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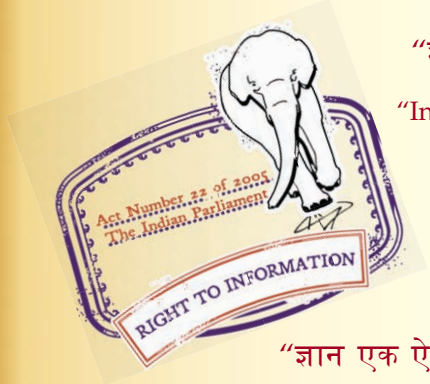
IS 1651 (1991): Stationary cells and batteries, lead-acid type (with tubular positive plates) [ETD 11: Secondary Cells and Batteries]



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"Knowledge is such a treasure which cannot be stolen"

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IS 1651 : 1991
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(तीसरा पुनरीक्षण)

Indian Standard

STATIONARY CELLS AND BATTERIES, LEAD-ACID TYPE (WITH TUBULAR POSITIVE PLATES) — SPECIFICATION

(Third Revision)

First Reprint JUNE 1993

UDC 621 : 355·2

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

November 1991

Price Group 5

Secondary Cells and Batteries Sectional Committee, ET 11

FOREWORD

This Indian Standard (Third 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.

The third revision of this standard has been undertaken to include some major amendments carried out in cell dimensions, test methods and test requirements.

IS 541 : 1954 'Specification for stationary accumulators, lead-acid type' was published as a tentative standard in 1954. At the time of its revision in 1960, it was split into the following two standards:

IS 1651 : 1960 Specification for stationary cells and batteries, lead-acid type with tubular positive plates); and

IS 1652 : 1960 Specification for stationary cells and batteries, lead-acid type (with plante positive plates).

Subsequently, IS 6304 : 1971 'Specification for stationary cells and batteries, lead-acid type with pasted plates' was also published to cover the requirements of batteries with pasted plate construction.

The first revision of this standard had been undertaken with a view to extending the scope to cover capacities up to 1 000 Ah and to delete the details about the inner construction of cells. The opportunity had also been utilized to incorporate all the four amendments issued to the 1960 version of the standard.

The second revision was brought out to modify the maximum overall dimensions and to include the requirements of endurance test, ampere-hour and watt-hour efficiency tests and test for voltages during discharge. The scope of the standard has been widened by covering lead-lined wood as well as FRP containers and by extending the capacity range of cells up to 5 000 Ah. The batteries with monobloc construction have been excluded.

The tests for performance specified in this standard are to be carried out in prevalent ambient conditions. The results of such tests should be corrected to the standard atmospheric conditions according to the correction factors specified.

Only cell interchangeability is feasible in the type of cells and batteries covered by this standard as opposed to the plate interchangeability achieved in batteries using plante positive plates. Further, size to size exchange of batteries using tubular plates with those using plante plates also is not possible since the cells with tubular plate construction are smaller in size.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the results of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. 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

STATIONARY CELLS AND BATTERIES, LEAD-ACID TYPE (WITH TUBULAR POSITIVE PLATES) — SPECIFICATION

(Third Revision)

1 SCOPE

This standard specifies rated Ah capacities, overall dimensions, performance requirements and tests for stationary lead-acid cells and batteries using tubular positive plates.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.0 For the purpose of this standard, the definitions given in IS 1885 (Part 8) : 1986 in addition to the following shall apply.

3.1 Fully-Charged Condition

The cell shall be considered as fully charged when the specific gravity readings and the voltage of the cell at a specific temperature remains constant over three consecutive hourly readings; the charging rate during the period being maintained constant.

3.2 High Discharge Performance Cells (HDP)

Specially designed cells with tubular positive plates and pasted negative plates.

3.3 Type Tests

Tests carried out to prove conformity with the requirements of this standard. These are intended to prove the general quality and design of a given type of battery.

3.4 Acceptance Tests

Tests carried out on samples selected from a lot for the purpose of verifying the acceptability of the lot.

3.4.1 *Lot*

All batteries of the same type, design and rating, manufactured by the same factory during the same period, using the same process and materials, offered for inspection at a time shall constitute a lot.

3.5 Routine Tests

Tests carried out on every battery.

4 RATING AND DESIGNATION

4.1 Ampere-Hour Rating

The rating assigned to the cell shall be the capacity expressed in ampere-hours (after correction to 27°C) stated by the manufacturer to be obtainable when the cell is discharged at the 10-hour rate (C_{10}) to a final voltage of 1·85 volts.

