NOTES

1 **1** The manufacturer should be consulted for operation at temperatures outside this range. Typically, the life expectancy of batteries will decrease with increasing operating temperature.

2 **2** Low temperature will reduce the discharge performance and the capacity of the batteries. For details, the manufacturer should be consulted.

4.3.10 *Charge Control*

Excessive overcharge does not increase the energy stored in the battery. Instead, overcharge affects the water consumption in vented batteries and consequently the service interval. In addition, valve-regulated lead-acid batteries may dry out resulting in a loss of capacity and/or overheating.

Overcharge can be controlled by the use of proper charge controllers. Most non-aqueous systems, such as lithium-ion batteries and similar, will not accept any overcharge without damage or safety problems. Such batteries are normally supplied with a BMS (battery management system) that prevents, independently from its charge controller that such overcharge happens.

The parameters of the regulator shall take into account the effects of the PV generator design, the load, the temperature and the limiting values for the battery as recommended by the manufacturer.

Vented lead-acid or nickel-cadmium batteries including those with partial gas recombination shall have sufficient electrolyte to cover at least the period between planned service visits. Overcharge in valve-regulated lead-acid batteries shall be carefully controlled to be able to reach the expected service life.

The water consumption is measured during the cycle test and can be used together with the system's design information to estimate the electrolyte service intervals.

4.3.11 *Physical Protection*

Physical protection shall be provided against consequences of adverse site conditions, for example, against the effects of:

a) uneven distribution and extremes of temperature;
b) exposure to direct sunlight (UV radiation);
c) air-borne dust or sand;
d) explosive atmospheres;
e) flooding, water vapour condensation and sea water spray;
f) earthquakes; and
g) shock and vibration (particularly during transportation).

5 GENERALREQUIREMENTS

5.1 Mechanical Endurance

Batteries for photovoltaic application shall be designed to withstand mechanical stresses during normal transportation and handling taking in account that PVES installations may be accessed via unpaved roads and installed by less qualified personnel. Additional packing or protection shall be used for off-road conditions.

Particular care shall be taken while handling unpacked batteries and manufacturer's instructions shall be observed.

In case of specific requirements regarding mechanical stresses, such as earthquakes, shock and vibration, these shall be individually specified or referred to in a relevant standard.

5.2 Charge Efficiency

The charge efficiency is the ratio between the quantity of electricity delivered during the discharge of a cell or battery and the quantity of electricity necessary to restore the initial state of charge under specified conditions.

Where no data is available from the battery manufacturer, the following efficiencies as given in Table 3 may be assumed.

NOTE — The quantity of electricity is expressed in Ampere- hour (Ah).

5.3 Deep Discharge Protection

Lead-acid batteries shall be protected against deep discharge so to avoid capacity loss due to irreversible sulphation or passivation effect. This could be achieved by using a system that monitors the battery voltage and automatically disconnects the battery before it reaches its maximum depth of discharge (see manufacturer's recommendations).

Vented and partial gas recombination nickel-cadmium batteries do not normally require this type of protection.

For the other types of batteries, the manufacturer's recommendations shall be followed.

5.4 Marking

5.4.1 Cells or monobloc batteries shall follow the instructions of the applicable standards defined in **7.2**.

5.4.2 For clear identification of secondary cells and batteries as per their chemistry (electrochemical storage technology), marking of symbols shall be in accordance with IEC 62902.

5.4.3 The cells and batteries conforming to the requirements of this standard may be certified as per the conformity assessment schemes under the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder, and the cells and batteries may be marked with the Standard Mark.

5.5 Safety

Applicable local regulations and the manufacturer's instructions for procedure to be observed during installation, commissioning, operation, taking out of service, and disposal shall be followed.

5.6 Documentation

The manufacturer shall provide documentation for transport, installation, commissioning, operation, maintenance, decommissioning and disposal of such cells and batteries for photovoltaic applications.

The manufacturer shall advise if there are special considerations to be observed for the initial charging of batteries when only the photovoltaic array is available as the power source.

