

# Automotive Storage Battery - Care Lead-Acid for now :)

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# Overview

Battery - About Me :)

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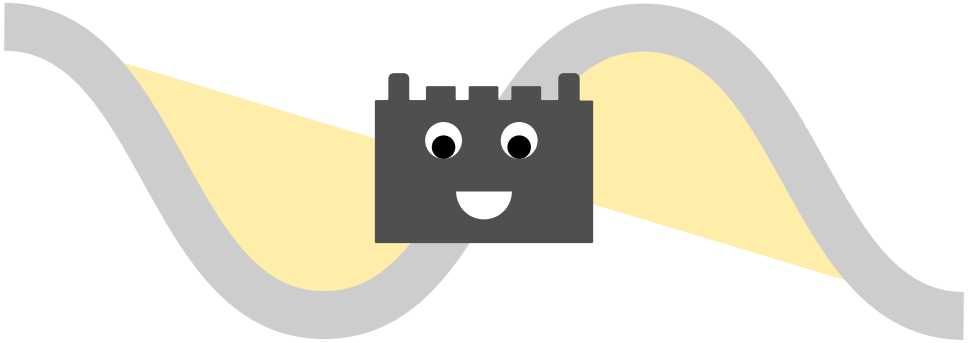
- Fault Tree Analysis

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credits



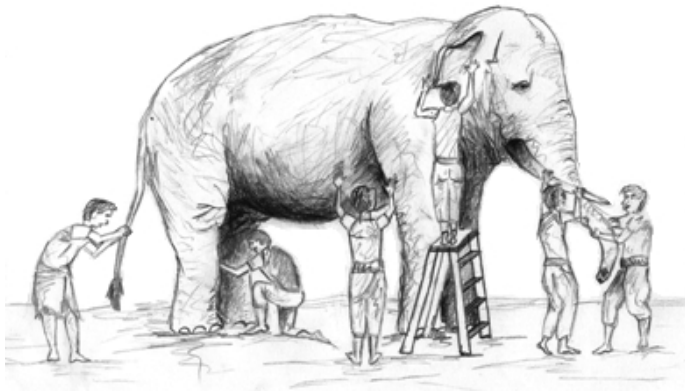
Hi there ! I am your battery

i work for automobiles mostly

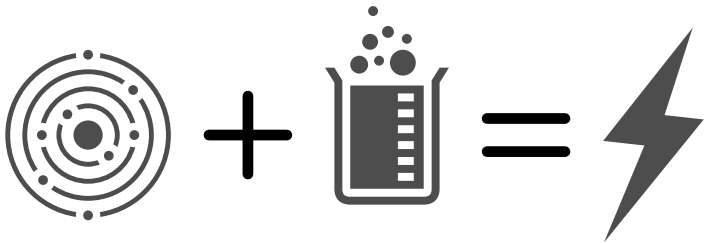


i do work for gadgets nowadays :)

How people view me ?



What am I really ?



# Automobile Electrical system

It constitutes the essentials of a public electricity supply system ...

- - - - -

- ▶ **Generation**  $\equiv$  Dynamo or Alternator
- ▶ **Storage**  $\equiv$  Battery
- ▶ **Utilization**  $\equiv$  Cranking, Ignition, Starting, lighting, etc...

# Battery

## Use:

- ▶ Battery serves to store electrical energy when there is little demand of current
- ▶ Acts as Standby Source



## Calibre:

- ▶ Robust Construction
- ▶ Must withstand severe Vibration
- ▶ Must withstand high charging rates & heavy discharge currents

## Fact:

- ▶ Not always in accessible location
- ▶ Not given proper attention

Hence, forms the **Weak Link** of the Automobile Electrical System



# Principle of Operation

Underlying Principle: **Electrolysis**

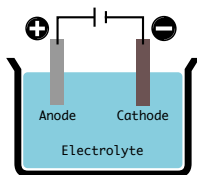
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## Constituents:

- ▶ **Electrodes:** Two dissimilar metals.
- ▶ **Electrolyte:** Chemical that causes greater chemical change in one of the electrode than in other.

