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RESEARCH DESIGNS AND STANDARDS ORGANISATION

POWER SUPPLY & EMU DIRECTORATE

TECHNICAL SPECIFICATIONS

FOR

LOW MAINTENANCE LEAD ACID BATTERIES FOR 110V TRAIN-LIGHTING AND AIR CONDITIONED SG COACHES

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SPECIFICATION FOR LOW MAINTENANCE LEAD ACID BATTERIES FOR 110V TRAIN-LIGHTING AND AIR CONDITIONED SG COACHES

FOREWORD

In 110V, train lighting system, 6V, 120 Ah capacity mono block battery is used in all types of conventional non air-conditioned BG coaches. 8V, 450Ah capacity mono block battery in MG air-conditioned coaches and 2V, 525 Ah & 2V, 800 Ah capacity cells in air-conditioned BG coaches are being used which are provided with under- slung air-conditioned equipment.

After gaining experience on 110V A/C and non A/C coaches and discussing the experience with Railway and production units, the following norms for use different type of batteries / cells for the above applications, as laid down.

NON AIR CONDITIONED BG COACHES

a) 18 Mono-blocs each consisting of 3 cell be used in series

b) All type of coaches shall have single set of battery of 18 mono-blocks.

c) The rated Ah capacity of battery shall be 120 Ah at 27 °C.

d) The production Units shall provide two battery boxes on under frame of coach and each box shall contain 9 Mono-blocs.

AIR CONDITIONED BG COACHES:

a) The batteries for air- conditioned coaches shall be of single cell construction and 56 cells will constitute one set.

b) All types of self-generating type air-conditioned coaches with under slung equipment shall have single set of battery.

c) The rated Ah capacity of the battery shall be 525 Ah / 800 Ah at 27 degree centigrade.

d) The production units shall provide two battery boxes in the under frame of the coach and each box shall contain 28 cells.

AIR CONDITIONED MG COACHES:

The connected load of self-generating MG Air-conditioned Coach is about 127 Amp at 110 V. For this load the battery capacity required will be about 650 Ah when calculated in accordance with provisions of IRS: E-45. Due to space limitations in the under frame of coach it is not possible to accommodate 650Ah battery. Therefore a battery of rated capacity 450 Ah in Mono-bloc construction is being provided on these coaches. The salient particulars of battery to be used are as under.

a) 14 Mono-blocks each consisting of 4 cells in series for 8V 450 Ah Battery

b) All types of coaches shall have single set of battery.

c) The ampere-hour capacity shall be 450 Ah at 27°C

The production units shall provide three battery boxes in under frame of each coach and each box shall be holding 4 mono-blocks each in two battery boxes and 6 mono-blocks in the remaining third battery box.

The supplier shall furnish information of performance as given in Annexure'A' and 'B' while submitting tenders.

In the preparation of this specification assistance has been drawn from the following publications

i) RDSO Spec. No. ELPS/SPEC/TL/09 of Dec.1996

ii) RDSO Spec No.EL/TL/53

iii) IS : 6848-1979 (latest)

iv) IS : 266-1993

v) IS : 1069-1993

vi) IS : 6071-1986

vii) IS : 3116- 1965

viii) IS : 8320-2000

ix) IS : 4905:1968

x) IS : 1146 – 1981

xi) IEC 61373 –1999

xii) IS 191-1980

1.0 SCOPE

1.1 This low maintenance specification covers the design, manufacture, method of testing and other requirements of low maintenance lead acid batteries to be used for train lighting / air conditioning application on passenger coaches having 110V system. For train lighting 6V, 120 Ah batteries shall be used in conjunction with brushless alternators with suitable rectifier cum regulators of 4.5 KW capacity with a nominal setting of 126 V, 37.5 Amp at full load and 1500 rev. / min. For A.C coaches 525 Ah and 800 Ah batteries shall be used in conjunction with two number of brush less alternators with suitable rectifier cum regulators of 18/25 KW capacity with a nominal setting of 129V, 133/193 Amp at full load and 1500 rev/min. 8V, 450 Ah battery shall be used in conjunction with brush- less alternators with suitable rectifier-cum regulators of 12.0 KW capacity with a nominal setting of 130V, 93Amp.

1.2 The Battery shall be of low maintenance design such that it shall require very less topping up. In the actual service frequency of topping up shall be not earlier than 6 months. However attempt should be made to increase this period upto 9 months except for 8V, 450 Ah where it should be 3 months.

1.3 If proper maintenance practice is followed after proper initial charge and battery does not remain in discharged condition for more than a week, expected life of battery is 4 years from date of commissioning

2.0 TERMINOLOGY

2.1 **TYPE TESTS**: - Test carried out to prove conformity with the requirement of this specification. These are intended to prove the general quality and design of a given type of battery.

2.2 **ACCEPTANCE TESTS**: - Test carried out on samples selected from a lot for the purpose of verifying the acceptability of the lot.

2.2.1 **LOT:** - All batteries of the same type, design and rating manufactured by the same factory during the same period using the same process.

2.2.2 **ELECTROLYTE**: - Aqueous solution of sulphuric acid for ionic conduction and Electro-chemical reaction during passage of current through cell.

2.3 **TERMINAL POST** (lug) :-A post (lug) of a cell or battery to which an external electrical circuit is connected.

2.4 **FLOAT**:- A device for indicating the level of electrolyte in the cell.

2.5 **SEALED FLOAT GUIDE**:- A removable bush of anti-splash and sealed type to facilitate easy vertical movement of float stem.

2.6 MICROPOROUS VENT-CUM-FILLING PLUG:- A removable plug for fitting into the filling-hole.

3.0 MATERIAL AND CONSTRUCTION

3.1 The cells/Mono-block units of the batteries shall be similar in type and shape.

3.2 The maximum and minimum overall dimensions and filled weight of the cells/ Mono-block shall not exceed the values given in the Table I. The maximum height dimensions shall be up-to the battery handle/ terminal and do not include the projection of float. The dimension shall be measured before and after the tests.

