PAKISTAN STANDARD

LEAD ACID STARTER BATTERIES -

Part-1:
General Requirements and Methods of Test

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PAKISTAN STANDARD SPECIFICATION FOR LEAD-ACID STATRER BATTERIES

Part-1: General requirements and methods of test

0. **FOREWORD**

0.1 This Pakistan Standard was adopted by the authority of the Board of Directors for Pakistan Standards and Quality Controkl Authority, after the draft Prepared by the Technical committee for "Dry cell Batteries & Accumulators (ENSC-6)" had been approved and endorsed by the Electrotechnical National Standards Committee on _19 -01-2012

0.2 This Standard is based on IEC: 60095-1/2009 "Lead-Acid Starter Batteries Part-1: General requirements and methods of tests. , and its use is hereby acknowledge with thanks.

0.3 This Standard has been prepared and finalized after taking into consideration the views and suggestions put forwarded by the representatives section of technologists, manufacturers and utilizing agencies.

0.4 This Standard is subject to periodical review in order to keep pace with the changing requirements and latest development in the industry. Any suggestions for improvement will be recorded and placed before he revising committee in due course.

0.5 This Standard covers technical provisions and it does not purport to include all the necessary provision of a contract.

CONTENTS

SECTION ONE – GENERAL

1.1 SCOPE

This standard is applicable to lead-acid batteries with a nominal voltage of 12v, used primarily as a power source for starting and igniting of internal combustion engines, lighting and also foe auxiliary equipment of internal combustion engine vehicles. There batteries are commonly called "starter batteries".

This standard is not applicable to batteries for other purposes such as the starting of railcar internal combustion engines.

1.2 OBJECT

The object of this standard is to specify:

- general requirements;
- certain essential functional characteristics; the relevant test methods and results requires;

For several classes of starter batteries:

- according to the general type of application;
- according to the climates in which they are predominantly operated.

1.3 Classification and Designation of Starter Batteries

1.3.1 According to their application, two classes of batteries are defined as follows:

- Class A: corresponds in particular to passenger vehicles, light commercial vehicles and similar application.
- Class B: corresponds in particular to trucks, buses, taxis, industrial cars, machinery used for public works and similar applications.

1.3.2 Batteries of Classes A and B are intended for use in temperature and cold climates. In these batteries, when fully charged, the density of the electrolyte shall be:

$$(1.28\ ^{+\ 0.02}_{-\ 0.01})\ \text{Kg/1 at } 25\ ^{0}\text{C}$$

1.3.3 Batteries intended for use in warm or tropical climate shall be designated by adding the letter T to the class-designations A and B, i.e. AT and BT. In these batteries- when fully charged – the density of the electrolyte shall be:

$$(1.23\ ^{+\ 0.02}_{-\ 0.01})\ \text{Kg/1 at } 25\ ^{0}\text{C}$$

1.4 **CONDITION ON DELIVERY**

New batteries may be supplied either:

- In a state ready for use, filed with the appropriate electrolyte to the maximum level. After an initial charge (according to (Sub-clauses 4.2.1 and 4.2.2), the electrolyte density shall correspond to the relevant figures of Sub-clause 1.3.2 or 1.3.3;
- in a dry-and-charged (or charge-conserved) state not filled with electrolyte. The density of the acid to fill these batteries before use shall be:

for class A and B 1.28±0.01Kg/1 at 25^{o}C, and
for class AT and BT 1.23±0.01Kg/1 at 25^{o}C

SECTION TWO – GENERAL REQUIREMENTS

2.1 **IDENTIFICATION, LABELLING**

Batteries according to this standard shall bear the following characteristics on at least one of their sides in indelible print:

2.1.1 Class of battery: (PS) A or B or AT or BT (see Clause 1.3).

2.1.2 Nominal voltage: 12 v

2.1.3 Capacity:

- either nominal capacity C_n (Ah)

- or reserve capacity C_r (min).
The value C_n or C_r for all classes of batteries according to Sub-clause 2.1.1 & shall correspond to the electrolyte density given in sub-clause 1.3.2.

