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टीएल/एसी कोच की वीआरएलए बैटरीज के अनुरक्षण की लघुपुस्तिका

MAINTENANCE HANDBOOK ON VRLA BATTERIES FOR TL/AC COACHES

CAMTECH/E/2003/VRLA/1.0

केमटेक/ई/2003/वीआरएलए /1.0

अक्टूबर, 2003

OCTOBER, 2003

Centre for Advanced Maintenance TECHnology

Excellence in

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MAINTENANCE HANDBOOK

ON

VRLA BATTERIES FOR TL/AC COACHES

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FORWORD

Proper upkeep of batteries is essential for their smooth functioning. They supply power to lights, fans and AC units during non-generation period and any malfunctioning can cause inconvenience to travelling public.

CAMTECH has prepared this handbook regarding maintenance of VRLA batteries. It contains their maintenance schedules and trouble shooting etc.

I hope the field staff will find it useful in upkeeping of VRLA batteries.

CAMTECH, Gwalior — *C.B.MIDDHA*
Dated: 21-10-2003 — ***Executive Director***

PREFACE

Battery is an important equipment of Train Lighting & AC system. Proper upkeep of battery is necessary to ensure that lights/fans & AC equipment work during non-generation period. This handbook on Maintenance of VRLA batteries has been prepared by CAMTECH with the objective of making our maintenance personnel aware of correct maintenance and overhaul techniques to be adopted in the field.

It is clarified that this handbook does not supersede any existing provisions laid down by RDSO or Railway Board and it is not a statutory document.

I am sincerely thankful to all officers and staff of PS & EMU directorate of RDSO/ LKO for their valuable suggestions and comments. I am also thankful to all field personnel who helped us in preparing this handbook.

Technological upgradation and learning is a continuous process, hence feel free to write to us for any addition/ modification in this handbook. We shall highly appreciate your contribution in this direction.

CAMTECH, Gwalior
Date: 21-10-2003

RANDHAWA SUHAG
Director/Elect

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ISSUE OF CORRECTION SLIP

The correction slips to be issued in future for this handbook will be numbered as follows:

CAMTECH/2003/E/VRLA/C.S. # XX date---------

Where "XX" is the serial number of the concerned correction slip (starting from 01 onwards).

CORRECTION SLIPS ISSUED

Sr. No.	Date of issue	Page no. and Item no. modified	Remarks

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CHAPTER 1

GENERAL

A battery is an electro-chemical device in which the free energy of a chemical reaction is converted into electrical energy by means of Electro-chemical Oxidation-Reduction reactions.

It is the only device which can store electrical energy in the form of chemical energy and hence is called as a storage battery. The electrical energy is stored in the form of chemical energy and on demand is converted into electrical energy to drive an external circuit.

Following are different types of storage batteries that are most commonly used:-

a. Lead Acid Battery.

   1. Conventional Flooded Battery
   2. Valve Regulated Lead Acid (VRLA) Battery

b. Alkaline Battery

   1. Nickle Cadmium Battery
   2. Silver Zinc Battery.

In Indian Railways only Lead Acid batteries are used for the Lighting and Air-conditioning of coaches.

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1.1 LEAD ACID BATTERY

The electro-chemical device which uses lead and its derivatives and sulphuric acid as the constituents is called Lead Acid Battery. Battery consists of positive plate (Anode), a negative plate (Cathode) and electrolyte. In a lead acid battry, the positive plate consists of an active material lead dioxide (PbO_2) and a grid structure of either pure lead or lead alloys which acts as a supporting structure as well as current carrying conductor. Similarly the negative plate consists of spongy lead (Pb) as active material and pure lead or lead alloy for the grid structure. The electrolyte used in a lead acid battery is diluted sulphuric acid.