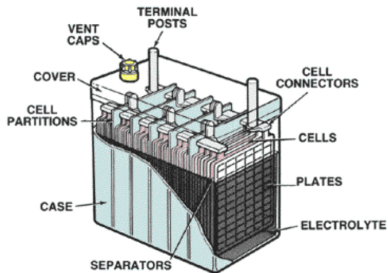
## Result:

- ▶ Difference in chemical action  $\propto$  Electrical pressure (*a Voltaic Cell*)
- ▶ Electrical Pressure  $\equiv$  Electromotive Force
- ▶ Since the Chemical reaction is reversible, it is a Secondary cell.



# Construction of Automobile Battery

A typical automotive battery consists of the following parts:



- ▶ Plates
- ▶ Separators
- ▶ Electrolyte
- ▶ Cell connectors
- ▶ Vent plug
- ▶ Cover & Jar
- ▶ Battery Case

Automotive battery plates are formed using **Faure Process**

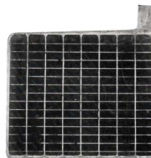
## Grid:

- ▶ A grid is initially made using Lead & Antimony.
  - ▶ Mechanical support for the active material.
  - ▶ Enabling the Current Conduction.
- ▶ **Positive Plate** : Grid is pasted with mix of Red Pb & other chemicals pasting, with dilute  $H_2SO_4$
- ▶ **Negative Plate** : Grid is pasted with mix of Litharge & other chemicals pasting, with dilute  $H_2SO_4$

# Plates ...



**Grid**



**Plate**



**+ve Plates**



**-ve Plates**

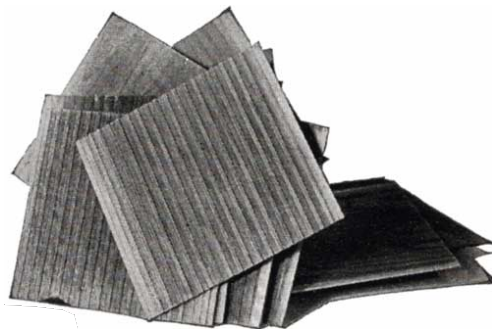


**Plates  
ready  
to form a  
cell**

# Separators

## Functionality:

- ▶ They are the insulators that prevent short circuiting between +ve & -ve plates.
- ▶ They also ease the diffusion of electrolyte in the cell. It is made of PVC or Glass wool.

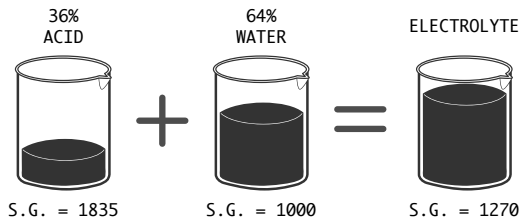


# Electrolyte

Battery electrolyte is a mixture of 36%  $H_2SO_4$  and 64% distilled water  $H_2O$ .

Today batteries have an electrolyte with a Specific gravity of 1270, when fully charged @ 20°C.

**Specific Gravity:** It is the weight of a given volume of liquid in comparison to the weight of the same volume of water. The higher the specific gravity of a liquid the denser(thicker) it is. It means *exact weight*.

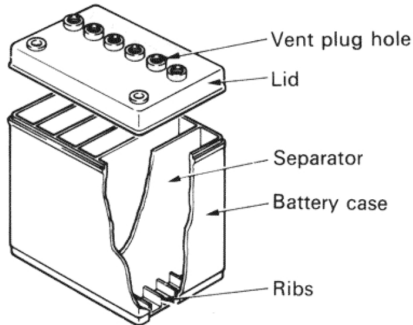


- ▶ Sulphuric Acid ( $H_2SO_4$ ) is used as the electrolyte for automotive batteries.
- ▶ ( $H_2SO_4$ ) **Specific Gravity** ranging from 1220 to 1280 is employed.
- ▶ Its concentration decides the chemical action in the cell.

# Battery Case

Battery case holds the electrolyte and the individual battery cells.

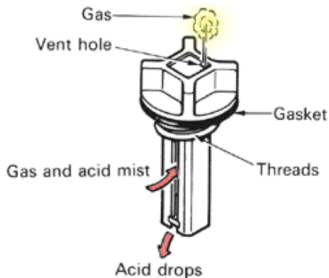
- ▶ The plates are raised up off the bottom of the case with ribs to prevent them from shorting out if any of the active materials (lead, etc.) should happen to fall from the plates.
- ▶ Usually made of polypropylene, hard rubber, plastic base materials.
- ▶ Translucent plastic cases allow checking electrolyte level without removing the vent caps - usually marked with upper & lower electrolyte level.