6 FUNCTIONAL CHARACTERISTICS

The following parameters need to be tested for qualification of a cell/battery according to this standard:

a) Rated capacity (*see* **8.1**);

b) Endurance (*see* **8.2**);

c) Charge retention (*see* **8.3**);

d) Cycling endurance in photovoltaic application (extreme conditions) (*see* **8.4**);

e) Recovery from sulphation test (*see* **8.5**); and

f) Water loss on float charge (*see* **8.6**).

Table 3 Battery Ah Efficiency at Different State of Charge at the Reference Temperature and a Daily Depth of Discharge of less than 20 Percent of the Rated Capacity

(*Clause* 5.2)

Sl No.	**State of Charge (SOC)**	**EfficiencyLead-Acid Cells**	**Efficiency Nickel-Cadmium and Ni-MHCells**	**EfficiencyLi-Ion Cells**
	Percent	Percent	Percent	Percent
(1)	(2)	(3)	(4)	(5)
i)	90	> 85	> 80	>> 95 %
ii)	75	> 90	> 90	>> 95 %
iii)	< 50	> 95	> 95	>> 95 %

7 GENERAL TESTCONDITIONS

7.1 Accuracy of Measuring Instruments

The accuracy of the measuring instruments shall be in compliance with the relevant requirements of the applicable standards listed in **7.2.**

The parameters and accuracy values shall be in accordance with relevant clauses of the applicable standards listed in **7.2.**

7.2 Standards to be Referred for Testing

The test batteries shall be prepared according to the procedures defined in the following standards or, in their absence, according to the manufacturer's instructions:

a) IS 1651 and IS 13369 for stationary lead-acid batteries (vented types);
b) IS 15549 for stationary lead-acid batteries (valve-regulated types);
c) IS 16220 (Part 1) for portable lead-acid batteries (valve-regulated types);
d) IS 16049 sealed nickel-cadmium batteries;
e) IS 10893 and IS 10918 for vented nickel-cadmium batteries;
f) IS 15767 for nickel-cadmium prismatic rechargeable single cells with partial gas recombination;
g) IS16048 (Part 1) for portable nickel-cadmium batteries;
h) IS 16048 (Part 2) for portable nickel-metal hydride batteries;
j) IS 16822 for lithium cells and batteries for use in industrial applications; and
k) IS 16047 (Part 3) for portable lithium batteries

8 TEST METHOD

8.1 Capacity Test

Test batteries shall be selected, prepared, installed and tested according to the applicable standards listed in **7.2**.

The verification of the rated capacity shall be performed by using a current of I_{10} (A) for lead-acid batteries, I_t /5 (A) for nickel-cadmium, Ni-MH and lithium batteries and I_{10} (A) for other batteries according relevant clauses in the Indian standards listed in **7.2.**

The verification of long duration capacity shall be performed by using a current of I_{120} (A) up to an end voltage of 1.85 V/cell (for lead acid batteries) or 1.00 V/cell (for Ni-Cd and Ni-MH batteries). In case of long duration capacity test, the discharge duration shall not be less than 120 h. For other batteries the test shall be performed considering the recommendation of manufacturer for C_{120} rated capacity and the corresponding end voltage.

8.1.1 *Requirement*

For batteries and cells, the capacity (excluding long duration capacity) shall not exceed 120 percent of the rated capacity.

8.2 Endurance Test

The test samples shall be tested according to the clauses, if any, of the applicable standards listed in **7.2**.

8.2.1 As per the standards mentioned in **7.2.**

8.3 Charge Retention Test

The test samples shall be tested according to the clauses, if any, of the applicable standards listed in **7.2.**

8.3.1 As per the standards mentioned in **7.2.**

8.4 Cycle Endurance in Photovoltaic Application (Extreme Conditions)

8.4.1 *General*

In photovoltaic applications the battery will be exposed to a large number of shallow cycles but at different states of charge. The test below is designed to simulate such service under extreme conditions by submitting the batteries at + 40 °C, to several aggregates of discharge/charge cycles each comprising 50 cycles at low state of charge (phase A) and 100 cycles at high state of charge (phase B).

NOTE — One set of 150 aggregate cycles is approximately equivalent to 1 year service in a PV energy storage application.