2.1.4 Nominal cranking current: I_s (see Sub-clause 3.1.1).

2.1.5 Safety labelling: Batteries shall be marked with six coloured symbols as shown in figure 1.

Figure .1

The symbols shall have common dimensions as shown in figure 2 with a minimum dimension of 10 mm.

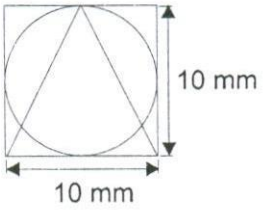

Figure 2

The symbols shall be located in a group as shown in figure 1, on the top of the battery.

No text in any language shall be used with the symbols.

In the original equipment market, the meaning of the symbols shall be found in the vehicle manual in the appropriate language.

In the replacement market, the meaning of the symbols shall be in the booklet supplied with the battery which already contains information for warranty, precautions for handling, instructions for use, etc.

The meaning of the symbols are:

(RED)	No smoking, no naked flames, no sparks
(BLUE)	Shield eyes
(RED)	Keep away from children
(YELLOW)	Battery acid
(BLUE)	Not operating instructions
(YELLOW)	Explosive gas

2.2 **MARKING OF THE POLARITY**

According to PS: 206-2 (section Five, Clause 14) at least the positive terminal shall be identified by a + mark on the cover or on the terminal itself.

2.3 ADDITIONAL DESIGNATION

Starter batteries may be designated as "Maintenance free according to PS Standard" by suitable abbreviation if they comply with the requirements of clause 5.8 functioning without adding water and the elevated requirements in Sub-clause 5.5.3.

Note: Starter batteries are subject to a wide variety of operating conditions. E.g. temperature, overcharge- voltage, etc., that have an influence on the electrolytic decomposition of water from the electrolyte, regardless of internal design features. So, the term "Maintenance free" in the sense of this standard is linked to well-defined conditions in clause 5.8 which do not cover the whole of practical operating conditions.

2.4 FASTENING OF THE BATTERY

If batteries are to be fastened to the vehicle by means of integral parts (e.g. bottom ledges), these shall be designed to withstand acceleration in crash conditions as specified by national standards, by legal requirements or by vehicle manufacturers.

SECTION THREE – FUNCTIONAL CHARACTERISTICS

For general definitions of terms see Chapter-486 of the International Electrotechnical Vocabulary (PS-3369).

3.1 ELECTRICAL CHARACTERISTICS

3.1.1 The cranking performance is the discharge current I_s, to be indicated by the manufacturer, which a battery can supply at

- 18 ^{0}C in case of class A and B
- 0 ^{0}C in case of class AT and BT.

for 60 s to a minimum voltage U_f = 8.4 v.

3.1.2 The capacity of a starter battery is defined for the temperature of 25 ± 2 ^{0}C. It may be indicated by the manufacturer either as:

- nominal capacity C_n or as
- nominal reserve capacity $C_{r,n}$.

The nominal capacity C_n is the electric charge (in Ah) which a battery can supply with a current

$$I_n = \frac{C_n}{20} \text{ (A)}$$

to a final voltage U_f = 10.5 v.

The effective capacity C_e shall be determined by discharging a battery with constant current I_n to U_f = 10.5 v (see clause 5.1). The resultant figure is used for the verification of C_n.

The nominal reserve capacity $C_{r, n}$ is the period of time (in minutes) for which a battery can maintain a discharge current of 25 A to a cut-off voltage U_f = 10.5 v.

The effective reserve capacity $C_{r, e}$ shall be determined by discharging a battery with the constant current I = 25 (A) to U_f = 10.5 v (see clause 5.2). The resultant discharge time (in minutes) is used for the verification of $C_{r, n}$.

Note – For the correlation (relationship) of C_n and $C_{r, n}$, see Appendix A.

3.1.3 The charge acceptance is expressed as the ratio I_{ca}:

- of the current I_{ca} which a partially discharged battery takes up at 0 ^{0}C and at constant voltage or 14.4V,
- and of I = C_e/20

$$I_{ca} = \frac{I_{ca}}{C_e/20}$$

(See clause 5.4)

3.1.4 Charge retention is defined as the cold cranking performance of the charged and filled battery after storage on open circuit under defined conditions (temperature, time) (see clause 5.5).