# Vent Plugs

Vent plugs primarily cover the holes that are used for adding electrolyte.

- ▶ Designed to separate the  $H_2SO_4$  mist & the  $H_2$  gas that forms when the battery charges.
- ▶ Condenses  $H_2SO_4$  mist and drop back into the battery, allowing  $H_2$  gas to escape through the vent holes to the atmosphere.
- ▶ Translucent plastic cases allow checking electrolyte level without removing the vent caps - usually marked with upper & lower electrolyte level.





## Cell Connectors:

- ▶ They provide electrical connection between the Cells of the battery.
- ▶ After assembling the cells in the case, they are burned to the strap posts.

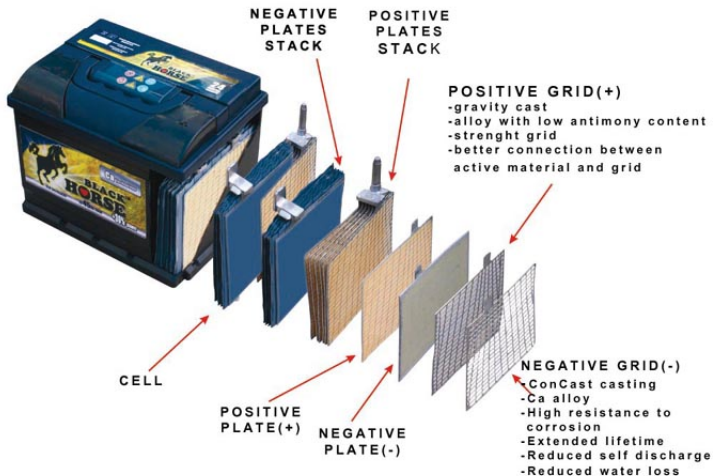
## Battery Terminal:

- ▶ Helps forming a connection to the automobile electrical circuit.
- ▶ Cables could be detachable using bolts or directly soldered to the terminal.

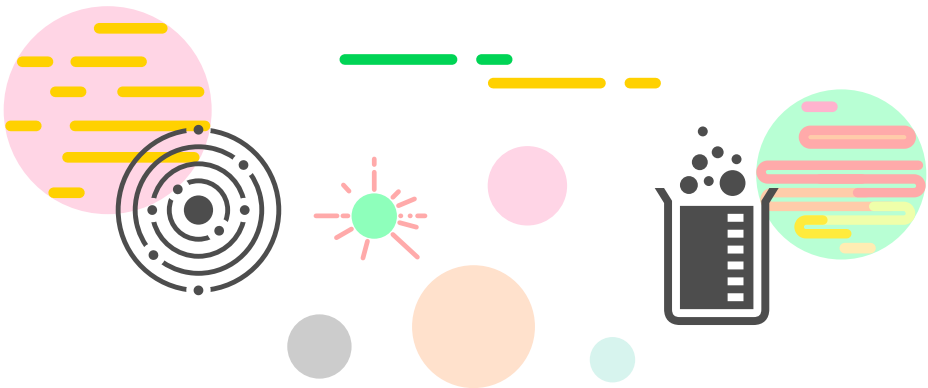
## Battery Cover & Jars:

- ▶ Cover facilitates the escape of gas during charge.
- ▶ Cover provides space for expansion of electrolyte when heated.

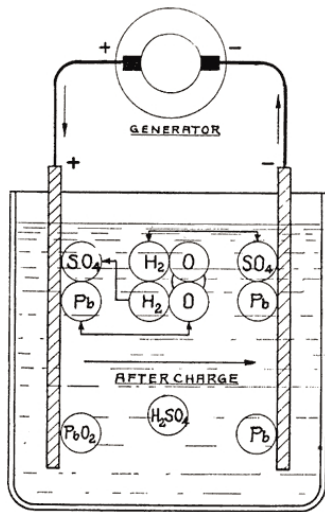
# Exploded View Example ...