The cells or batteries shall therefore comply with the requirements of the test below, which is a simulation of the photovoltaic energy system operation:

a) the test battery shall be selected, prepared and installed according to the applicable standards listed in **7.2**;
b) the test shall be carried out with a battery composed of such a number of cells that its open circuit voltage is ≥ 12 V;
c) the test battery shall meet or exceed the rated capacity value when tested for capacity according to **8.1**;
d) the test shall be started with the battery fully charged;
e) the test battery shall be brought to a

temperature of + 40 °C ± 3 °C and stabilized at this temperature for 16 h; and

f) the test battery shall be maintained at + 40 °C ± 3 °C throughout the test phase A) and phase B).

8.4.2 *Phase A: Shallow Cycling at low state of Charge* (*see Table* 4)

8.4.2.1 *Lead-Acid batteries and other batteries*:

a) Discharge the battery for 9 h with a current I_{10} (A);

b) Recharge for 3 h with a current 1.03 I_{10} (A); and

c) Discharge for 3 h with a current I_{10} (A).

8.4.2.2 *Nickel-Cadmium, NI-MH and lithium batteries*

a) Discharge the battery for 9 h with a current 0.1 I_t (A);

b) Recharge for 3 h with a current 0.103 I_t (A); and

c) Discharge for 3 h with a current 0.1 I_t (A).

The steps b) and c) shall be repeated 49 times

At the termination of the 49th execution of step c) the test batteries, still at + 40 °C ± 3 °C, shall be fully charged according to the manufacturers recommendations and then cycling as specified for phase B shall be continued.

8.4.3 *Phase B: Shallow Cycling at High State of Charge* (*see Table* 5)

8.4.3.1 *Lead-acid batteries and other batteries*

a) Discharge the battery for 2 h with a current 1.25 I_{10}; and

b) Recharge for 6 h with a current I_{10} A until for lead-acid batteries a voltage of 2.40 V/cell is reached, unless otherwise specified by the manufacturer, and then continue charging at 2.40 V/cell until a total charging time of 6 h is reached. For other batteries, the charge voltage shall be limited to a safe level as specified by the manufacturer.

8.4.3.2 *Nickel-Cadmium, Ni-MH and Lithium Batteries*

a) Discharge the battery for 2 h with a current 0.125 I_t A; and

b) Recharge for 6 h with a current 0.1 I_t A until, for vented Ni-Cd batteries, a voltage of 1.55 V/cell is reached unless otherwise specified by the manufacturer, then continue charging at 1.55 V/cell until a total charging time of 6 h is reached.

For Ni-MH and lithium batteries the charge voltage shall be limited to a safe level as specified by the manufacturer.

The steps i) and ii) shall be repeated 99 times.

At the termination of the 99th execution of step ii) the test battery shall be submitted to a capacity test according to **8.4.4.**

Table 4 Phase A Shallow Cycling at Low State of Charge

(*Clause* 8.4.2)

Sl No.	**Discharge Duration**	**Charge Duration**	**Lead-Acid and other Batteries**	**Nickel-Cadmium, Ni-MH and Lithium Batteries**
	h	h	Current A	Current A
(1)	(2)	(3)	(4)	(5)
i)	9	—	I_{10}	0.1 It
ii)	—	3	1.03 I_{10}	0.103 It
iii)	3	—	I_{10}	0.1 It

Repeat ii) to iii) 49 times and continue to phase B

Table 5 Phase B Shallow Cycling at High State of Charge

(*Clause* 8.4.3)

Sl No.	Discharging Time	Charging Time	Lead-Acid and Other Batteries Current	Nickel-Cadmium, Ni-MH and Lithium Batteries
	h	h	A	Current A
(1)	(2)	(3)	(4)	(5)
i)	2	—	1.25 I_{10}	0.125 I_t
ii)	—	6	I_{10} (For lead-acid batteries charge voltage limited to 2.40 V/cell unless otherwise specified by the manufacturer)	0.1 I_t (For vented nickel-cadmium batteries charge voltage limited to 1.55 V/cell unless otherwise specified by the manufacturer)