4.2 Designation

The cell shall be designated by symbols given below, arranged in the following sequence:

(*Type of Positive Plate*)	(*Ah Rating of Cell*)	(*Type of Container*)
(*see* **4.2.1**)	(*see* **4.2.2**)	(*see* **4.2.3**)

NOTES

1 The plates are not replaced in this type of construction therefore, this designation does not include the number of positive plates; and

2 The designation of partially plated cells is not being standardized because partial plating of cells in this type of construction is not done.

4.2.1 The positive plates being of tubular type shall be designated by the letter '*T*'.

4.2.2 The capacity rating shall be indicated by a number equal to the capacity in Ah.

4.2.3 The material of container shall be designated by any one of the following letters as the case may be:

G — for glass;
H — for hard-rubber;
P — for plastics;
W — for wood, lead-lined; or
F — for fibre reinforced plastics (FRP).

Example: *T* 400H *HDP* — designates a high discharge performance cell having tubular positive

plates and a capacity of 400 Ah at 10-hour rate in hard-rubber container.

5 MATERIALS

5.1 Containers

The containers shall be made of hard rubber, glass, leadlined wood, plastics or fibre reinforced plastics (FRP).

5.1.1 Hard rubber, fibre-reinforced plastic (FRP) and plastics containers shall conform to IS 1146 : 1981.

5.1.2 Glass containers shall be sufficiently robust, transparent and free from flaws.

NOTE — The requirements for lead-lined wood and glass shall be subject to agreement between the user and the manufacturer.

5.2 Electrolyte

The sulphuric acid and water used for the preparation and maintenance of electrolyte shall conform to IS 266 : 1977 and IS 1069 : 1964 respectively.

5.3 Sealing Compound

Sealing compound, if bitumen based, shall conform to IS 3116 : 1965.

5.4 Separators

The separators used shall be either wooden or synthetic. The wooden separators when used shall conform to IS 652 : 1960 and the synthetic separators to IS 6071 : 1986.

6 CONSTRUCTIONAL REQUIREMENTS

6.1 Cell Lids

Cell lids shall be provided for cells of capacities up to and including 1 000 Ah. Above 1 000 Ah, the cells may be of open or closed type. When provided, cell lids shall be either drop on type together with suitable rubber or plastics gasket or of the deep sealing type suitable for use with bituminous or a suitable sealing compound, with close-fitting terminal posts and with vent-holes suitable for accommodating the venting device.

NOTE — Other methods of sealing when used shall not contaminate the electrolyte when these come in contact. A suitable method for determining such requirements is under consideration and shall be included at a later date.

6.2 Venting Device

The venting device shall be of anti-splash type with more than one exit hole and shall allow the gases to escape freely but shall effectively prevent acid particles or spray from coming out. For capacities 120 Ah and above, there shall be two vent holes, one serving as a guide for the acid-level-indicator for checking the electrolyte level and the other to permit drawing of electrolyte samples, servicing, checking of specific gravity, etc.

6.3 Electrolyte Level Indicator

A suitable electrolyte level indicator indicating lower and upper limits shall be fitted to facilitate checking of electrolyte level in opaque containers. The materials used shall be acid proof and shall not deteriorate during service.

6.4 Terminal Posts

Positive and negative terminal posts shall be clearly and unmistakably identifiable.

6.5 Connectors

The manufacturer's identification shall be embossed/impressed on the connectors. Where it is not possible to bolt the cell terminals directly to assemble a battery, separate lead, copper or aluminium connectors of suitable size shall be provided to enable connection of the cells. In some cases, it may be necessary to connect individual cells in parallel. In such cases the connectors shall be suitably designed. Copper connectors or aluminium connectors, suitably coated to withstand corrosion due to sulphuric acid, may be used where the cells are called upon to discharge at very high rates. In such cases, the thickness of lead-coating-of connectors should be not less than 0·025 mm. The lead coating thickness shall be measured in accordance with Appendix F of IS 6848 : 1979.

6.6 Nuts and Bolts

The material for bolts and nuts shall be brass however mild steel can be used subject to the agreement between the purchaser and the supplier. Bolts and nuts, for connecting the cells, shall be effectively lead-coated to prevent corrosion.