# Chemical Action

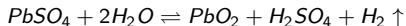


# Chemical Action During Charge



# Chemical Action During Charge ...

**At +Ve Plate:**



**At -Ve Plate:**

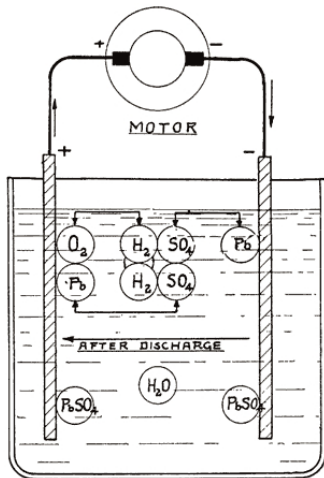


**Entire Charging Action:**



On continuous charging  $H_2$  and  $O_2$  rise to the surface of the electrolyte and escape from the cell. This is defined as **gassing**, which is an indication of the cell is fully charged. **During Charge, acid is driven out of the plates.**

# Chemical Action During Discharge

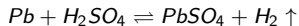


# Chemical Action During Discharge ...

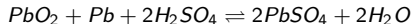
**At +Ve Plate:**



**At -Ve Plate:**

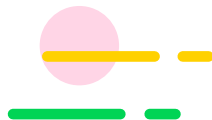
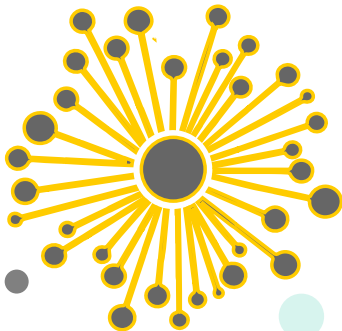
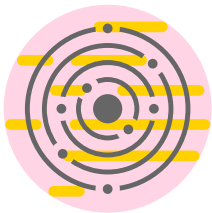


**Entire Charging Action:**



Chemically discharging consists of changing the spongy lead and lead peroxide into lead sulphate and the abstraction of the acid from the electrolyte. **During discharge the acid goes into the plates.**

# Electrical Action



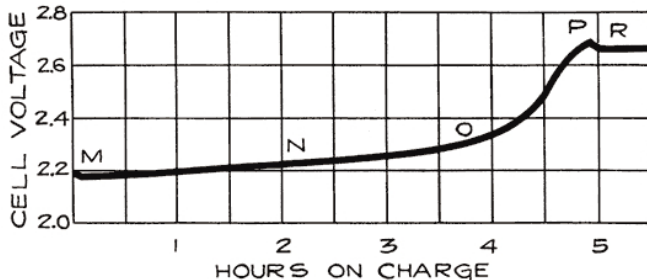


# Interaction

Considered electrically, the changes are more complex. The following parameters and interaction between them must be considered:

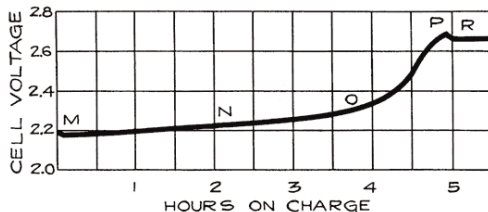
- ▶ Voltage
- ▶ Internal resistance
- ▶ Rate of discharge
- ▶ Capacity

# Electrical Action During Charge



Voltage rises rapidly for a fraction of the first minute of the charge, & drops rapidly to a normal value and thereafter begins to raise steadily to the end of the charge.

# Process...

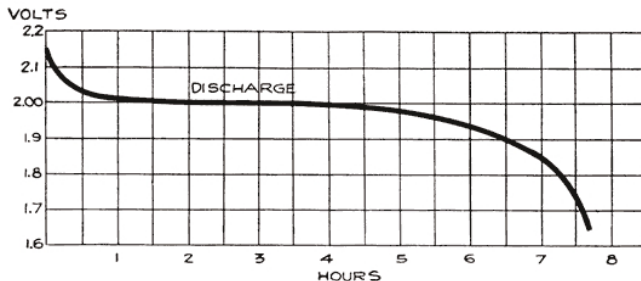


- ▶ At point **O** the voltage begins to rise very rapidly due to the  $PbSO_4$  in the plate decreasing. Bubbles of gas rises throughout the electrolyte.
- ▶ At point **P** the last portion of  $PbSO_4$  are removed and acid is no longer formed.  $H_2$  &  $O_2$  gases are formed rapidly.
- ▶ Voltage becomes constant at **R**  $\approx 15$  to 16 Volts.