TABLE - 1

SN	Rated capacity at 27ºC	Overall dimensions in mm			thickness in mm (minimum) for hard rubber container		Maximum weight in kg of one monobloc/ cell
		Length	Width	Height	Outer	partition	
1	120Ah	445 ± 10	178±5	380±5	-	-	55
2	450Ah	724 max.	225 max.	470 max.	10.0	5.0	175
3	525Ah	400 max.	194max	500max	14.5	-	75
4	800Ah	400 max.	194 max	500 max	14.5	-	80

3.3 The battery shall be so designed that the initial charging of battery shall be completed within 75 hours as per the charging method to be prescribed by the manufacturer for the battery. The manufacturer will furnish these details to the type testing authority as well as in the Maintenance Manual of the batteries. Subsequent charging for conducting various tests shall be restricted to 15 hours.

3.4 **CONTAINER AND LID**:

3.4.1 **HARD RUBBER CONTAINER:**

3.4.1.1 The cell shall be supplied in container, which shall conform to IS:1146-1981 with latest amendment. The Container shall be provided with moulded/ rope lifting handle for 120Ah / 800Ah / 525 Ah & 450 Ah cell/battery. The minimum thickness of container shall be as per table number 1.

3.4.1.2 For the ball drop test the minimum height from which the ball, with procedure as defined in IS: 1146-1981,when dropped which causes the fracture, shall not be less than 400 mm (min. one time drop) for each side before and after High voltage test. The design will provide for adequate safety margins for achieving the required strength so that containers do not bulge / crack in service.

3.4.1.3 **CELL LIDS**: Cell Lids shall be of the deep-sealing type suitable for use bituminous sealing compound, with close-fitting terminal post outlets and with vent-holes suitable for accommodating the float guide and filling cum vent plugs.

3.4.1.4 ~~The 6V, 120Ah mono-blocks shall be supplied with plastic containers/lids. Other rating~~ Batteries can also be supplied in PPCP container. The container / lid shall have adequate strength with design margins to meet the actual field conditions as prevalent over Indian Railways for which battery manufacturers shall be wholly responsible notwithstanding the approval given by RDSO. Adequate measures shall also be taken by manufacturers to avoid bulging of cells along shorter/longer sides of the cells. Despite of the above design measures having been taken by the manufacturers, if failures of cells on account of the container / lid material / inadequate designs are reported from the field, the manufacturers shall replace these cells with new cells as approved by RDSO free of cost within the warranty period. The design of container and lids shall generally conform to the following specifications:

i) Material specification for container/ lid — PP-CP (Polypropylene Co-Polymer)

ii) Outer wall thickness of container without ribs. — 3.5 mm to 6.5 mm

The outer wall thickness shall be measured on all the sides of the container i.e. longer side, shorter side and base. However, the minimum wall thickness of container / lid shall not be less than 3.0 mm for 120Ah only, if design of the container / lid is with strengthening members/ribs which may be provided inside and/or outside of the container/lid.

iii) Partition wall thickness — 2.2 mm to 2.8 mm

For PPCP batteries moulded/rope handle can be provided on the container. It is desirable that manufacturers, earlier approved with handle on lid, should modify the mould and provide moulded / rope handles on container.

iv) **Tests:** These PP-CP containers shall be subjected to the tests as per Clause 7 of IS: 1146-81 and the following tests shall be conducted during prototype testing:

1. Verification of constructional requirements
2. Verification of marking
3. High voltage test
4. Drop ball test
5. Izod impact test
6. Plastic yield test
7. Acid resistance test

(v) Inter-cell connections: The inter cell connections in the mono-block shall be provided inside the container in 120 Ah batteries.

3.4.2 **MICRO – POROUS VENT PLUG**: - Each cell shall be provided with adequate means, both for venting and for servicing of the electrolyte. The vent-cum-filling plug shall generally conform to RDSO drawing No. SKEL- 4020/A with the dome/filter made of ceramic or any other suitable fire retardant material. The vent-cum-filling plug shall allow free escape of gases evolved during service and shall not permit electrolyte to come out on the surface of the lid. On removal of vent-cum filling plug, drawing of the electrolyte samples, servicing, checking and topping of electrolyte shall be possible.

3.4.2.1 The material used for micro-porous vent plug shall have uniform porosity. It shall also be free from abnormalities such as crack, breakage, foreign matter, dents and shall conform to the following. The following tests shall be applicable on micro-porous dome of the vent plug only and dome shall be taken out for this purpose: -

a) Porosity : 35$\pm$ 5%

Porosity of micro-porous filter shall be calculated given below:-

Weigh the sample in air (W1) – keep the sample in boiling water with few drops of wetting agent (Teepol) for 30 Mts. Weigh the sample in water (W2) Next weigh the wet sample outside water (W3). Calculate porosity as under:

$$\text{Porosity \%} = \frac{(W3 - W2) - (W1 - W2)}{(W3 - W2)} \times 100$$

b) Breaking strength : Shall not be brittle before and after Acid resistance. To test this, a steel ball of 200 gm shall be dropped two times from the height of 400 mm on the top and side of micro- porous dome.

c) Acid resistance : Dry and weigh the (micro-porous body) .dome.(W1), Keep the dome in sulphuric acid of Sp.Gr.1.3 at 40 degree centigrade for 100 hours. Remove it from Acid. Wash free of acid dry and weigh (W2).Calculate the percentage loss as follows.

$$\frac{W1 - W2}{W1} \times 100$$

The loss of weight shall not be more than 0.5 percent.

d) Permeability : The full charged cell shall befitted with vent plug and charged at 2.5 times of C10 rate for 4 hours. All sealed float guides shall be positioned properly except the one where manometer with water is fitted. The cell shall not develop positive pressure more than 2mm of water column inside the cell.

e) Dimension : Dimension shall conform to RDSO Drg. No. SKEL 4020 / A Alt.3 or as approved by RDSO.

f) Plastic components : Plastic component to which the micro porous top is bounded shall be free from crack, flash, pinhole, air bubbles, uneven shrinkage foreign particles etc. and shall conform to the following (Ref Drg SKEL – 4020 Alt.3)

g) Material : ABS Fire retardant or superior quality

h) Acid Resistance : No perceptible change

i) Heat : No deformation at 70 deg.C

3.4.2.2 **DIA AND PITCH THREAD**: - The micro –porous vent-cum filling plug diameter shall be 27mm and pitch of thread shall be 3mm as per drawing No. SKEL-4020/A Alt .3.