6.7 Spray Arrestor

Open cells shall be provided with spray arrestors of adequate area over the plates. These may be of glass sheet at least 3 mm thick or some suitable plastics sheet and shall be adequately supported.

7 CAPACITIES AND DIMENSIONS

7.1 The ampere-hour capacities and dimensions of the cells shall be in accordance with Table 1.

Table 1 Maximum Overall Dimensions of 2 V Cells

(*Clause* 7.1)

Capacity at 10-Hour Rate	Maximum Overall Dimensions		
	Length	Width	Height
(1)	(2)	(3)	(4)
Ah	mm	mm	mm
20	105	170	365
40	105	170	365
60	140	170	365
80	165	190	365
100	190	190	450
120	190	190	450
150	190	190	550
200	265	215	550
300	320	215	550
400	380	215	550
500	390	235	550
600	390	235	715
800	515	235	715
1 000	515	300	750
1 500	450	400	865
2 000	500	450	865
2 500	650	450	865
4 000	900	480	1 240
5 000	900	480	1 240
6 000	900	500	1 240
7 000	1 100	500	1 240
8 000	1 100	500	1 240

NOTES

1 The length and width dimensions given in this table may be interchanged.

2 In the case of batteries with built-in cell connectors, the height of the interconnector shall be disregarded.

3 For capacities not covered in this table, the cell dimensions shall not exceed the dimensions of the cell of next higher size covered by this table.

7.2 The capacities of cells of high discharge performance design shall conform to Table 4 for Type I and Table 5 for Type II.

8 MARKING AND PACKING

8.1 Marking

The following information shall be indelibly and durably marked on the outside of the cell:

a) Indicating the source of manufacture;
b) Ah capacity at 10-hour rate;
c) Upper and lower electrolyte level in case of transport containers;
d) Year of manufacture; and
e) Country of origin.

8.1.1 Each cell and battery may also be marked with the Standard Mark.

8.2 Packing

The cells shall be suitably packed so as to avoid any loss or damage during transit.

9 MANUAL INSTRUCTIONS

9.1 The manufacturer shall supply one copy of instruction manual for initial treatment and routine maintenance during service, with every batch of batteries.

9.2 The following information shall be provided on the instruction cards:

a) Designation of cell or battery (*see* **4.2**);
b) Ah capacity;
c) Nominal voltage;
d) Manufacturer's instructions for filling, initial charging;
e) Normal and finishing charging rates; and
f) Maintenance instructions.

10 CONDITIONS OF SUPPLY

10.1 To facilitate procurement of correct type of stationary cells, it is recommended that the user should furnish information regarding his requirements given in Annex B at the time of enquiry or order. Similarly, the manufacturer should furnish the information given in Annex C.

10.2 Other conditions of supply shall be subject to agreement between the purchaser and the supplier.

11 GENERAL REQUIREMENTS FOR TESTS

11.1 Temperature for Testing

Unless it become unavoidable, test discharge should not be taken when the temperature of the electrolyte exceeds 35°C.

11.2 Test Equipment

11.2.1 *Voltmeter*

The voltmeter used for tests shall be of an accuracy class not inferior to 0·5 in accordance with IS 1248 : 1983. The resistance of the voltmeter used shall be at least 1 000 ohms per volt (*see* IS 1248 : 1983). The range of the voltmeter used shall be such that the magnitude of the voltage to be measured falls in the last third part of the scale.

11.2.2 *Ammeter*

The ammeter used for tests shall have an accuracy class not inferior to 1·0 (*see* IS 1248 : 1983). The range of ammeter used shall be such that the magnitude of the current to be measured falls in the last third part of the scale.

11.2.3 *Thermometer*

A thermometer with an appropriate scale shall be used for measuring temperature and one division of the graduated scale shall represent at the most 1°C.

NOTE — The voltmeter, the ammeter and the thermometer of digital read-out type of similar accuracy also can be used. Chart recorders shall be used for life cycle testing.

11.2.4 *Hydrometer*

The specific gravity of the electrolyte shall be measured by a hydrometer provided with a graduated scale, one division of which shall represent at the most 0·005 unit of specific gravity.

The accuracy of calibration shall be not less than 0·005 unit of specific gravity.

NOTE — In view of the compact construction of this type of cells, it may not be possible to measure the specific gravity directly by floating hydrometer. Hence, the use of syringe type of hydrometer will generally have to be resorted to.

11.3 First Charge

The cell if received in dry uncharged condition shall be filled with the electrolyte and shall be first charged in accordance with the manufacturer's instructions.