3.1.5 Endurance in cycles represents the ability of a battery to perform repeated discharge/recharge cycles and long rest periods on open circuit. This ability shall be tested by a series of cycles and rest periods under specified conditions after which the cold cranking performance shall be determined (see clause 5.6)

Note - In the Eastern Asiatic and North –American regions another test is in use to evaluate the endurance of batteries with discharge/charge cycles, the depth of discharge of which is less than specified here.

3.1.6 Water consumption: Maintenance-free service of a battery requires a low rate of electrolytic water decomposition through overcharge (see Clause 5.8).

3.1.7 Dry charged battery (conserved charge battery): A new battery may be designated as dry charged (conserved charge) if it can be activated – ready for service – just by filling it with the appropriate electrolyte and if it then conforms to the requirements of clause 5.11.

3.2 MECHANICAL CHARACTERISTICS

3.2.1 Vibration resistance represents the ability of a battery to maintain service under periodic or irregular acceleration forces. Minimum requirements are to be verified by a test (see clause 5.9)

3.2.2 Electrolyte retention is the ability of a battery to retain the liquid electrolyte under specified mechanical conditions (see clause 5.10).

SECTION FOUR – GENERAL TEST CONDITIONS

4.1 SAMPLING OF BATTERIS

All tests shall be carried out on new battery samples. Samples shall be considered as new not later than:

- 30 days after shipment date of the manufacturer in case of filled batteries.
- 60 days after shipment date of the manufacturer in case of dry-charged or charged-conserved batteries.

4.2 PREPRATION OF BATTERIES PRIOR TO TEST – DEFINITION OF A FULLY-CHARGED BATTERY

All tests – except that in clause 5.11 – shall commence with fully-charged batteries.

Batteries shall be considered as fully-charged if they have undergone one of he two charging procedures of sub-clauses 4.2.1 or 4.2.2 carried out at $25 \pm 10\ ^0$C.

4.2.1 Charging at constant current
The battery shall be charged:

- at a current of 2 I_n (see Sub-clause 3.1.2), until the voltage reaches 14.4v, and
- then with the same current for 5 substance hours.

In the case of recharging after a test for cranking performance (according to clause 5.3) the time shall be limited to 3 h instead of 5 h.

4.2.2 Charging at modified constant voltage.
The battery shall be charged at a voltage of 16.0v for 24 h with the maximum current limited to 5 I_n (see Sub-clause 3.1.2).

In the case of recharging after a test for cranking performance (according to clause 5.3) the charging time may be limited to 16 h.

Note: If neither complete knowledge of the battery construction nor a specification from the manufacturer is available, the charging according to the present sub-clause is recommended.

4.3 ACTIVATION OF DRY-CHARGED OR CHARGE-CONSERVED BATTERIES

Dry charged batteries shall be filled with the appropriate electrolyte (according to sub-clause) 1.3.2) to the maximum level indicated by internal or external marks according to the manufacture's instructions.

4.4 MEASURING INSTRUMENTS

4.4.1 Electrical Measuring Instruments

The range of instruments used shall be appropriate for the magnitude of the voltage or current to be measured.

For analogous instruments the readings shall be taken in the top third of the scale.

- Voltage measurement
  The instruments used for measuring voltages shall be voltmeters having an accuracy class of 1 or better. The resistance of the voltmeters shall be a t least 300Ω/V.

- Current measurement
  The instruments used for current measurement shall be ammeters having an accuracy class of 1 or better. The assembly of ammeter, shunt and leads shall have an overall accuracy of class 1 or better.

4.4.2 Temperature Measurement

The thermometer used for measuring temperature shall have an appropriate range, and the value of each scale division shall not be greater than 1 K. The accuracy of the calibration of the instruments shall be not less than 0.5 K.