3.4.2.3 Each cell shall have one float guide sealed type and one vent-cum-filling plug for 120Ah and two vent-cum-filling plug for 525Ah / 800Ah batteries as mentioned above. For 8V, 450 Ah vent cum sealed float guide shall be used.

3.4.2.4 In order to have standardization of float guides for TL/AC batteries float guides as per drawing No.RDSO/PE/SK/TL/0058-03 (Rev.1) or latest of RDSO approved make shall be used.

3.4.2.5 Each cell/monoblock (i.e 120Ah, 450Ah & 525 Ah) unit shall be provided with two terminal lugs made of lead alloys, one negative and one positive according to fig.1 of IS 6848 except the thickness of lug which shall be 9mm for 120Ah. For 800Ah capacity two positive and two negative terminals lugs to be provided as per fig. 1 of IS 6848. The positive terminal lugs shall have rounded edges and the negative terminal lugs shall have pointed edges, so to be easily distinguishable.

3.5 INTER-CELL INTER UNIT AND END CELL CONNECTORS.

3.5.1 Inter-unit connectors for one set consisting of 18 mono-bloc of 120Ah shall conform to drawing No.SKEL-4037 Alt.4. The fasteners shall be in accordance with IS 6848-79. For 8V, 450Ah mono-block 9 number inter unit connectors to suit the connections in the battery box shall be supplied by the manufacturer with each set of 14 Mono-blocks. The inter unit connector shall be flexible single core

multi strand copper cable of 95 mm sq Cable shall be of elastomeric type of RDSO approved make conforming to specification No. SPEC/E-14/01 Part-I (Rev-II) 1993 and shall be suitably insulated and protected from acid fumes. Lugs sockets of electrolytic copper conforming to IS 191 should be used with suitable coating. Hydraulic crimping should be done using W-dies. Millivolt drop across the connector shall not exceed 15 mV at C10 rate. If inter connectors are sourced from sub vendor, sample check should be done.

3.5.2 For connecting terminal lugs of adjacent cells of 525Ah a pair of inter cell connector consisting of one inner and one outer strip shall be used except for 800 Ah capacity, where two pairs of inter-cell connectors each consisting of one inner and one outer strips as specified in fig 2A of IS 6848 shall be used. The fasteners shall be as per fig 2B of IS 6848-79.

3.5.3 For each set of 56 cells of 800Ah battery. 16 end cell connectors and for 525 Ah 8 end cell connectors as specified in fig.3 of IS 6848 shall be provided. Suitable copper connectors can also be used for inter cell and end cell connections.

3.6 ELECTROLYTE:- It shall be prepared from battery grade sulphuric acid conforming to IS 266-1993 with latest amendment.

3.6.1 The level of electrolyte shall be at least 50 mm above the top of separator protector in fully topped up condition.(up to the green level of float indicator)

3.6.2 The specific gravity of electrolyte when the battery is in fully charged condition at 27 degree centigrade shall be between 1.210 to 1.220 for 120Ah. However, the specific gravity of electrolyte for 450 Ah, 525Ah / 800Ah capacity cells shall be between 1.240 and 1.250. The specific gravity shall be corrected to 27 degree centigrade using the formula given under C1.3.2.2 of IS 8320-1982.

3.7 WATER

The water used for topping up and preparing electrolyte shall conform to IS:1069 – 1993.

3.8 SEPARATOR

Separator shall be PVC or any other suitable material conforming to IS 6071-1986. The volume porosity shall not be less than 35%. In case of PE separator complete wetting of sample shall be completed within 10 minutes duration.

3.9 SEALING COMPOUND

Sealing compound, if bitumen based shall conform to IS: 3116 – 1965 with latest amendment.

4.0 SERVICE CONDITION

4.1 The cells are required to work at ambient temperatures up to 55 Degree Centigrade and will be subjected to vibration and dust in service when installed in the battery boxes suspended from the under frame of the coaches. The

design and construction of cells shall be suitable to withstand the above service condition.

RATING & TEST:

5.1 **RATED CAPACITY: -** The rating assigned to the battery shall be capacity (C10)in ampere hour (after correction at 27 degree centigrade temperature) when the cell/battery is discharged at 10 hr. rate to the end voltage of 1.8V per cell.

5.2 **DECLARED CAPACITY**: - Since the declared C10 capacity of battery is generally higher than the rated C10 capacity, the manufacturer will advice the declared C10 capacity of the battery.

5.3 **OBTAINED CAPACITY: -** Obtained capacity is the capacity obtained during discharge of cell up to 1.8V per cell. at 10 hours rate of the rated capacity of battery. The variation between declared capacity and obtained capacity shall not be more than $\pm$ 3 percent.

5.4 **TESTS AND PERFORMANCE**

5.4.1 Classification of tests.

5.4.2 Type tests – The following shall constitute the type tests. All these tests shall be started after 3 cycles of charge / discharge at 10 hour rate. Tests shall be conducted at 20 and 32 degree centigrade only.

a. Capacity at 10 hrs rate according to C1 5.6 of this specification.

b. Capacity at 5 hrs rate as tested to Cl.5.7 of this spec.

c. Capacity at 3 hrs rate as tested to Cl 5.8 of this specification.

d. Watt-hour and ampere-hour efficiency as per clause 5.9 of this specification.

e. Retention of charge according to clause 5.10 of the specification.

f. Life test according to clause 5.11 of this specification. After completion of life cycle test the battery shall be cut opened and examined to arrive at the reason for reduction in capacity. Report along with photographs to be submitted to RDSO.

g. Storage test according to clause 5.12 of this specification.

h. Loss of water as per clause 5.13 of this specification.

i. Equilibrium float current test as per clause 5.14 this specification

j. Air pressure test according to clause 5.15 of this specification.

k Vibration test according to clause 5.16

l. Internal resistance of cells/batteries as per clause 5.17 of this specification.

m. Capacity test at 0°C as per clause 5.18 of this specification

n.. Test for sealing of PPCP batteries with lid as per clause 5.15 of this specification

o. Material and component specification verification test according to clause 5.22 of this specification.

p. Test of Micro-porous vent plug as per clause 3.4.2 of this specification.

q .Checking of dimensions, mass marking and workmanship according to clause 3.2 and 6.0 of this specification.