11.4 Specific Gravity of Electrolyte

The standard specific gravity of a fully charged cell shall be adjusted to $1{\cdot}200 \pm 0{\cdot}005$ corrected at 27°C in accordance with **10.4** of IS 8320 : 1982.

11.5 Temperature Factors of Capacity

11.5.1 The correction of the capacity to 27°C shall be carried out in accordance with **11.5.2**. The values for correction factors shall be chosen from Table 2.

11.5.2 The capacity shall be corrected to 27°C by the following formula:

$$\text{Capacity at } 27°\text{C} = C_t + \frac{C_t \times R \times (27 - t)}{100}$$

where

C_t = observed capacity at t°C;

R = variation factor chosen from Table 2; and

t = average electrolyte temperature, °C (*see* **12.5.3**).

Example

Capacity at C 10 measured at 24°C = 1 000 Ah

Capacity at 27°C =

$$1\,000 + \frac{1\,000 \times 0{\cdot}43 \times (27 - 24)}{100} = 1\,012{\cdot}9 \text{ Ah}$$

11.6 Observation

11.6.1 While charging the cell, the voltmeter, hydrometer and thermometer readings shall be recorded at suitable intervals.

11.6.2 During the discharge at 10-hour rate the voltmeter readings shall be recorded every hour for the first eight hours and every fifteen minutes thereafter up to the end voltage.

11.6.3 The hydrometer and thermometer readings at hourly intervals and at the end of the discharge shall be recorded only on the pilot cell(s).

11.6.4 The first and the last reading of hydrometer and thermometer shall be made on all the cells.

11.7 Water shall be added, if required to correct the electrolyte level during a test, just before the charge so that thorough mixing with electrolyte is facilitated.

Table 2 Variation of Capacity with Temperature

(*Clause* 11.5.1)

Discharge Rate	Factor for Variation in Capacity per °C, R
(1)	(2)
	Percent
C 10	0·43
C 9	0·45
C 8	0·47
C 7	0·50
C 6	0·54
C 5	0·58
C 4	0·62
C 3	0·68
C 2	0·76
C 1	0·90

NOTE — Capacity-temperature correction is not a true linear relationship.

12 TESTS

12.1 Classification of Tests

12.1.1 *Type Tests*

The following shall constitute Type test and shall be carried out in the given sequence:

a) Verification of constructional requirements (**12.2**),
b) Verification of marking (**12.3**),
c) Verification of dimensions (**12.4**),
d) Test for capacity (**12.5**) — Test for voltage during discharge (**12.10**),
e) Ampere-hour and watt-hour efficiency tests (**12.9**),
f) Test for loss of capacity on storage (**12.7**), and
g) Endurance test (**12.8**).

12.1.1.1 For conducting type tests, formed positive plates along with components for the three cells shall be chosen at random.

Out of the three cells chosen for type tests, two samples shall undergo for all tests except capacity and endurance tests and the other sample shall be tested only for capacity and endurance test.

If any of the samples fails in the relevant type test testing authority may call for fresh samples not exceeding twice the original number and subject them again to all tests or test in which the failure has occurred as agreed between the manufacturer and the buyer. If there is any failure in any of the retest, the type shall be considered as not having passed the requirements of this standard.

12.1.2 *Acceptance Tests*

The following shall constitute the acceptance tests:

a) Marking and packing,
b) Verification of dimensions,
c) Test for capacity, and
d) Test for voltages during discharge.

12.1.2.1 Acceptance tests shall, normally, be carried out, at the discretion of the purchaser, on each cell after installation at site. The date and place of testing shall be subject to agreement between the purchaser and the supplier.

12.1.2.2 *Sampling scheme and criteria for acceptance*

The sampling scheme and criteria for acceptance for cells up to and including 600 Ah capacity shall be in accordance with **11.1.4** of IS 8320 : 1982. The sampling scheme for cells of higher capacities shall be subject to agreement between the user and the manufacturer.

12.2 Verification of Constructional Requirements

The cells shall meet the requirements specified under **6**.

12.3 Verification of Marking and Packing

The marking on the cells and their packing shall be in accordance with the requirement of **8**.

12.4 Verification of Dimensions

The overall dimensions of cells of standard capacities shall conform to the requirements given in Table 1.