4.4.3 Density Measurement

The density of the electrolyte shall be measured with hydrometers furnished with a graduated scale, the value of each division of which is equal at most to 0.005 Kg/1. The accuracy of calibration shall be 0.005 Kg/1 or better.

4.4.4 Time Measurement

The instruments used for measuring time shall be graduated in hours, minutes seconds or in hours and centihours ch (= $\frac{1}{100}$ h). They shall have an accuracy of at least ± 1%.

4.5 **TEST SEQUENCE**

4.5.1 Batteries filled and charged. Initially the batteries are subjected to the following series of tests:

1st	C_e or $C_{r,e}$ check
1st	Cranking performance test
2nd	C_e or $C_{r,e}$ check
2nd	Cranking performance test
3rd	C_e or $C_{r,e}$ check
3rd	Cranking performance test

For both C_e or $C_{r,e}$ and the cranking performance the specified values shall be met in at least one of the three relevant discharges above.

The tests according to the following table shall be applied only if this is the case, but not later than at most one week after completion of the first part.

TABLE – 1

Battery	1	2	3	4	5
Endurance Clause 5.6	X				
Charge retention Clause5.5		X			
Charge acceptance Clause5.4			x		
Electrolyte retention Clause5.10			x		
Vibration resistance Clause 5.9				x	
Water consumption Clause 5.8					X

Note: The test for water consumption should be applied only to "Maintenance-free" batteries according to Clause 2.3.

4.5.2 Dry-charged or conserved-charge batteries.

- Initial cranking performance after filling with electrolyte (see clause 5.11).
- Cauasity test (see clause 5.1)

5.1 CAPACITY CHECK C_e

5.1.1 Throughout the duration of the tests, the battery shall be placed in a water-bath at a temperature of 25±2 ^{0}C. The upper surface of the battery shall be at least 15 mm but no more than 25 mm (see sub-clause 23.2 of PS: 206-1/1987 and see also sub-clause 5.8.2 of this standard) above the level of the water. If several batteries are in the same water-bath then the distance between them and also the distance to the walls of the bath shall be at least 25 mm.

5.1.2 The battery shall be discharged with the current I_n (calculated according to Sub-clause 3.1.2) kept constant at ± 2% of the nominal value until the terminal voltage falls to 10.5 ± 0.05V. The duration t(h) of this discharge shall be recorded. The beginning of the discharge shall take place form 1 h to 5 h from the time of the end of charging.

5.1.3 The capacity C_e is:

$$C_e = t.I_n(Ah)$$

5.2 RESERVE CAPACITY CHECK $C_{r,\,e}$

5.2.1 The battery shall be placed in a water-bath according to Sub-clause 5.1.1.

5.2.2 1 h to 5 h after the end of charging according to clause 4.2 the battery shall be discharged with a current of 25 A ± 1% until the terminal voltage has fallen to U_f = 10.5±0.05V. The duration t(min) of the discharge shall be recorded.

5.3 CRANKING PEREFORMANCE TEST

5.3.1 After a rest period of 1 h to 5 after preparation according to Sub-clause 4.2.1 the battery shall be placed in a cooling chamber with (forced) air circulation a t temperature of -18±1 ^{0}C for a minimum of 20 h or until the temperature in one of the middle cells has reached -18±1 ^{0}C; see note below.

5.3.2 The battery shall then be discharged – either within or outside the cooling chamber – within 2 min after the end of the cooling period with a current I_s (see Sub-clause 3.1.1). This current shall be kept constant to within ±0.5% during the discharge.

5.3.3 After 60 s discharge, the terminal voltage shall be recorded. It shall be not less than 8.4V.

Note: For batteries in classes AT or BT (according to Sub-clause 1.3.3) the cranking performance should be tested at 0 ^{0}C.

5.4 CHARGE ACCEPTANCE TEST

5.4.1 The battery shall be discharged at an ambient temperature between 0 and 30 ^{0}C.

$$\text{at a current } I_o = \frac{C_e}{10} \text{ for 5 h}$$

The value C_e shall

- either be taken the maximum value C_e of the three pervious discharges according to clause 5.1.
- or be calculated from the maximum value C_r of the three pervious discharges according to clause 5.2 with the correlation formula in Appendix A.