Repeat i) to ii) 99 times

8.4.4 *Residual Capacity Determination*

a) At the conclusion of phase B, the battery shall be cooled down, under continued charge, to the temperature defined for a capacity test in the applicable standards as listed in **7.2**, and then stabilized at this temperature for 16 h;

b) The residual capacity test for lead acid and other batteries shall be carried out with the I_{10} current to 1.80 V × *n* cells for lead acid batteries and at the 0.2 I_t current to 1.00 V × *n* cells for nickel-cadmium, and Ni-MH batteries. For lithium batteries and other batteries, the end voltages are defined by the battery manufacturer;

c) At the completion of the residual capacity test, and if no condition for test termination is encountered (*see* below), the batteries shall be recharged according to the manufacturer's specifications and a new set of phase A) cycles initiated; and

d) When the residual capacity is found in b) below 80 percent, then the fully recharged batteries shall be submitted also to a determination of the C_{120} capacity according to **8.1**.

8.4.5 *Test termination*

The cycling endurance test in photovoltaic applications shall be considered terminated when one of the conditions below is fulfilled:

a) When during the discharge c) of phase A, a battery with *n* cells showed a voltage of *n* ×1.5 V/cell for lead acid batteries, *n* × 0.8 V/cell for nickel-cadmium or Ni-MH batteries or *n* × XYZ V/cell that is the manufacturer's recommended minimum safe cell voltage for lithium and other batteries;

b) When during the residual capacity determination according to **8.4.4**, the determined capacity was found lower than 80 percent of the rated capacity; and

c) The cycling endurance in photovoltaic applications shall be expressed in terms of completed aggregate phase A + B cycles before a limit, as specified in a) or b) above, was encountered together with the value of C_{120} capacity, expressed in per cent of the rated one, as determined at the conclusion of the test.

8.4.6 *Water Consumption of Flooded Battery Types and Cells with Partial Gas Recombination*

During the cycle endurance test, vented type batteries may be topped up with water to the level indicated and with a quality specified by the manufacturer. The amount of water added shall be measured and reported.

8.4.7 *Requirements*

The minimum number of completed A + B phase cycle sequences (150 cycles each) shall be not less than 3.

8.5 Sulphation Test (Applicable for Lead Acid Batteries only)

The test is to be carried out on one fully charged cell/ battery. The test shall be carried out as described in **8.5.1**:

8.5.1 *Test Method*

a) Discharge at a rate of 0.013 5 × C_{10} for a period of 24 h;

b) Leave the battery for 120 h;

c) Recharge at 0.056 × C_{10} for 4 h followed by 0.013 5 × C_{10} for 12 h; and

d) Discharged at 120 h rate (that is 0.012 5 × C_{10} to an end voltage of 1.9 V/cell).

8.5.1.1 *Requirement*

The battery discharge duration shall be at least 108 h.

8.6 Water Loss Test (Valid for Flooded Lead Acid Batteries only)

The water loss test shall be done as per the latest version of the relevant specification with all its amendments mentioned in **7.2** of this specification.

8.6.1 *Requirement*

As per the standards mentioned in **7.2**.

9 TESTS

9.1 Type Tests

The following shall constitute the type tests:

a) Verification of marking and dimensions (**5.4** and **7.2**);

b) Rated capacity test (**8.1**);

c) Endurance test (**8.2**);

d) Charge retention test (**8.3**);

e) Cycling endurance test in photovoltaic application (extreme condition) (**8.4**);

f) Sulphation test (applicable for lead acid batteries only) (**8.5**); and

g) Water loss test (valid for flooded lead acid cells/batteries only) (**8.6**).

The minimum number of samples shall be eight and sequence of tests shall be as given in Table 6.

9.2 Acceptance Test

9.2.1 *Factory Test*

The acceptance test shall be agreed between the customer and the supplier. Compliance to marking, labeling rated capacity may be verified.

9.2.2 *Commissioning Test*

A commissioning test is recommended to prove the integrity of the installed battery system bymeans of a capacity test at 10 hour rate for lead-acid batteries or 5 hour rate for Ni-Cd/Ni-MH and Li-ion batteries.