12.5 Test for Capacity

12.5.1 After standing on open circuit for not less than 12 hours and not more than 24 hours, from the completion of a full charge, the cell shall be discharged through a suitable variable resistance at a constant current of $I = 0{\cdot}1\ C10$ amperes. The discharge shall be stopped when the closed-circuit voltage across the cell falls to 1·85 volts. If however, a test discharge cannot be conducted within the specified rest period due to any exigencies, a freshening charge may be given to the cell/battery at the finishing rate of charge recommended by the manufacturer for a period of 1 hour after every 24 hours or part thereof, of extended rest period. The capacity test, however, can be started after a minimum period of two hours elapsing after this freshening charge.

12.5.2 The time in hours elapsing between the beginning and the end of discharge shall be taken as the period of discharge.

12.5.3 The average temperature (t°C) of the electrolyte during discharge shall be the average of the temperatures of the electrolyte noted at hourly intervals.

12.5.4 Unless otherwise agreed, capacity test as described above, and conducted immediately after the first charge of the cell is normally to be treated as the test discharge for the purpose of acceptance of the cell. On the first discharge the cell shall give not less than 85 percent of the rated capacity and the rated capacity shall be reached within specified number of charge/discharge cycles given by the supplier subject to maximum of 10 discharges subsequent to the initial charge. Once the rated capacity has been

met on any discharge/further discharge cycles for capacity shall not be continued.

12.5.5 For the purpose of acceptance test, the test for capacity may, by agreement between the purchaser and the supplier, be carried out at a rate other than the 10 h rate. In such cases, the 5 h rate is recommended. Capacities at various rates of discharge and corresponding final voltages are given in Table 3. For the purpose of acceptance, the capacity test shall be carried out at one rate only.

12.5.6 Correction for the variation of capacity with temperature shall be made in accordance with **11.5**. The measured temperature shall be as specified in **12.5.3**.

12.5.7 *Requirement*

12.5.7.1 The actual capacity shall not be less than the rated capacity and not more than 120 percent of the rated capacity when the test is carried out at the 10 h rate.

12.5.7.2 For the acceptance test when the test is carried out at a rate other than the 10 h rate, the actual capacity shall be not less than the corresponding rated capacity.

12.6 Alternative Rates of Test Discharges

12.6.1 An alternative test for capacity may, by agreement between the purchaser and the manufacturer, be conducted for the two types (Type I and Type II) of High Discharge Performance-HDP cells at the rates given in **12.6.2** and **12.6.3**.

12.6.2 *Type I—HDP Cells*

The capacity shall be tested at rates of 3 hour, 5 hour and 10 hour only for Type I—HDP cells. The capacities at these rates of discharge shall be in accordance with Table 4.

12.6.2.1 Correction for the variation of capacity with temperature shall be made in accordance with **11.5**. The measured temperature shall be as specified in **12.5.3**.

12.6.2.2 *Requirement for Type I—HDP cells*

The actual capacity shall not be less than the rated capacity and not more than 120 percent of the rated capacity when the test is carried out at the 10 hour rate.

12.6.3 *Type II—HDP Cells*

The capacity shall be tested at a rate from 1 hour to 10 hour for Type II—HDP cells. The capacities shall be in accordance with Table 5.

Table 3 Capacities and Final Cell Voltage at Various Rates of Discharge at 27°C

(*Clause* 12.5.5)

Rate of Discharge	Capacity Expressed as Percentage of *C*10 Capacity Rating	End Voltage
(1)	(2)	(3)
	Percent	Volts
*C*1	50·0	1·75
*C*2	63·3	1·78
*C*3	71·7	1·80
*C*4	78·2	1·81
*C*5	83·3	1·82
*C*6	87·9	1·83
*C*7	91·7	1·83
*C*8	95·0	1·84
*C*9	97·9	1·84
*C*10	100·0	1·85

Table 4 Capacities and Discharge Current at 27°C of Type I High Discharge Performance Cells at Various Rates of Discharge

(*Clauses* 7.2 *and* 12.6.2)

Period of Discharge	AH-Capacities as Percentage of Standard Rating	Discharge Current as Percentage of Standard Rating	Cell End Voltage
(1)	(2)	(3)	(4)
Hours	Percent	Percent	Volts
3	81·1	27·0	1·80
5	90·0	18·0	1·82
10	100·0	10·0	1·85

Table 5 Capacities and Discharge Current at 27°C of Type II High Discharge Performance Cells at Various Rates of Discharge

(*Clauses* 7.2 *and* 12.6.3)