5.5 SEQUENCE OF TYPE TESTS : The Sequence of type tests and the number of samples required shall be in accordance with Annexure "C".

Note : The cell shall be covered by the type approval certificate from appropriate authority. Separate type approval certificates shall cover significant variations in the design. The cell of new design shall be prototype tested for which samples offered by the manufacturer shall be accepted. The battery shall be re-type tested every 5-year for revalidation and samples shall be drawn from mass production at random. In case of unsatisfactory performance of cells in field, retype testing either part or full can also be done earlier at the discretion of the approving authority.

5.5.1 If any of the samples fails in the relevant type test, the testing authority may call for fresh samples not exceeding twice the original number of cells tested in that particular test and subject them again to the test (s) in which failure occurred. If there is any failure in the retest(s) the type shall be considered as not having passed the requirements of this standard. If any sample fails in second time, the retype test shall be considered after six months from date of second test.

5.5.2 **DURATION OF TYPE TEST:** Type test as per clause 5.4.2 shall be completed within six months (Maximum) from the date of starting the type test, except storage test.

5.5.3 **INSPECTING AUTHORITY:** The type test as per clause 5.4.2 of cells/mono bloc batteries shall be conducted by the representative of RDSO / Lucknow, India at the works of manufacturers for which all the test facilities shall be made available by the manufacturers at their cost.

5.5.4 ~~**RENEWAL OF TYPE TEST:** After successful prototype testing and fulfilling requirements of specification, certificate approval shall be given by RDSO shall be valid for five years. Before expiry of validity manufacturer shall apply for renewal of type test approval. During renewal of type test, following tests shall be carried out on two samples at firm's premises or any Government lab. having data logging facility for revalidation of type test approval. Cost of testing and sending the sample to lab shall be borne by manufacturer.~~

~~a) Ah and Wh efficiency test as per clause 5.9~~
~~b) C3 discharge test as per clause 5.8~~

- ~~This shall not vary by more than ± 5% from the value obtained during prototype testing subject to minimum 72% of C10 obtained during test (a).~~

c) ~~Equilibrium float current and water loss test as per clause5.14 and 5.13 respectively.~~

~~The manufacturer shall offer the battery for retype testing. For this purpose sample shall be picked up from any production lot at random. It shall be checked for dimension, mass, marking/workmanship and components verifications by RDSO representative. RDSO representative shall witness the above test or seal the sample and manufacturer shall send it to lab for testing and submit the copy of receipt of sealed sample by Government laboratory. The full report of testing shall be submitted to RDSO for the purpose of evaluation as per latest specification.~~

5.5.5 **ACCEPTANCE TESTS.**

5.5.5.1 The following tests shall be conducted as acceptance tests.

a. Capacity test at 5 hrs rates according to clause 5.7 of this specification. The Capacity obtained shall not have variation of more than $\pm$ 5 percent of the C5 capacity obtained (average cap. at 27 deg. C) during prototype testing. The weight of dry cell shall not vary more than $\pm$ 5 percent of the weight obtained during prototype testing. In one lot weight of dry cells/Batteries shall not vary more than $\pm$ 5 percent.

b. Checking of dimensions, mass markings and workmanship according to clause 3.2 and 6.0, 6.1, 6.1.1, 6.1.1.1.

c. Checking of container strength on assembled battery shall be done by dropping a ball as per clause 7.8 of IS 1146-1981. The container should pass the clause 3.4.1.2. For Verification of crack, air pressure test shall be done, as per Clause 5.15.and cell/ batteries shall pass the clause. This test shall be conducted on five No. of assembled batteries for each lot.

d. Checking of heat-sealing in PPCP batteries shall be done as per clause 5.15 before the ball drop test and battery / cell shall pass the test.

5.5.6 **SAMPLING SCHEME AND CRITERIA FOR ACCEPTANCE**

A recommended sampling scheme and criteria for the acceptance of the lot for various lot sizes is given in Annexure “D”

5.6 TEST FOR CAPACITY AT 10 HRS. RATE.

5.6.1 After standing on open circuit condition for not less than 12 hrs. and not more than 24 hrs. from the completion of a full charge, the battery shall be discharged through a suitable resistance at constant current I=0.1 x C10 amperes, and the discharge shall be stopped when the closed circuit voltage across the battery terminals falls to 1.80.volts per cell / 1.80 x n volts for mono bloc batteries.

5.6.2 At this rate of discharge, hourly voltage readings shall be taken until the battery voltage approaches 1.90 volts per cell / 1.90 x n volt for mono bloc batteries after which the readings shall be taken every 15 minutes until the voltage falls to 1.80 V / Cell / 1.80 x n volt for mono bloc batteries

5.6.3 The capacity in Ampere-hour shall be obtained by multiplying the discharge current by the total time of discharge in hours and the product so obtained shall be corrected to a temperature of 27 degree centigrade by the following formula.

$$\text{The capacity at 27 deg. } C = \frac{Ct}{1+K\,(t-27)}$$

Where Ct is the observed capacity at t degree centigrade. K is correction factor 0.0043. t is average electrolyte temperature in degree centigrade during discharge. (mean value of initial and final temperature)

5.6.4 The capacity at 10 hrs. rate shall be within $\pm$3 percent of declared capacity.

After 10 hrs discharge, the cells/ battery should be charged at the normal charging rate within 15 hrs at the rate of I= 0.1 x C10 Amps.