The basic reaction that takes place in a lead acid battery is given by the following equation:

$$PbO_2 + Pb + 2H_2SO_4 \underset{\text{Charge}}{\overset{\text{Discharge}}{\rightleftharpoons}} \underset{\text{(pos. plate)}}{PbSO_4} + \underset{\text{(neg. plate)}}{PbSO_4} + 2H_2O$$

From the above equation it can be seen that the reaction is reversible and based on which the lead acid battery is classified as Secondary Battery which can give number of discharge and charge cycles. During discharge, the lead dioxide in positive plate and spongy lead in negative plate react with sulphuric acid in the electrolyte to form lead sulphate both in positive and negative plates and water in the electrolyte.

The chemical reactions for the same are shown below:

Electrolyte: $2H_2SO_4 \longrightarrow 4H^+ + 2SO_4^{-2}$

At Neg. plate: $Pb \longrightarrow Pb^{+2} + 2e^-$

$Pb^{+2} + SO4^{-2} \longrightarrow PbSO_4$

$Pb + SO4^{-2} \longrightarrow PbSO_4 + 2e^-$

At Pos. Plate: $PbO_2 + 4H^+ + 2e^- \longrightarrow Pb^{+2} + 2H_2O$

$Pb^{+2} + SO_4^{-2} \longrightarrow PbSO_4$

$PbO_2 + 4H^+ + 2e^- + SO_4^{-2} = PbSO_4 + 2H_2O$

So, during discharge as the lead dioxide and spongy lead reacts with sulphuric acid (electrolyte) and gradually transform into lead sulphate, the sulphuric acid concentration decreases in the electrolyte due to the depletion of sulphate ions to the positive and negative plates. Conversely, when the battery is charged, the positive and negative active materials which have been turned into lead sulphates, gradually revert to lead dioxide and spongy lead respectively releasing sulphuric acid engulfed in the active materials during which the sulphuric acid concentration increases.

When the battery charging approaches its final stage, the charging current is consumed solely for electrolyte decomposition of water in the electrolyte, resulting in generation of oxygen gas from positive plate and hydrogen gas from negative plate. So the generated gas will escape outside the battery causing a decrease of the electrolyte quantity in the battery. Hence the battery needs to be replenished with water. This is the common

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phenomenon observed in all the conventional flooded type lead acid batteries requiring constant monitoring and maintenance of the battery. In order to overcome this phenomenon of replenishment with water, the maintenance free valve regulated lead acid (VRLA) battery has been developed, which needs no replenishment with and has got several other advantages both constructional and performance wise.

1.2 VRLA TECHNOLOGY

The electrode reactions in all lead acid batteries including VRLA battery is basically identical. As the battery is discharged, the lead dioxide positive active material and spongy lead negative active material both react with the sulphuric acid electrolyte to form lead sulphate and water. During charge, this process is reversed. The coulombic efficiency of the charging process is less than 100% on reaching final stage of charging or under over charge conditions, the charging energy is consumed for electrolytic decomposition of water and the positive plates generate oxygen gas and the negative plates generate hydrogen gas.

Under typical charging conditions, oxygen at the positive plate occurs before hydrogen evolution at the negative. This feature is utilized in the design of VRLA batteries. In flooded cells, the oxygen gas evolved at the positive plate bubbles upwards through the electrolyte and is released through the vents. In VRLA batteries the oxygen gas evolved at the positive instead of bubbling upwards is transported in the gas phase through the separator medium to the negative plate. The separator is a highly absorbent glass mat type with very high porosity designed to have pore volume in excess of the electrolyte volume (starved electrolyte design), due to which the oxygen gas finds an unimpeded path to the negative plate. The oxygen gas gets reduced by reaction with the spongy lead at the negative plate turning part of it into a partially discharged condition, thereby effectively suppressing the hydrogen gas evolution at the negative plate. This is known as the oxygen recombination principle. The part of negative plate which was partially discharged is then reverted to original spongy lead by subsequent charging. Thus a negative plate keeps equilibrium between the amount which turns into spongy lead by charging and the amount of spongy lead which turns into lead sulphate by absorbing the oxygen gas generated at the positive plate. The oxygen recombination principle can be shown by the following reaction mechanism.