Period of Discharge	AH-Capacities as Percentage of Standard Rating	Discharge Current as Percentage of Standard Rating	Cell End Voltage
(1)	(2)	(3)	(4)
Hours	Percent	Percent	Volts
1	60·0	60·0	1·75
2	73·8	36·9	1·78
3	81·1	27·0	1·80
4	86·2	21·5	1·81
5	90·0	18·0	1·82
6	93·0	15·5	1·83
6	95·1	13·6	1·83
7	97·1	12.1	1·84
9	98·8	11·0	1·84
10	100·0	10·0	1·85

12.6.3.1 Correction for the variation of capacity with temperature shall be in accordance with **11.5**. The measured temperature shall be as specified in **12.5.3**.

12.6.3.2 *Requirement for Type II — HDP cells*

The actual capacity shall not be less than the rated capacity and not more than 130 percent of the rated capacity when the test is carried out at the 10 hour rate.

12.6.4 For the acceptance test of both Type I and Type II HDP cells, when the test is carried out at a rate other than the 10 hour rate the actual capacity shall be not less than the corresponding rated capacity.

12.7 Loss of Capacity on Storage

12.7.1 This test shall be carried out on the two cells which have successfully passed the capacity test in accordance with **12.5**.

12.7.2 The cell shall be fully recharged at the current specified by the manufacturer and shall then be submitted to two consecutive capacity tests in accordance with **12.5**, the value of the initial capacity C being calculated as the mean of the two results thus obtained.

12.7.3 After a complete recharge and the cleaning of electrolyte from its surface the cells shall be left on open circuit for a period of 28 days without disturbance at a temperature of 27 ± 2°C.

12.7.4 After the storage for 28 days, the cell shall be discharged in accordance with **12.5**. The value of capacity measured after storage is denoted by C'.

12.7.5 The loss of capacity S expressed as a percentage is calculated from the following formula:

$$S = \frac{C - C'}{C} \times 100$$

12.7.6 *Requirement*

The loss in capacity thus measured shall not exceed 10 percent.

12.8 Endurance Test

12.8.1 The test shall be conducted on cells which have not been subjected to any other tests subsequent to initial charge as per the manufacturers' instructions.

12.8.1.1 The test shall be conducted on a complete cell up to a capacity of 500 Ah. However, for those cells, above this rating, a test cell with a suitable number of positive plates (of the type used in that particular cell along with negative plates and separators and other accessories) such that the cell capacity does not exceed 500 Ah, shall be built in a suitable sized container.

12.8.2 The cell shall be charged continuously at a current $I = 0{\cdot}1 \times C_{10}$ amperes for total periods of 2 000 hours as given below:

a) 2-Cycles of 300 h charging followed by test discharge;

b) 3-Cycles of 200 h charging followed by test discharge; and

c) 8-Cycles of 100 h charging followed by test discharge.

The above cycle is applicable to HDP type cells. However for normal cells, the total period will be 1 500 hours as given below:

a) 1-Cycle of 300 h charging followed by test discharge;

b) 2-Cycles of 200 h charging followed by test discharge; and

c) 8-Cycles of 100 h charging followed by test discharge.

12.8.2.1 Throughout these periods of charge the cell shall be immersed in a tank of water the temperature of which shall be maintained at 40 ± 3°C. The cell shall be so immersed that the top of cell is 25 mm above the water level in the tank. If several cells are placed in the same tank, a distance of 25 mm shall be maintained between them. This distance between a cell and the side of the tank shall be at least 25 mm.

12.8.3 At the end of each period of charging (a), (b) and (c) as specified in **12.8.2**, the cell shall be subjected to a test discharge (C_{10}) to an end voltage of 1·85 V. This discharge shall be conducted without undue delay and without removing the cell from the water bath and shall be made within two hours of termination of the charging current (**12.8.2**).

If for any reason, the time between the termination of charging (**12.8.2**) and the test discharge exceeds 2 hours, the cell in the water bath may, at the option of the manufacturer, be kept on a 'trickle charge' not exceeding $I = 0{\cdot}01 \times C_{10}$ amperes until the time of test discharge.

12.8.3.1 When the test discharge is complete, the cell shall be immediately subjected to the next period of continuous charge without any recharging.

12.8.4 *Requirement*

The ampere-hour efficiency shall be calculated as per **12.8.1** and shall be not less than 90 percent.