5.4.2 Immediately after the discharge, the battery shall be cooled for 20 h to 25 at 0 ± 0.1 ^{0}C.

5.4.3 At this temperature, the battery shall be charged at a constant voltage of 14.4 ± 0.1V. After 10 min, the charging current I_{ca} shall be recorded.

5.4.4 The ratio

$$i_{c\,a} = \frac{I_{ca}}{C_e/20}$$

shall be ≥ 2.

5.5 CHARGE RETENTION TEST

5.5.1 Standard requirement
A fully-charged battery (according to clause 4.2) with its vent plugs firmly in place and a clean, dry surface shall be store at 40 ± 2 ^{0}C for 21 days on open circuit. No connecting clamps or cables shall be attached to be terminals.

5.5.2 After this storage period the battery shall be submitted-with out-out recharge – to a cold cranking performance test according to Sub-clause 5.3.1 and 5.3.2. The voltage after 30 s of a discharge shall be not less than 7.2 V.

5.5.3 Elevated requirement

Under the same conditions as in Sub-clause 5.5.1 the battery shall be stores for 49 days. The cold cranking performance shall be according to Sub-clause 5.5.2.

5.6 ENDURANCE TEST FOR BATTERIES CLASS A

5.6.1 Throughout the whole test period, with exception of the rapid discharge test at the temperature –18 ^{0}C (see Sub-clause 5.6.5) the batteries are placed in a water-bath at a temperature of 40 ± 2 ^{0}C in Sub-clause 5.8.2.

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

a) a discharge for 1 h at a current

$$I = \frac{C_n}{4} \text{ (A)}$$

b) a recharge (immediately followed by) for 2 h at constant voltage of 14.8 ± 0.05 V, the maximum current being limited to

$$I_{max} = \frac{C_n}{2} \text{ (A)}$$

5.6.3 After a series of 32 cycles of discharge and recharge, in accordance with Sub-clause 5.6.2, the batteries shall be disconnected from the endurance circuit and allowed to remain on open circuit for a period of 72 h. They shall be recharged according to Item b) of Sub-clause 5.6.2.

5.6.4 The whole sequence of 32 cycles, followed by the open-circuit period, constitutes one endurance test unit.

5.6.5 After three such units the batteries are submitted to another series of 32 cycles and an open-circuit period of 72 h. The batteries are then, without recharge, removed from the water bath, cooled to an electrolyte temperature of -18±1 ^{0}C (measured in a central cell or for a minimum of 20 h), and discharged at the current I_s (see Sub-clause 3.1.1).

5.6.6 After 30 s of discharge the voltage across the battery terminals shall be measured. It shall be not less than 7.2 V. The discharge shall then be terminated.

Note: For batteries class AT or BT, the final control of cranking performance at -18 ^{0}C should be replaced by a test at 0 ^{0}C with the current I_s.

5.7 CYCLIC ENDURANCE TEST FOR BATTERIES IN CLASS B

5.7.1 The test shall be carried out on fully-charged batteries in accordance with clause 4.2.

5.7.2 Through the whole test period, with exception of the discharge test at the temperature -18 ^{0}C (see 5.7.6 below), the batteries are placed in a water-bath at a temperature of 40 ^{0}C ± 2 ^{0}C.

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

a) a charge for 5 h at a constant voltage of 14.8V±0.05V the maximum current being limited to:

$$I_{max} = 5\ I_n \pm 2\ \%(A).$$

Immediately followed by

b) a discharge for 2 h with a current 5 I_n.

5.7.4 At the end of the discharge of cycle no. 14 the final discharge voltage shall be not less than 10.0V. After recharging according to 5.7.3 a), the batteries shall be disconnected from the endurance test circuit and allowed to remain on open circuit for a period of 70 h.

5.7.5 The whole sequence of 14 cycles, followed by, the open-circuit period, constitutes one endurance test unit-Class B.