5.7 TEST FOR CAPACITY AT 5 HRS RATE.

5.7.1 After standing on open circuit condition for not less than 12 hrs. and not more than 24 hrs. from the completion of a full charge, the battery shall be discharged through a suitable resistance at constant current I= 0.2 x C5 amperes, Where C5 = 0.83 x C10 and the discharge shall be stopped when the closed circuit voltage across the battery terminals falls to 1.75.volts per cell / 1.75 x n volts for mono bloc batteries.

5.7.2 At this rate of discharge, hourly voltage readings shall be taken until the battery voltage approaches 1.90 volts per cell after which the readings shall be taken every 15 minutes until the voltage falls to 1.75 V / Cell.

5.7.3 The capacity in Ampere-hour shall be obtained by multiplying the discharge current by the total time of discharge in hours and the product so obtained shall be corrected to a temperature of 27 degree centigrade by the formula referred in clause 5.6.3 using the values for correction factor K as 0.0058.

5.7.4 Capacity at the 5 hrs. rate when tested as above shall not be less then 83 percent of obtained capacity.

5.7.5 After 5 hrs discharge, the cells/ battery should be charged at the normal charging rate within 15 hrs at the rate of I= 0.1 x C10 Amps.

5.8 TEST FOR CAPACITY AT 3 HR. RATE

5.8.1 After standing on open circuit condition for not less than 12 hrs. and not more than 24 hrs. from the completion of a full charge, the battery shall be discharged through a suitable resistance at constant current I= 0.33 x C3 amperes, Where C3 = 0.72 x C10 and the discharge shall be stopped when the closed circuit voltage across the battery terminals falls to 1.70 volts per cell/1.70 x n volts for monobloc batteries

5.8.2 At this rate of discharge, hourly voltage readings shall be taken until the battery voltage approaches 1.90 volts per cell / 1.90 x n volts for monobloc batteries

after which the readings shall be taken every 15 minutes until the voltage falls to 1.70 V / Cell / 1.70 x n volts for mono bloc batteries

5.8.3 The capacity in Ah shall be obtained by multiplying the discharge current by the total time of discharge in hours and the product so obtained shall be corrected to a temperature of 27 degree centigrade by the formula referred in clause 5.6.3 using the values for correction factor K as 0.0068.

5.8.4 Capacity at the 3 hrs. rate when tested as above shall not be less then 72 percent of obtained capacity.

5.8.5 After 3 hrs. discharge, the cells / battery should be charged at the normal charging rate within 15 hrs. at the rate of I= 0.1 x C10 Amps.

5.9 **TEST FOR AMPERE HOUR AND WATT HOUR EFFICIENCY:**

Ampere hour and Watt hour efficiency, when tested and calculated as described in Annexure 'E', shall not be less than 92 percent and 80 percent respectively.. While conducting this test a minimum rest of 12 to 24 hours shall be given between each charge / discharge.

5.10 TEST FOR RETENTION OF CHARGE:

5.10.1 The object of this test is to determine the loss of capacity of a battery unit in

open circuit during storage for a specified period.

5.10.2 The fully charged battery unit shall be subjected to two consecutive capacity test discharges in accordance with clause 5.6, the value of the initial capacity 'C' being calculated as the mean of the two results thus obtained.

5.10.3 After a complete recharge and after cleaning of the electrolyte from the surface, the battery unit shall be left on open circuit for a period of 14 days without disturbance at 27$\pm$ 5 deg C

5.10.4 After 14 days of storage the battery unit shall be discharged in accordance with clause 5.6. The value of the capacity after storage measured shall be denoted by C1

5.10..5 After the discharge the battery unit shall be fully charged at the normal charging rate recommended by manufacturer.

5.10.6 The loss of capacity expressed as percentage shall be calculated by formula:

$$S = \frac{C - C1}{C} \times 100$$

5.10.7 Requirement: The loss of capacity calculated as in 5.10.6 shall not be more than 3 percent over 14 days storage period.

5.11 LIFE TEST

5.11.1 The number of life test units obtained under the following conditions defines the life of cell/ battery.

5.11.2 The life test is carried out on at least two cells/batteries, which have satisfactorily passed the tests in accordance with clause 3.2, 5.6 & 6.0.

5.11.3 The battery is to be fully charged. When fully charged the level and the specific gravity of the electrolyte of each battery shall be checked and if necessary adjusted.

5.11.4 The cell / batteries shall be kept in a water bath. Which is maintained at 50 ± 2 degrees centigrade. A minimum distance between the cells and the sides of water bath shall be 25mm. The cell shall be immersed in vertical direction that the top of the cell is 25 mm above water level in the tank.

5.11.5 After standing in open circuit for not less than 12 hours but not more 24 hours in 50 ± 2 degree centigrade from the completion of a full charge the battery shall be discharged through a suitable resistance at a constant current I=0.10 X C10 Amps and discharge shall be complete when the closed circuit voltage across the battery terminal falls to 1.80 V per cell / 1.80 x n volts for mono bloc batteries.

5.11.6 At this rate of discharge hourly voltage reading shall be taken until battery voltage reaches 1.90 V per cell / 1.90 x n volts for mono bloc batteries after which the reading shall be taken every 15 minutes until voltage falls to 1.80 V per Cell/ 1.80 x n volts for mono bloc batteries.

5.11.7 The capacity in Ah shall be obtained by multiplying the discharge current by the total time of discharge in hours This capacity shall be called as original test capacity (OTC).

5.11.8 The battery shall be charged at the normal charging rate immediately after the discharge.

5.11.9 During the tests battery shall be subjected to a series of discharges and charges continuously.

5.11.10 The discharge shall be for 4 hours at a current of 0.25 x C10 Amp This shall be followed by Charge at a current of 0.25 x C10 Amps for 20 hours the charge and discharge cycle shall be carried out five times.

5.11.11 After above cycles of discharges and charges the cell/battery shall be kept on open circuit for 12-24 hours at 50±2 deg. Centigrade. After this open circuit stand, they shall be test discharged at the rate of I= 0.1 x C10 Amp. The discharge is continued to an end voltage of 1.80 volts per cell.