1. Reaction at positive plate:

$H_2O \longrightarrow \frac{1}{2} O_2 + 2H^+ + 2e^-$ ……… (1)

2. Reaction at negative plate:

$Pb + \frac{1}{2}O_2 \longrightarrow PbO$ …… (2)

$PbO + H_2SO_4 \longrightarrow PbSO_4 + H_2O$

To reaction (1)…..(3)

$PbSO_4 + 2H^+ + 2e^- \longrightarrow Pb + H_2SO_4$

To reaction (3)…(4)

To reaction (2)

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3. The total reaction at negative plate

$$\frac{1}{2} O_2 + 2H^+ \longrightarrow H_2O$$

Thus, the recombination technology makes the battery virtually maintenance free.

Figure 1.1 VRLA Cell

1.3 OVERALL DIMENSIONS AND MASSES

The maximum dimensions and mass of each module shall not exceed the values given in Table 1.1 for respective capacities.

TABLE -1.1

MAXIMUM DIMENSIONS AND WEIGHTS

S N	Capacity at 27°C and module voltage	Rate of Discharge	Overall length	Max. dimensions		Maximum weight in Kg. (module)
				Height	width	
1	120 Ah (18 V)	10 hr.	550	220	450	120
2	500 Ah (6 V)	10 hr.	580	220	600	115
3	800 Ah (6 V)	10 hr.	700	210	600	250
4	1100 Ah (8/10V)	10 hr.	1095	315	675	475

1.4 CONSTRUCTION

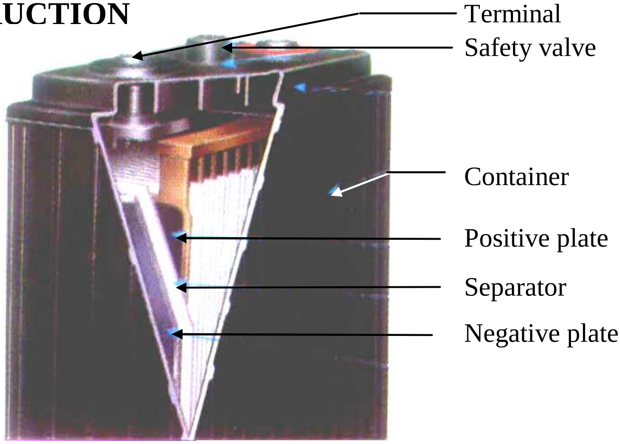

Figure 1.2 Cross Sectional view of VRLA battery

(i) Positive plate

Positive plate is made of lead-calcium tin alloy providing lower corrosion & less self discharge.

Figure 1.3 Positive plate

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(ii) Negative plates

It is made of lead-calcium tin alloy.

Figure 1.4 Negative plate

(iii) Container

Container of battery is made of suitable flame retardant Polypropylene Copolymer Plastic (PPCP) with high insulating strength to resist acids and low permeability to water vapours. The container is enclosed in epoxy coated steel trays. The steel tray is so designed as to permit both vertical and horizontal stacking of cells.

(iv) Electrolyte

The sulfuric acid and water used as electrolyte for the battery confirming to IS: 266–77 and IS : 1069–64 respectively.

(v) Separators

Separators consists of either of microporous glass mat or synthetic material having high absorption capabilities and also resistant to sulfuric acid.

Figure 1.5 separator

(vi) Safety vent plug

The plug is explosion resistant and is of pressure regulation type. Safety vent plug does not permit ingress of air into the unit.

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(vii) Terminals

The terminals of battery generally comprise of lead coated copper terminals.

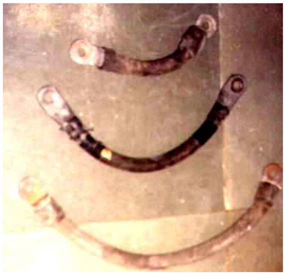

Figure 1.6 Inter Cell Connectors

(viii) Nuts and Bolts

Nuts and bolts used to connect the cells are made of copper, bras or stainless steel. These are effectively lead coated in order to prevent corrosion.