12.9 Ampere-Hour and Watt-Hour Efficiency Tests

12.9.1 *Ampere-Hour Efficiency*

A fully charged cell shall be discharged at $I = 0{\cdot}1 \times C_{10}$ amperes to an end voltage of 1·85 volts, careful calculations being made of the exact number of ampere-hours delivered. On recharge the same number of ampere-hours are put back at the same current. A second discharge shall then be made to the same cut-off voltage as before. The efficiency of the cell is then calculated as the ratio of the ampere hour delivered during the second discharge to the ampere-hour put in on the charge.

12.9.1.1 *Requirement*

The ampere-hour efficiency when calculated as described in **12.9.1** shall be not less than 90 percent.

12.9.2 *Watt-Hour Efficiency*

The watt-hour efficiency shall be calculated by multiplying the ampere-hour efficiency by the ratio average discharge and recharge voltage. The values of discharge and recharge voltages shall be calculated from the log sheets for ampere-hour efficiency test. The average voltage shall be calculated from the 'hourly' readings of the discharge voltage but including the voltage immediately after start of discharge and last reading, namely, 1·85 V.

Similarly for calculating the average voltage during recharge the only 'hourly' voltage readings (including the voltage immediately after starting the charge and the last reading before charge is terminated) shall be taken.

12.9.2.1 *Requirement*

The watt-hour efficiency when calculated as described in **12.9.2** shall be not less than 75 percent.

12.10 Test for Voltage During Discharge

The cell need not be discharged specially for this test. For the purposes of this test the voltages shall be obtained from the log sheets for capacity test (*see* **12.5**) in which the cell meets the rated capacity.

12.10.1 *Requirement*

The closed circuit voltage of cell shall not be below the values given in col 2 below:

Duration After Commencement of Discharge	*Closed-Circuit Voltage at Cell-Terminals*
(1)	(2)
	V (*Min*)
Ten minutes after putting on load	1·98
6 hours	1·92
10 hours	1·85

ANNEX A

(*Clause* 2)

LIST OF REFERRED INDIAN STANDARDS

IS No.	*Title*
266 : 1977	Sulphuric acid (*second revision*)
652 : 1960	Wooden separators for lead-acid storage batteries (*revised*)
1069 : 1964	Water for storage batteries (*revised*)
1146 : 1981	Rubber and plastic containers or lead-acid storage batteries (*second revision*)
1248 : 1983	Direct acting indicating analogue electrical measuring instruments and their accessories
1652 : 1991	Stationary cells and batteries, lead-acid type with Plante positive plates (*third revision*)
1885 (Part 8) : 1986	Electrotechnical vocabulary: Part 8 Secondary cells and batteries (*first revision*)
3116 : 1965	Sealing compound for lead-acid batteries
6071 : 1986	Synthetic separators for lead-acid batteries (*first revision*)
6848 : 1979	Lead-acid batteries for train lighting and airconditioning services (*first revision*)
8320 : 1982	General requirements and methods of test for lead-acid storage batteries (*first revision*)

ANNEX B

(*Clause* 10.1)

INFORMATION TO BE FURNISHED BY THE PURCHASER WITH ENQUIRY OR ORDER

B-1 When enquiring for or ordering stationary cells lead acid type, the following information should be furnished by the purchaser:

a) Number of identical batteries required;

b) Number of cells per battery;

c) Details, if it is proposed to use any of the cells of a battery at different rates of charge and discharge;

d) Capacity (in ampere-hours at the 10-hour rate) and discharge duty of batteries;

e) Cell designation in accordance with this standard;

f) The proposed method of working, that is charge-discharge, float working or stand by with or without trickle charging (in case of float working, the floating voltage the limits of regulation are to be indicated);

g) Whether stands are required and if so, details of layout or space available;

h) The proposed location of installation and the expected dates of tests to be conducted;

j) Accessories and spares required, if any; and

k) Special conditions, if any.