5.11.12 On completion of this discharge the cell/batteries shall fully recharge. The combination of discharge and recharge cycles as described above together with 12-24 hours. Open circuit stand period the test discharge and subsequent recharge shall be one unit of life test.

5.11.13 **REQUIREMENT:** The batteries shall be subjected to repeated test units described in 5.11.10, 5.11.11, 5.11.12 till unit capacity measured in any test discharge falls to 80 percent of original test capacity (OTC). The number of life units the cell/battery has yielded shall not be less than 15 units.

5.12 **STORAGE TEST:** The cell/battery unit shall capable of being stored unfilled for a period of 24 months from the date of sealing by inspecting authority. After

storage for the specified period, the battery unit shall satisfy the requirement of capacity test (see clause 5.6). The capacity shall not be less than 5 percent of obtained capacity.

5.13 **LOSS OF WATER TEST**: After fully charging the battery it should be cleaned and dried. It should be weighed immediately but not exceeding one hour after drying with an accuracy of 0.05 percent or maximum least count of 50 gm for the balance used. Then all vent-cum-filling plugs should be closed tightly and connected to constant voltage charger keeping the voltage 2.4 ± 0.05 volt per cell (2.4 x n) ± 0.05 volt for mono block batteries for 21 days in water bath at a temperature of 50 ± 2 degree centigrade. Thereafter battery is removed from circuit, dried and after this it is weighed accurately.

5.13.1 The water loss shall not exceed 0.8 gm/ Ah/Cell of the obtained capacity.

5.13.2 The water loss variation between two cells/batteries shall not be more than 5%.

5.13.3 Water topping interval shall be 6 months (minimum) based on water loss obtained in 21 days except for 8V, 450 Ah batteries in HR container.

5.14 **EQUILIBRIUM FLOAT CURRENT TEST:**

This test shall be conducted during the initial three days (72 hours) of water loss test the battery under test shall be kept in water bath at 50± 2 degree centigrade. Charging voltage shall be 2.4± 0.05 V per cell / 2.4 x n volt for mono bloc batteries. The float current shall be measured and recorded It shall not be more than 3 mA / AH of the obtained test capacity.

5.15 **TEST FOR AIR PRESSURE**: The sealing of hard rubber each cell / battery shall be checked by compressed air at a pressure equal to 700 mm of water. The volume of tubes and auxiliary parts in connections with the cell under pressure shall not exceed 0.5 litre. Air pressure in the cell shall be noted 15 seconds after the supply has been disconnected and it shall not fall below 690 mm of water.

To check the leakage and sealing strength in PPCP cell / batteries compressed air at the pressure of 5 psi shall be applied for 1 minutes during type testing. The cell lid shall not show any visible sign of movement due to the air pressure and drop in pressure due to leakage

Note: This test shall be carried out on unfilled cells. This leak test shall be done on 100% cells / mono blocs of PPCP at the pressure of 4–5 PSI for 15 seconds as routine test by manufacturers.

5.16 **VIBRATION TEST**: The fully charged battery shall be subjected to vibration and shock testing as per IEC 61373 - 1999.

a) Random vibration test as per clause 8 Table-1, category 1 Class B
b) Simulated long life test as per clause 9, Table-2, category1 Class B
c) Shock test as per clause 10, Table-3, category 1 Class B

C10 capacity test shall be carried out prior to commencing and on completion of above tests. RDSO representative shall witness the capacity tests.

5.16.1 Requirements- There shall be no spillage of electrolyte during the test. RDSO representative shall witness the capacity tests and it shall not vary more than 3% after the vibration test.

5.17 **INTERNAL RESISTANCE OF CELLS/BATTERIES.**

After charging and rest of not less than 12 hours, the cell/battery unit shall be discharged for one hour at 10-hour rate. The test shall be continued by increasing the discharge current to approximately equal to 1.5 times the value of discharge current as per I=0.1x C10 (A1) and after an interval not exceeding 5 minutes, the current shall be decreased to half the value as above (A2). The current A1 and A2 in amperes and the corresponding cell/battery terminal voltages V1 and V2 in volts shall be measured simultaneously.

The internal resistance expressed in milliohm of the cell/battery under test shall be calculated from the formula given below:

$$R = \frac{(V2-V1)\ 1000}{(A1-A2)} \text{ milliohm}$$

The variation in Internal resistance of two cells/batteries shall not exceed 15%

5.18 **Capacity test at 0°C.**

The cell/battery charged according to clause 5.8.5 shall be stored for 12 hour to 24 hours at the temperature 0°C with a tolerance of ±1°C. The cell shall then be discharged maintaining the same temperature with constant current I = 0.1xC10 Amps to a final discharge voltage of 1.75 volts per cell. The capacity in Ampere-hour obtained from the cell/battery shall be measured. The capacity shall not be less than 70% of actual obtained capacity.

5.19 **PROVISION OF HANDLE ON CELLS/BATTERIES CONTAINER:**

The handle arrangement shall not be provided on the lid. Either moulded or rope handle is acceptable on container. Old design batteries should also come in line with above.

5.20 **TEST EQUIPMENTS**

The voltmeter, Ammeters, Thermometer & Hydrometer etc. required for the tests specified in this standard shall meet the requirement given in Clause10.2 of IS: 8320. Where digital ammeter/voltmeter are used, the meter shall be capable of displaying up to two decimals in the range 0 to 99 volts and one decimal in 100 and above volts range. Use of digital ammeter/voltmeter is essential for testing and system shall be capable of displaying C10, C5, C3 Ah & Wh efficiency, ROC and life cycle testing with continuous logging facility of voltage, Current, AH input/output with reference to time. Manually recording not permitted.

5.21 **TEMPERATURE FOR TEST**: - The ambient room temperature for tests shall be between 20 degree and 32 degree centigrade.