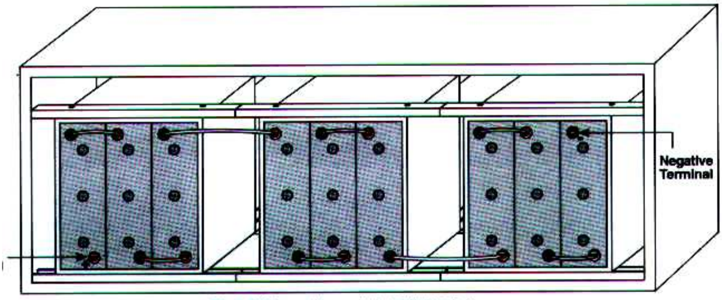

Figure 1.7 54 Volt layout (one cradle) of 120 AH Battery

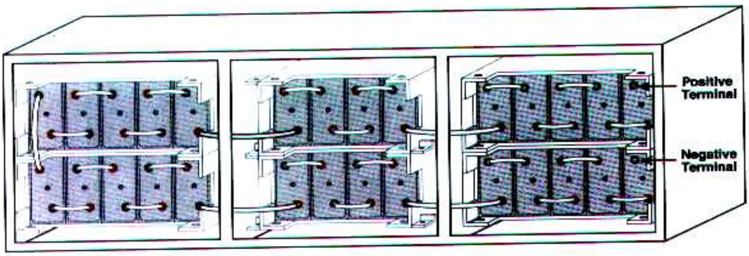

Figure 1.8 56 Volt layout (one cradle) of 1100 AH battery

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CHAPTER 2

MAINTENANCE

(RDSO SMI No.RDSO/PE/SMI/TL/0024-2003)

2.1 VOLTAGE SETTING OF ALTERNATOR

Ensure that the setting of the alternator cum regulator is as under:

Battery	Passenger	Mail/express	Super fast
56 cells battery bank (AC Coaches fitted with VRLA batteries)	--	126 ± 0.5 V	125 ± 0.5 Volts
54 cells battery bank (TL coaches fitted with VRLA batteries)	123 ± 0.5 Volts	122 ± 0.5 V 120 ± 0.5 V	120 ± 0.5 Volts

Alternator voltage settings as mentioned above shall be done at half load i.e. 97 A and 19A for AC and TL coaches respectively, at 1500 rpm.

2.2 TRIP INSPECTION

(i) Check for bye passing of failed cells. If bye-passed cells are found, replace these failed cells immediately with the healthy ones.

(ii) If dust accumulation is observed, clean with dry cotton cloth.

(iii) If cell cover/container is cracked or burst, replace the cell with a healthy one.

(iv) In case of battery terminal/cable over heating sign, check for loose connection at the cell terminal post/cable end. If required, replace the cable.

(v) If protective lid on safety valve is missing, provide new one.

(vi) Check for arrival time of the Train. If train has arrived late due to heavy detention en-route due to some reasons, charge the coach battery bank as per table – 2.1 to bring up the state of charge of the battery Bank before putting the AC coaches again in service.

(vii) Do not boost charge the cells for more than 12 hours.

TABLE – 2.1

Voltage Current setting for terminal charging & pre cooling of TL & AC coaches

A. For 2 Volt, 56 Cells :	
Voltage setting	128.8 V (2.3 Volt per cell)
Max. charging current	220 Amp. (0.2 C)
B. For 2 Volt, 54 Cells :	
Voltage setting	124.2 V
Max. charging current	24 Amp

2.3 QUARTERLY INSPECTION AT YARDS/DEPOTS

(A) The following physical check shall be made:

i. Confirm the tightness of terminal bolt with torque wrench. (Amararaja – 11 Nm, Exide – 22Nm, HBL Nife – 10 Nm)

ii. If terminal post corrosion is observed, remove the cable and clean the terminal post and cable lug with brass brush or fine emery paper and apply petroleum jelly.