# Density

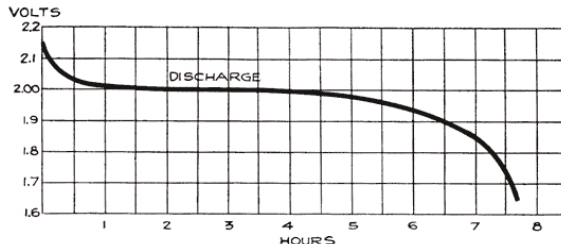
Progress of the Charge is generally determined the density/Specific Gravity of the electrolyte in the range 1220 to 1280 measured at 23°C.

# Electrical Action During Discharge



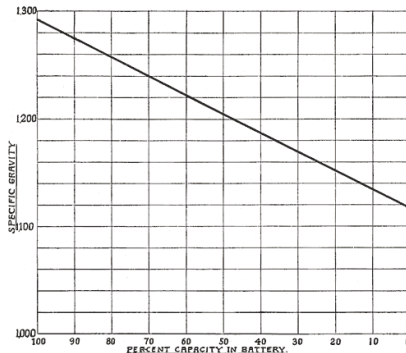
As soon as charging circuit is opened the cell voltage drops rapidly to about 2.1V, within 3 or 4 minutes due to the formation of thick layer of  $PbSO_4$  on the surface of -Ve plate & between lead peroxide and the metal of the +Ve plate.

# Process...



- ▶ When current is being drawn from the battery the sudden drop is due to the **internal resistance of the cell**, formation of more sulphate and the abstraction of the acid from the electrolyte which fills the pores of the plate.
- ▶ The limiting value of 1.75V/cell applies to a continuous discharge at a moderate rate. During cranking it may be permitted to a lesser voltage.
- ▶ Voltage does not depend upon the area of the plate surface but upon the nature of active material and electrolyte.

# Density



The discharge process may be continued upto a Specific Gravity of 1.150 at normal temperature due to the fact that further discharge will reduce the life of the battery and battery capacity cannot be expected below 1.150 as shown above.

# Capacity of automotive battery

## What is it ?

- ▶ Capacity is the product of Current( $I$ ) drawn from the battery & no. of Hours( $T$ ) the current flows, measured in **Ampere Hour**.
- ▶ Leading health indicator of a battery.

## Limit:

- ▶ In practice we do not discharge the battery to a voltage less than 1.75V/cell, except when the rate of discharge is high, like during cranking.

## So ?

- ▶ Thus capacity is measured by the no. of hours it can furnish before its voltage drops below 1.75V/cell.



# Capacity Ratings

**What is it ?:** Several Battery capacity ratings have been established by Battery Council International (BCI) that helps to determine the current capacity of a battery. It is an indication of battery's ability to develop and deliver high amperage current to the starter and provide reserve power to the electrical system.

- ▶ **Cold Cranking Amps (CCA) rating:** Indicates the ability to deliver specified current @ low temperatures - of a fully charged battery for 30 sec. @ 0degF (-17.8°C) with terminal voltage not less than 7.2V.
- ▶ **Cranking Amps (CA) rating:** Indicates the ability to deliver a cranking current at 32degF.
- ▶ **Reserve Capacity rating:** It is the time in minutes a vehicle can be driven **after the charging system fails**. It is the length of time a fully charged battery can supply 25A, before the terminal voltage falls below 10.5V @ 26.7°C.
- ▶ **Ampere Hour rating:** It is the amount of current a fully charged battery could supply for 20 hrs. without having the terminal voltage below 10.5V, @ 26.7°C.

# Capacity Factors ...

## **Based on Design & Construction:**

- ▶ Area of plate surface.
- ▶ Quantity, arrangement & porosity of active material.
- ▶ Quantity & Strength of electrolyte.
- ▶ Circulation of electrolyte.

## **Based on Conditions of Operation:**

- ▶ Rate of discharge
- ▶ Temperature

# Internal Resistance of automotive battery

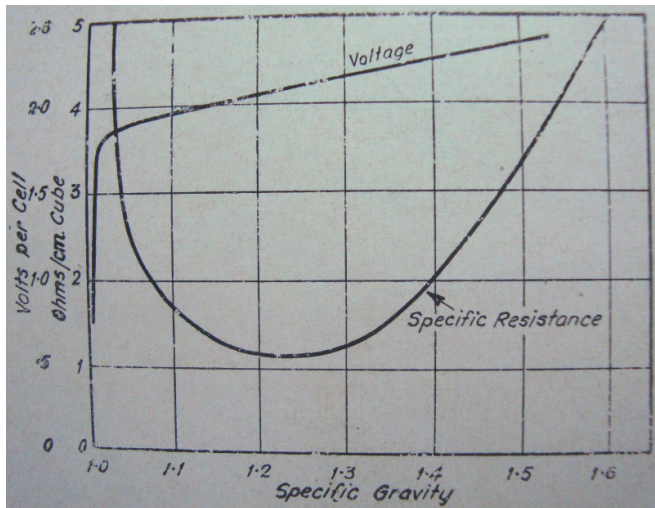
## What is it ?