5.7.6 Immediately after five such test units the batteries shall-without recharge- be removed form the water-bath, cooled to an electrolyte temperature of -18 ^{0}C±1 ^{0}C, (measured in a central cell) for a least 20 h and then discharged with the current.

$$I_s\ (A)$$

After 30.0 s ± 1 s of discharge the voltage across the battery terminals shall be measured. It shall be not less than 7.2 V. The discharge shall be terminated.

5.8 WATER CONSUMPTION TEST

5.8.1 The battery, after being charged according to Clause 4.2 shall be cleaned, dried and weighed to an accuracy of ± 0.05%.

5.8.2 The battery shall be placed in a water-bath maintained at a temperature of 40 ± 2 ^{0}C. The top of the battery case shall emerge not more than 25 mm above level of the water. A minimum space of 25 mm shall be maintained around each battery.

5.8.3 The battery shall be charged at a constant voltage of 14.4 ± 0.05V (measured across the battery terminals) for a period of 500 h.

5.8.4 Immediately after this overcharge period, the battery shall be weighed under the same conditions as in Sub-clause 5.8.1 with the same scales.

5.8.5 The loss in weight shall not exceed the value 6 g/Ah C_e (or 4 g/min $C_{r,e}$) or as specified in national requirements.

5.8.6 Alternatively, the battery shall be submitted, without water addition, to a cold cranking performance test to the end voltage U_f = 7.2V. The minimum duration of the discharge shall be specified in national requirements.

5.9 VIBRATION RESISTANCE TEST

5.9.1 After charging according to clause 4.2 the battery shall be stored for 24 h at a temperature of 25 ±10 ^{0}C.

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

- the bottom hold-downs or ledges on the lower art of the container and suitable hold-down clamps and bolts with M8 thread, tightened to a torque of at least 15 Nm, or

- an angle-iron frame covering the upper edges of the battery case/cover assemble for a minimum width of X mm (see table II), connected to the vibration table by four screwed rods with M8 thread, tightened to a torque of at least 8 Nm.

5.9.3 The battery shall be subjected for a period of T h (see Table II) to a vertical vibration of frequency of 30 Hz to 35 Hz, these vibrations being as nearly sinusoidal as possible.

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

5.9.4 After a maximum of 4 h form the end of the vibration, the battery shall be subjected without recharge- to a discharge at a temperature of 25±2^{o}C with a current I_s.

The terminal voltage discharge after 60s shall be not less than 7.2 V.

TABLE - II

Battery Class	A, AT	B, BT
X	15 mm	33 mm
T	2 h	8 h
Z	30 ms^{-2}	50 ms^{-2}

5.10 ELECTROLYTE RETENTION TEST

5.10.1 After charging according to Clause 4.2 the battery shall be stored for 4 h on open circuit.

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

5.10.3 The battery shall then be titled in either direction at intervals of not less than 30 s between each tilting as follows:

a) the battery shall be tilted through 45^{o} from the vertical for a maximum period of 1 s;
b) the battery shall be maintained this position for 3 s;
c) the battery shall be returned to the vertical position for a maximum period of 1 s.

5.10.4 After this test, no liquid shall visible on the vent plugs.

5.11 CRANKING PERFORMANCE FOR DRY-CHARGED (OR CONSERVED-CHARGE) BATTERIES AFTER ACTIVATION

5.11.1 The dry-charged battery and a sufficient amount of electrolyte supplied by, or according to the manufacturer's specifications, shall be stored at 25±5 ^{0}C for at least 12 h (before filling).

5.11.2 The electrolyte shall be filled up to the level indicated by the manufacturer.

After a rest period of 20 min at the same ambient temperature the battery shall be discharged at a current $I_{s.}$

After 150 s the terminal voltage shall be not less than 6.0 V.

APPENDIX - A

The value of C_n (Ah) may be estimated from C_r (min) by use of the following equation:

$$Cn = -133.3 + \sqrt{(17778 + 208.3.C_r)}$$

This formula is not recommended for:

$$C_r \geq 480 \text{ min } (C_n \geq 200 \text{ Ah}).$$