(B) Check open circuit voltage.

(a) If the total battery bank open circuit voltage for AC and TL coaches is as under:

AC Coaches	:	115.0 volts or above
TL Coaches	:	112.0 volts or above

The following steps shall be followed:

i. Discharge the battery bank with full coach load for 15 minutes.

ii. Note down the individual cell readings after 15 minutes while the coach is still connected during the discharge.

iii. If all the cell voltages are 1.98 volts and above then cells are in healthy condition. Charge the cells as per the table no. 2.1 and the same to be put in service.

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iv. If some of the cell voltages are less than 1.98 volts then give boost charging with 2.30 VPC for 12 hrs. by charging them separately with current limited to 0.2C.

Figure 2.1 : Charging of cells

v. The weak cells, which are charged separately must be checked through a discharge @ C-10 rate for 30 minutes, the end of discharge voltage should be above 2.0 V. If such a re-charged cell fails to qualify the above test, it should not be replaced back in the coach.

vi. After performing the discharge test on revived cells, the cells need to be charged at least for 4 hours, prior to fitment in the coach.

(b) If the total battery bank open circuit voltage is as under for AC and TL coaches:

AC Coaches	:	Less than 115.0 volts
TL Coaches	:	Less than 112.0 volts

Charge the cells for 12 hrs. with 2.30 VPC and then carry out the discharge test as per item no.2.3 B (a) above.

2.4 POH SCHEDULE:

The below given instructions are to be followed when the coach comes for periodic overhaul (POH) to the workshop.

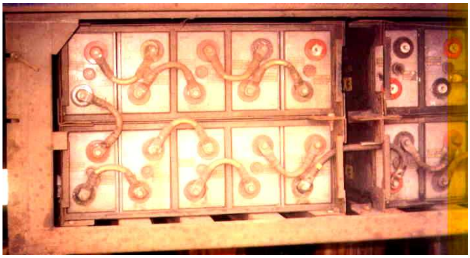

Figure 2.2 Fitment of battery in the coach

i. Remove all the cell terminal bolts, flat washers, spring washers, inter cell cables, connectors etc. (use insulated tools only)

ii. Care should be taken to avoid any shorting of cell terminals while removing inter cell cable connectors.

iii. Remove the stacking bolts used for fixing battery modules to battery box/ cradle and between the trays.

iv. Remove the modules with batteries from battery box/ cradle by using suitable tool.

v. Clean all the cell terminal posts and inter cell connectors/cable lugs with a brass wire brush to remove any sulphation layer.

vi. Re-fix the inter cell connectors/cables and tighten the bolts along with flat and spring washers to specified torque. Replace old spring washers 100%. Quality of new spring washers should be checked as per IS 3063 especially permanent set test.

vii. Discharge the battery bank @ 0.1C and by pass each cell whenever it reaches end cell voltage of 1.75 V.

viii. Charge the cells at 2.3Volts per cell with maximum charging current limited to 20% of rated cell capacity, till the voltage reading of cells become stable for 2-3 hours. For a 56-cell set, voltage setting should be 128.8 Volt.

ix. Again give rest to the cells for 6-8 hours.

x. Discharge the cells at 12A for 120Ah and 110A for 1100 Ah till the cells reach 1.75 V. Duration of discharge shall be recorded. If the discharge duration of the cells is found to be more than 8 hrs., these can be put back in service after charging.

xi. If the cells do not give more than 8 hrs of discharge duration before reaching end cell voltage of 1.75 V, repeat this charging and discharging cycle two more times. Cells should not be discharged below 1.75 V.

xii. Even then, if the cells do not give more than 8 hrs. then the cells shall not be put in service.

xiii. Clean and repaint the modules/ cell trays. These may be numbered with the help of stenciling to identify the modules consisting of a battery set for a coach (say Module No./ set No.e.g.08/01 means 8^{th} module of set. No.1). The other details like cell number, date of manufacture as indicated on the cell lid and date of fitment shall also be recorded to monitor age-wise performance of the cells.