5.22 **MATERIAL AND COMPONENT VERIFICATION TEST**: **-**

5.22.1 The Cell/battery shall be examined in the dismantled condition to see that the manufacturing is as per approved outline and assembly drawing and the various components are conforming to the specification as detailed in this specification. The samples of sealing compound, separator, and container shall be taken at random from the manufacturing line and tested to see that they meet the requirement of the relevant specifications.

5.22.2 Sample of positive spine and negative grid shall be taken from the cell under component verification and firm shall furnish report of alloy composition either from own or outside (govt.) lab based on microprocessor-controlled spectro photometric absorption or emission test methods. If required, RDSO will test again in future for verifying the consistency.

6.0 **MARKING AND PACKING:**

6.1 Marking- Both the shorter or longer sides of container shall have the following details embossed on the container:

a) Manufacturer ‘s name, trademark and place of manufacturing.
b) Rating at 10 hrs. discharge rate and,
c) Specific gravity of the electrolyte in the fully charged condition at 27 degree centigrade.

Note : STICKER not permitted on cell/ battery.

6.1.1 The year and month (e.g. April 05 can be shown as 04/05) of manufacturer shall be punched on positive terminal lug base with letter size not less than 6 mm height and on Negative terminal side commissioning of cells/batteries, month/year shall be marked by Railways. In PPCP container, the manufacturing date shall be hot punched of letter size not less than 6 mm on the lid. Marking shall also be done by acid proof paint on shorter side of HR / PPCP containers. Code wise date shall not be accepted.

6.1.1.1 Manufacturer name or trademark and rating of battery will be impressed or embossed on the connector or on lid in PPCP battery if marking is not possible to be embossed on container

6.1.2 Manufacturer shall be responsible for safe transportation of battery. Battery should be delivered in good condition to consignee at his depot. If there is any damage manufacturer shall replace the battery free of cost.

7.0 **STANDARDIZATION –** RDSO has approved components and their suppliers to be used in battery such as vent plug, sealed float guide, inter unit / inter cell and end cell connectors. These components have been standardized for the purpose of interchangeability among all the makes. Manufacturers are advised to use only RDSO approved components to have interchangeability.

8.0 **DRAWING**

8.1 The manufacturer shall supply one set of drawing in A4 size listed as below for approval while offering the cell / mono-bloc for type testing.

a) Detail drawing with dimensions of front, top and side view of cell/mono-bloc.

b) Detailed drawings of container showing different sections with dimensions

c) Part drawings with sectional details of

(1) Container
(2) Terminal post (Positive and Negative).
(3) Container lid.
(4) Pole (+ve & -ve).
(5) Plates (+ve & -ve groups assembly).
(6) Separator.
(7) Float guide.
(8) Microporous vent plug.
(9) Inter cell/unit and end cell connector.

9.0 RELIABILITY

9.1 RDSO approval means the approval of general design features. Not with standing the approval, manufacturer is wholly and completely responsible for performance, life and reliability of battery during service.

9.2 Before offering the batteries/ cells for prototype testing, all relevant drawings as considered by the RDSO, shall have the approval of competent authority. The manufacturer shall produce only drawings approved by competent authority during the prototype Inspection and shall not under take any modification till such time cell / battery under prototype testing is completed and the observations of RDSO are recorded.

9.3 After the prototype approval no designs change shall be undertaken by manufacturer on prototype cell/batteries without prior approval of RDSO, failing which the prototype approval may be with drawn by RDSO at any time

9.4 If considered necessary RDSO may undertake re-testing of some or all prototype tests as per this specification at any time to ensure proper effective quality control being exercised by the manufacturer at different stage of manufacture ring.

9.5 RDSO may, also undertake some special tests associating manufacturers to validate the design changes for which all the necessary testing equipment/instruments etc. shall be arranged by the manufacturer free of cost.

10.0 DESIGN DOCUMENTS AND INSTRUCTIONS MANUAL

Following documents shall be submitted to RDSO.

a) One set of drg, as per clause 8.0 of the specification before offering for type tests for approval.

b) After submitting in house test results no any change/ modification in drawing / design

c) In house test result as per appendix ‘A’ and ‘B’ shall be sent to RDSO before offering for type test. After completion of tests following documents in bound booklet should be submitted in duplicate.

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I. Bill of Material with details of sub vendors

II. Design details

III. ISO Certificate with letter of issuing authority

IV. Drawings

V. Prototype test results

VI. Quality assurance inspection plan.

d) Maintenance manual in soft and hard copy should be submitted in advance for approval.

e) Alternative superior design can be considered provided necessary technical justification with benefits in furnished for scrutiny.

11.0 INFRASTRUCTURE FOR QUALITY ASSURANCE

The facilities considered essential to be available with the firm for the manufacture of quality and reliable product are indicated in STR No. RDSO/PE/STR/TL/0014-2010 (Rev.2) separately.

~~12.0 INFORMATION REQUIRED FOR RENEWAL OF TYPE TEST~~

~~After completion of revalidation test manufacturers shall apply for renewal of type test approval. During type test renewal following information shall be furnished by the manufacturers.~~

~~1. Any deviations from bill of material and QAP approved by RDSO earlier.~~
~~2. Implementation confirmation of modifications issued by RDSO, if any.~~
~~3. Addition / Deletion of Machinery and Plant.~~
~~4. Supply orders executed by the manufacturer in last 3 years. Following details should be given.~~
~~a) PO No. / Date~~
~~b) Consignee and date of supply~~
~~c) Quantity~~
~~d) Rate (inclusive of all taxes)~~
~~e) Warranty failures reported (nature of failure and action taken).~~

13.0 IN FRINGEMENT OF PATENT RIGHTS

Indian Railways/ RDSO shall not be responsible for infringement of patent rights arising due to similarity in design, manufacture process, use of components, use in design, development and manufacture of cells / batteries and any other factor, which may cause such dispute. The responsibility to settle any dispute lies with the manufacturer.

14.0 AFTER SALES SERVICE

14.1 The successful tenderer shall make necessary arrangements for closely monitoring the performance of cells/batteries through periodical (preferably once in three months during the warranty period) visits to the location where they have been Installed for observations and interaction with the operating and maintenance personal of the Indian Railways. Arrangements shall also be made by the successful tenderer for emergency / stand by spare parts being kept

readily available to meet exigencies warranting replacement so as to keep the cell/battery in service with least down time.