- ▶ Resistance offered by the battery to the flow of the current through it results in a loss of voltage & heating. Usually it is measured about  $0.05\Omega$ , between the terminals of the cell/battery.

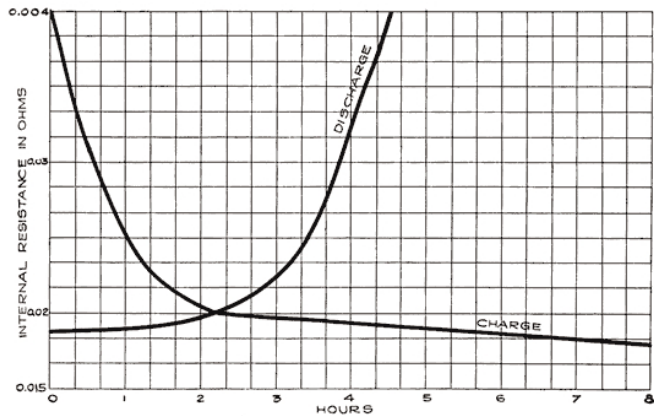
## Why is it there ?

- ▶ Due to grids including terminals, connecting links & framework upon which active materials are pasted, that vary as the temperature of the grid varies.
- ▶ Electrolyte - main cause of internal resistance, can be reduced to optimum value by maintaining the Specific Gravity of 1150 to 1280.
- ▶ Active material - includes its own resistance & electrolyte in the pores of the active material that varies during charging and discharging.

# Internal Resistance & Specific Gravity of Electrolyte



# Internal Resistance during Charging & Discharging





# Battery Caring



# Battery Care in Vehicles

## In General:

- ▶ Keep interior of battery box clean & dry.
- ▶ Put nothing but battery in battery box.
- ▶ Keep battery clean and dry to avoid leakage of current.
- ▶ Firm fixation.
- ▶ Sufficient slack in cables connected to the battery.
- ▶ Inspect the battery twice a month in winter & every week in summer.



# Battery Care in Vehicles ...

## Specific Gravity:

- ▶ Specific Gravity (Sp.gr.) of the electrolyte measured periodically are recorded permanently for future reference.
- ▶ Electrolyte must not spill over while testing the electrolyte.
- ▶ Electrolyte must be returned to same cell during testing.
- ▶ Sp.gr. of all cells should rise and fall together.
- ▶ If Sp.gr of one cell is lower than the other cells in series, it has internal trouble(may be short circuit).
- ▶ If entire battery shows a Sp.gr below 1200, then the battery is not receiving enough charge.

## During Idle/Not in Use:

- ▶ Filled with distilled water & given a complete charge.
- ▶ After every 6 to 8 weeks, battery is given a freshening charge without rising the temperature.

# Troubles



# What are the Troubles ?

When there is slackness in caring the battery, it becomes subjective to a number of ***preventable*** diseases that leads to inefficiency.

- - - - -

Most battery diseases are contagious and if one part fails,  
eventually other related parts also affected.

## Major troubles are with:

- ▶ Plates
- ▶ Separators
- ▶ Jars
- ▶ Container
- ▶ Cell connectors & Terminals
- ▶ Electrolyte

# Plate Troubles

Plates are the ***vitals*** of the battery that affect life of the battery than other parts.

They are also very difficult to diagnose the troubles associated.

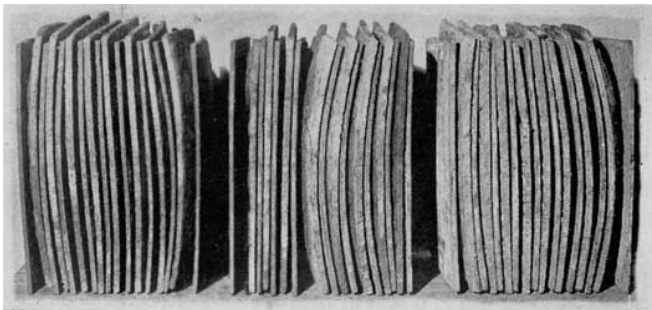
**Sulphation:** Formation of lead sulphate ( $PbSO_4$ ) on plates.