Note: All the new VRLA cells shall be given a boost charging if the cells have been lying in the depot/workshop for more than 6 month period from the date of manufacture.

2.5 LOADING ON TO THE COACH

i. After recharge, remove all the inter cell connectors/ cables etc., to avoid shorting of the cells during loading on to the battery box/ cradle.

ii. Apply Petroleum jelly over the inter cell connectors, wherever necessary.

iii. Do not mix ordinary conventional/ low maintenance cells with VRLA cells.

iv. Put back the trays into the battery box/ cradle as per the connection diagram and fix the stacking bolts between the steel tray to battery box/ cradle and tray to tray.

v. Do not mix the cells of different capacities and makes.

2.6 STORAGE OF CELLS

The cells shall be stored only at the places which are not exposed to direct sun light, rain, dust etc. The stored area should be clean, dry and preferably indoor & ambient temperature should be between 15 degrees to 35 degree. Preferably the battery modules shall be stacked in not more than 5 tiers to avoid damage to the cell modules/ cells at the bottom layer.

CHAPTER 3

TROUBLE SHOOTING

CAUSES, EFFECTS AND REMEDIES

Trouble	Cause	Effect	Prevention
Over Charging	▪ Continuous charging of batteries at a higher voltage (i.e. more than specified value) can cause overcharging of batteries. ▪ The higher voltage can be due to either the set point in charger itself is high or connecting less than required number of cells (or) some cells in the bank are removed/by-passed (or) due to calibration error in the measuring instrument.	▪ Excessive gassing resulting in loss of water. ▪ Dry out of separator ▪ Increases the temperature of the cell. ▪ This over charging causes corrosion of positive plates.	The corrective action for this is ▪ Adjust the float voltage to 2.25 VPC at 20% (max.) current limit of the rated capacity. ▪ Connect the required number of cells. ▪ Isolate the battery bank from heat sources.

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Trouble	Cause	Effect	Prevention
Under charging	▪ Continuous charging of batteries at a lower voltage (i.e. less than specified value) can cause under charging of batteries. ▪ The loose terminal bolt connections can also cause under charge. ▪ Setting voltage is low in the charger or calibration error in the measuring instrument.	▪ Consistent under charging of the battery results in a gradual running down of the cells. ▪ In-sufficient charging causes buckling of plates. Since the lead sulphate occupies more space than the original material.	When this occurs, charge the cells at 2.25 volts until all the cells reaches to normal condition.
Difficulties with charging system	▪ Malfunctioning of Charger/Rectifier. ▪ Failure of any component used in Charger/rectifier. ▪ Sudden failure of charging voltage controlling circuit. ▪ Under voltage, over voltage protections are not provided. ▪ Higher ripple content.	It causes over charging or under charging.	Once in three months, these protections have to be checked.

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Trouble	Cause	Effect	Prevention
Corroded Terminals	▪ Sulphation formed on the terminal posts. ▪ Terminal posts not cleaned properly. ▪ Batteries stored in open place.	▪ Corroded terminals may prevent a battery from delivering sufficient current. ▪ Voltage drops suddenly during discharge	Remove the connectors and clean the terminals with brass brush. After giving connection, apply a thin film of petroleum jelly.
Cracked/ broken jars and covers	▪ Cracks on cover, jar or heat-seal area. ▪ Damaged during transit. ▪ Damaged during unloading. ▪ Damage caused due to mishandling.	▪ A slight crack on cover will effect the recombination efficiency & results in diminishing the capacity of the cell. ▪ Cracks at heat seal will result in the gradual discharge of cells. ▪ Cell will become dry.	Cells having this defect should be replaced.