Table 6 Sampling and Sequence of Tests

(*Clause* 9.1)

Sl No.	Type Test	Battery							
		1	2	3	4	5	6	7	8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
i)	Physical verification (verification of marking and dimensions) (**5.4** and **7.2**)	✓	✓	✓	✓	✓	✓	✓	✓
ii)	Capacity test (**8.1**)	✓	✓	✓	✓	✓	✓		
iii)	Endurance test (**8.2**)							✓	✓
iv)	Charge retention test (**8.3**)	✓	✓						
v)	Cyclic endurance in photovoltaic application (**8.4**)			✓	✓				
vi)	Sulphation test (**8.5**) (only for lead-acid batteries)					✓	✓		
vii)	Water loss test (**8.6**) (only for flooded types lead-acid batteries)	✓	✓						

ANNEX A

(*Clause* 2)

LIST OF REFERRED STANDARDS

IS No./Other Publication	*Title*
IS 1651 : 2013	Stationary cells and batteries, lead-acid type [with tubular positive plates]
IS 1885 (Part 15) : 2008/IEC-482 : 2004	Electrotechnical vocabulary: Part 15 Primary and secondary cells and batteries (*second revision*)
IS 10893 : 1984	Specification for sealed nickel-cadmium button type rechargeable single cells
IS 10918 : 1984	Vented types nickel-cadmium batteries
IS 12834 : 2013/ IEC/TS 61836 : 206	Solar photovoltaic energy systems — Terms, definitions and symbols (*second revision*)
IS 13369 : 1992	Stationary lead-acid batteries [with tubular positive plates] in monobloc containers
IS 15549 : 2005	Stationary valve regulated lead-acid batteries — Specification
IS 15767 : 2008/IEC 62259 : 2003	Secondary cells and batteries containing alkaline or other non-acid electrolytes — Nickel-cadmium prismatic secondary single cells with partial gas recombination
IS 16047 (Part 3) : 2018/IEC 61960 - 3 : 2017	Secondary cells and batteries containing alkaline or other non-acid electrolytes- secondary lithium cells and batteries for portable applications: Part 3 Prismatic and cylindrical lithium secondary cells, and batteries made from them.
IS 16048	Secondary cells and batteries containing alkaline or other non-acid electrolytes — Portable sealed rechargeable single cells
(Part 1) : 2021/ IEC 61951-1 : 2017	Nickel-cadmium (*first revision*)
(Part 2) : 2021/ IEC 61951-2 : 2017	Nickel-metal hydride (*first revision*)
IS 16049 : 2013/ IEC 60622 : 2022	Secondary cells and batteries containing alkaline or other non-acid electrolytes-sealed nickel-cadmium prismatic rechargeable single cells
IS 16220 (Part 1) : 2015/IEC 61056-1 : 2012	General purpose lead-acid batteries (Valve — Regulated Types): Part 1 General requirements, functional characteristics — Methods of test
IS 16822 : 2019/ IEC 62620 : 2014	Secondary cells and batteries containing alkaline or other non-acid electrolytes — Secondary lithium cells and batteries for use in industrial applications
IEC 62902	Secondary cells and batteries — Marking symbols for identification of their chemistry

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website-www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: ETD 11 (15802).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices:		*Telephones*
Central	: 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002	2323 7617
Eastern	: 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091	2367 0012 2320 9474
Northern	: Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019	265 9930
Southern	: C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113	2254 1442 2254 1216
Western	: Plot No. E-9, Road No.-8, MIDC, Andheri (East), Mumbai 400093	2821 8093

Branches : AHMEDABAD. BENGALURU. BHOPAL. BHUBANESHWAR. CHANDIGARH. CHENNAI. COIMBATORE. DEHRADUN. DELHI. FARIDABAD. GHAZIABAD. GUWAHATI. HIMACHAL PRADESH. HUBLI. HYDERABAD. JAIPUR. JAMMU & KASHMIR. JAMSHEDPUR. KOCHI. KOLKATA. LUCKNOW. MADURAI. MUMBAI. NAGPUR. NOIDA. PANIPAT. PATNA. PUNE. RAIPUR. RAJKOT. SURAT. VISAKHAPATNAM.

Published by BIS, New Delhi