ANNEX C

(*Clause* 10.1)

INFORMATION TO BE FURNISHED BY THE SUPPLIER

C-1 When supplying stationary cells and batteries the following particulars should be furnished by the supplier:

a) Capacity of battery at the 10-hour rate;

b) Manufacturer's name;

c) Type of negative plates;

d) Method of connection between cells, that is, whether bolted or burnt;

e) Recommended starting and finishing rates of charge;

f) Voltage of cell at the end of charge at the finishing rate;

g) Recommended trickle charging rates for different types of working;

h) The type and material of the separators;

j) Material of container;

k) Amount and specific gravity of electrolyte per cell required for first filling;

m) Recommended specific gravity of electrolyte at the end of a full charge;

n) Expected specific gravity of electrolyte at the end of the discharge at 10-hour rate;

p) Overall dimensions of each cell;

q) Distance between the centres of cells when erected;

r) Weight of cell complete with acid;

s) Recommended maximum period of storage before the first charge;

t) Internal resistance of the cell; and

u) Maximum number of charge/discharge cycles required to reach the rated capacity.

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The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

Bureau of Indian Standards

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Indian Standards are reviewed periodically and revised, when necessary and amendments, if any, are issued from time to time. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition. Comments on this Indian Standard may be sent to BIS giving the following reference:

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BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones : 331 01 31, 331 13 75

Telegrams : Manaksanstha
(Common to all Offices)

Regional Offices :	Telephone
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	{331 01 31 {331 13 75
Eastern : 1/14 C. I. T. Scheme VII M, V. I. P. Road, Maniktola, CALCUTTA 700054	{37 84 99, 37 85 61 {37 86 26, 37 86 62
Northern : SCO 445-446, Sector 35-C, CHANDIGARH 160036	{53 38 43, 53 16 40 {53 23 84
Southern : C. I. T. Campus, IV Cross Road, MADRAS 600113	{235 02 16, 235 04 42, {235 15 19, 235 23 15
Western : Manakalaya, E9 MIDC, Marol, Andheri (East) BOMBAY 400093	{632 92 95, 632 78 58. {632 78 91, 632 78 92

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TO
IS 1651 : 1991 STATIONARY CELLS AND BATTERIES, LEAD-ACID TYPE (WITH TUBULAR POSITIVE PLATES) — SPECIFICATION

(Third Revision)

(*Page* 2, *clause* **5.2**, *line* 3) — Substitute 'IS 266 : 1993' *for* 'IS 266 : 1977' and 'IS 1069 : 1993' *for* 'IS 1069 : 1964'.

(*Page* 2, *clause* **6.1**, *second sentence*) — Delete ' Above 1 000 Ah.....open or close type'.

[*Page* 3, *clause* **8.1**(c), *line* 2] — Substitute 'transparent' *for* 'transport'.

[*Page* 3, *clause* **8.1**(e)] — Insert the following at the end:

'f) Symbol for lead recycle; and

g) Symbol for 'DO NOT DISPOSE OFF'.

(*Page* 3 , *clause* **11.2.1**, *lines* 3 *and* 5) — Substitute 'IS 1248 (Part 2) : 2003' *for* 'IS 1248 : 1983'.

(*Pages* 3 *and* 4, *clauses* **11.2.1** *and* **11.2.2**) — Insert the following note at the end of both the clauses:

'NOTE — Digital/Analog meters may be used.'

(*Page* 4, *clause* **11.2.2**, *line* 2) — Substitute 'IS 1248 (Part 2) : 2003' *for* 'IS 1248 : 1983'.

(*Page* 4, *clause* **11.4**, *line* 3) — Substitute 'IS 8320 : 2000' *for* 'IS 8320 : 1982'.

(*Page* 5, *clause* **12.1.2.2**, *line* 4) — Substitute 'IS 8320 : 2000' *for* 'IS 8320 : 1982'.

(*Page* 6, *clause* **12.5.7.2**) — Insert the following note at the end:

'NOTE — The required capacity shall be reached within 3 cycles of charge and discharge.'

(*Page* 6, *Table* 5, *col* 1, *seventh row*) — Substitute '7 ' *for* '6 '.

(*Page* 6, *Table* 5, *col* 1, *eighth row*) — Substitute '8' *for* '7'.

(*Page* 8, *clause* **12.8.4**) — Substitute the following for the existing:

'**12.8.4** *Requirement*

C_{10} capacity at the end of 2 000 h of over charge shall not be less than 90 percent of the rated capacity.'

(*Page* 8, *Annex* A) — Substitute the following:

'IS 266 : 1993' *for* 'IS 266 : 1977', 'IS 1069 : 1993' *for* 'IS 1069 : 1964', 'IS 1248 (Part 2) : 2003' *for* 'IS 1248 : 1983' and 'IS 8320 : 2000' *for* 'IS 8320 : 1982'.

(ET 11)

Reprography Unit, BIS, New Delhi, India