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Trouble	Cause	Effect	Prevention
Sulphation	▪ Both positive and negative plates got sulphated (i.e. forming of Pb SO_4) ▪ Keeping the battery in discharged condition for a long time. ▪ Continuous undercharging.	Gradually capacity of the cell will be running down. Sudden drop in voltage will be observed.	Battery may be put on charge at low rate of current i.e. 3% of the rated cell capacity till the cell voltage reaches 2.15 to 2.20 V.
Grid corrosion	▪ Oxidation of positive grid structure. ▪ Continued higher setting of charging voltage in chargers/rectifiers.	Long continued over-charging cause oxidation of the positive grid structure, decreasing the cross section of grid wires and eventually leading to collapse of the plate.	Adjust the charging voltage as per specification.
Cell reversal	▪ Showing negative voltage when measured across terminals of a cell. ▪ Reversal may be caused by the over discharge of a cell. ▪ Terminal bolts not properly tightened.	Total voltage suddenly drops.	Battery may be put on charge at a low rate of current i.e. 3% of the rated cell capacity till the cell voltage reaches 2.15 to 2.20 V.

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CHAPTER 4

DO’S AND DON’TS

4.1 DO’s

1. Clean the batteries as and when dust accumulates.

2. The terminal bolt connections to be tightened with specified torque.

3. Re-torque the connections once in every six months.

4. Always use a spring washer wherever bolt connections are provided.

5. Keep the batteries away from heat source, sparks, fire etc.

6. Charge the batteries once in every six months if stored for long periods.

7. Note down individual cell voltage readings once in every three months.

8. Always use cell puller to take out the cells.

4.2 DON'Ts

1. Do not tamper with safety valves.
2. Do not over tighten the terminal bolts.
3. Do not allow any metal objects to rest on the battery or to fall across the battery terminals.
4. Do not boost charge the batteries for more than 12 hours.
5. Do not mix batteries of different capacities or different makes.
6. Do not mix conventional/low maintenance batteries with maintenance free VRLA batteries.
7. Do not overcharge battery.
8. Do not undercharge battery.
9. Do not keep batteries in direct sunlight.
10. Do not keep loose connection.
11. Do not keep battery in discharge condition for a long period.
12. Do not add water to VLRA battery.
13. Do not keep cells stored in discharged conditions. If any cell/ cells have been removed, make use of small charger to charge the cell/ cells.

ANNEXURE - A

REQUIREMENT OF CHARGING SYSTEM FOR VRLA CELLS

SR.N	DESCRIPTION	VALUES
1.	Voltage regulation	Set voltage ± 2%
2.	Max. Charging current for boost/normal charging	20% of rated amp hr. current
3.	Voltage/current ripple a. Voltage ripple factor b. current ripple factor	 Less than 2% Less than 2%
4.	Over voltage protection For boost/normal charging	Trip at 2.35 V/cell

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ANNEXURE - B

TOOLS & FACILITIES REQUIRED

At Depots

1. Constant voltage, current limit charger for full bank of 56 cells.
2. Constant voltage, current limit charger for 1 to 6 cells in step of one.
3. Drive to test alternator/RRU.
4. Infra red temperature sensor.
5. Torque wrenches with suitable sockets.
6. Adequate charging/pre-cooling points with 70 sq. mm copper cable.
7. Clamp on meters, multi-meters.
8. Trolleys for carrying batteries.
9. Cell Puller

At Workshops

In addition to the above following is required :

1. Fork lift.
2. Integrated charge/discharge unit regenerative type, suitable for 2.3 volt per cell, 220mp. (max.) charging and 110 Amp. discharging for 1100 Ah battery and with suitable current and voltage setting for 120 Ah battery.
3. Constant voltage, current limit charger for 6 to 12 cells in step of one.

REFERENCES

1. SMI No. RDSO/PE/SMI/TL/0024-2003 (Rev. 0)

2. Specification no. RDSO/PE/SPECC/D/TL/ 0009 - 99 (Rev. 0) with amendment No.1 for VRLA battery.

3. BG ICF Coaching Maintenance Manual issued by IRCAMTECH/ Gwalior

4. Papers presented by the participants during seminar cum workshop on "Maintenance of VRLA batteries for TL & AC Coaches" held at CAMTECH/ Gwalior on 08/08/2003.