14.2 The successful tenderer shall respond promptly and in a workman like manner to any cell given by Indian Railways for any assistance by way of attending to failures. Investigation into the cause of failure including tests, to be done and for such other items with a view to seeing that the equipment serves the purpose for which it is intended. Technical guidance to ensure proper operation and maintenance of the equipment shall be constantly rendered.

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ANNEXURE 'A'

SCHEDULE OF DESIGN PARTICULARS

The following particulars are required to be supplied by the manufacturer with the quotation:

S.No.	Description	Particulars to be filled in
1.	Make	……
2.	Type of unit	……
3.	Manufacturer's nomenclature	……
4.	Overall dimensions of unit (length x width x height)	……
5.	Mass per unit with acid	……
6.	Cell container material	……
7.	Type of positive plates	……
8.	Type of negative plates	……
9.	Separators	……
10.	Maximum electrolyte temperature that the cell/battery withstand without any damage	……
	(a) Continuously	…… deg. C
	(b) For a short period	…… deg. C
11.	Electrolyte height above the top of the separators	……mm.
12.	Electrolyte height below the bottom plates	……mm.
13.	Quantity of electrolyte per cell.	…… litres
14	Sp.Gr.of electrolyte for initial filling at 27 degree centigrade	……..
15.	Details of initial treatment recommended.	……
16.	Material of terminal and inter-cell connectors	……..
17.	Normal charging rate	……..Amps
18.	Frequency of topping up	…… .months

ANNEXURE 'B'

SCHEDULE OF PERFORMANCE

S.No.	Description	Particulars to be filled in
0.0	Batteries offered according to this standard shall be covered by a type approval certificate from an appropriate authority. All variations in the design shall be covered by a separate type approval certificate. Following particulars reg: the type tests shall be supplied by the manufacturer along with the certificate against any quotation or tender	
1.	Amper-hour capacity (Actual) a) C10 b) C5 c) C3	…… ……..Ah ……..Ah ……..Ah
2.	Amper-hour efficiency	……..
3.	Watt hour efficiency	……..
4.	Retention of charge	…….
5.	Expected Life)	…….
6.	Storage	…….
7.	Rise in electrolyte temperature above the Ambient air temp. when charged from duly discharged to fully charged conditions at normal rate.	……
8.	Charge and discharge curves with voltage versus time showing the performance of the cell for discharge at 10 hours rate and charge at normal rate.	……
9.	Loss of water	……
10.	Equilibrium float current	……
11.	Internal resistance	----------
12.	Capacity (C10) at 0 deg.C	----------

ANNEXURE 'C'

SEQUENCE OF TYPE TESTING

TEST	SAMPLE NUMBER									
	1	2	3	4	5	6	7	8	9	10
a. (*)Checking of dimensions, mass, markings and workmanship	x	x	x	x	x	x	x	x	x	x
b. Capacity at 10 hrs. rate	x	x	x	x	x	x	-	-	-	x
c. Material and component specification verification test	-	-	-	-	-	-	-	-	x	-
d. Air pressure	-	-	-	-	-	-	x	x	-	-
e. Storage	-	-	-	-	-	-	x	x	-	-
f. Life	-	-	x	x	-	-	-	-	-	-
g. Watt hour and ampere hour efficiency	-	-	-	-	x	x	-	-	-	-
h. Capacity at 5 hr. rate	-	-	-	-	x	x	-	-	-	-
i. Capacity at 3 hr. rate	-	-	-	-	x	x	-	-	-	-
j. Retention of charge	-	-	-	-	x	x	-	-	-	-
k. Internal resistance	x	x	-	-	-	-	-	-	-	-
l. Capacity at 0 deg C -	x	x	-	-	-	-	-	-	-	
m. Equilbrium float current -	x	x	-	-	-	-	-	-	-	
n. Water loss -	x	x	-	-	-	-	-	-	-	
o. Vibration x	-	-	-	-	-	-	-	-	-	

(*) Mass to be checked only for sample number 1 to 7.
(x) Samples to be subjected for tests.

ANNEXURE 'D'

SAMPLING PROCEDURE FOR ACCEPTANCE TESTS

1. LOT

1.1 In the consignment, all the batteries of the same rating manufactured from the same material under similar conditions of production shall be grouped together to constitute a lot.

1.1.1 These batteries in the sample shall be drawn from the lot at random. For the purpose of random selection, reference may be made to IS: 4905-1968.

2. SAMPLE SIZE AND CRITERIA FOR CONFORMITY

2.1 The Acceptance tests shall be conducted on minimum two samples up to a maximum of 1 percent of each type in a lot, the samples being drawn at random by the purchasing or inspecting authority as specified in Appendix "G" of IS: 6848 –79 with Amendment No.1,2 &3.

2.2 If any of the sample batteries fail in any of the acceptance test, twice the original number of samples shall be taken and subjected to all the acceptance tests. If there is failure in re-test, the lot may be rejected.

ANNEXURE 'E'

TEST FOR AMPERE HOUR & WATT HOUR EFFICIENCY

The following method shall be used for determining the maximum ampere-hour and watt-hour efficiencies.

Ampere - hour efficiency:

A fully charged battery shall be discharged at I = 0.1 x C10 amperes to a end voltage of 1.80 volts / cell, careful measurements being made of exact number of ampere hours delivered. On the 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 battery is then calculated as the ratio of the ampere- hour delivered during the second discharge to the ampere-hour put on the charge.

Watt - hour efficiency:

The watt - hour efficiency shall be calculated by multiplying the ampere - hour efficiency by the ratio of average hourly discharge and recharge voltages. The average voltage shall be calculated from the hourly readings of the charge / discharge voltage, including closed circuit voltage immediately after start (5-10 minutes reading) of charge / discharge and last reading of end cell voltage. The values of discharge and recharge voltages shall be calculated from the log sheets for ampere - hour efficiency.

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