- ▶ Over discharge
- ▶ Keeping idle
- ▶ Starvation
- ▶ Electrolyte below the top of plates
- ▶ Impurities
- ▶ Adding acid instead of distilled water
- ▶ Over heating



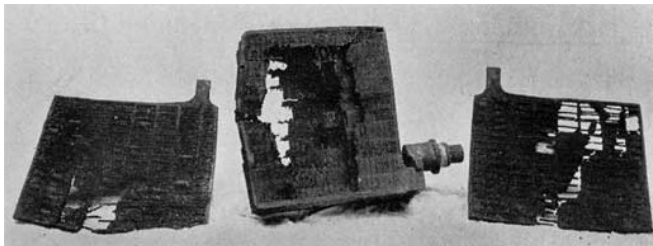
**Buckling:** Bending & Twisting of plates due to unequal expansion of different parts of the plates due to:

- ▶ Over discharge
- ▶ Continued operation in discharged condition
- ▶ Charging at high rates
- ▶ Non-Uniform distribution of currents over the plates
- ▶ Defective grid alloy



**Shedding/Loss of Active Material:** Loosening of lead peroxide of +ve plate which reduces the capacity of the plates due to:

- ▶ Normal Shedding
- ▶ Over charging/Excessive charging rate
- ▶ Charging sulphated plates at too high rate
- ▶ Charging only **part** of the plate
- ▶ Freezing



**Loose Active Material:** Active material are no longer in contact with the grid, may be one of the cause of chemical action on grids shifted from active material to the grid itself, due to:

- ▶ Over discharge
- ▶ Buckling

**Impurities:**

- ▶ That attack the plates due to the acids other than  $H_2SO_4$  which dissolve the lead grids – disintegrating plates into pieces.
- ▶ That do not attack grid/separators, but cause internal self discharge due to methods other than lead causing hydrogen bubbles giving electrolyte a milky appearance.

**Corroded grids:** Thin, weak & corroded due to the chemical action of electrolyte over the grid

- ▶ Impurities other than  $H_2SO_4$
- ▶ High temperature
- ▶ Aging



# Separator Troubles

Separators are the weakest part, performing important duty for the battery.

Troubles are:

- ▶ Not properly expanded before installation.
- ▶ Improper inspection (cracked separator).
- ▶ **Treeing** between plates, causing short circuit.
- ▶ Improperly treated separators will cause battery to show low voltage at high rates of discharge, particularly in cold weather.
- ▶ Rotted/Carbonized, due to overage, over heating or high gravity electrolyte.
- ▶ Pores clogged due to dust, impurities from impure water &  $PbSO_4$ .
- ▶ Edges chiseled off – buckling plate cut through lower edges of separator.

# Container Troubles

Eventhough modern day batteries are made with polypropylene/high grade components, to reduce the weight, still troubles occur due to:

- ▶ Rough handling.
- ▶ Battery not properly fitted.
- ▶ Any weight placed on top of the battery.
- ▶ Freezing.
- ▶ Defective Jars.
- ▶ Expansion in cell.

# Cell Connectors & Terminal Troubles

This is a common trouble which should be guarded very carefully.

**Corrosion:** Indicated by the presence of greenish substance on the battery terminals (especially +ve) due to:

- ▶ Too much water added to cells.
- ▶ Battery not fastened firmly.
- ▶ Battery poorly sealed.
- ▶ Vent cap loose.
- ▶ Electrolyte spilled on top of cover while measuring Sp.gr.
- ▶ Battery cables damaged or loose.
- ▶ Attaching bare wires on battery terminals.
- ▶ Loose connections in the terminals.

# Electrolyte Troubles

- ▶ Low gravity due to addition of distilled water.
- ▶ High gravity due to addition of acid instead of distilled water.
- ▶ Low level due to improper topup maintenance of battery.
- ▶ No rise in Sp.gr. due to plates not taking full charge or water is used to replace the spilled electrolyte.
- ▶ **Stratification** of electrolyte due to starvation of charge.
- ▶ **Milky electrolyte:** mixing of  $PbSO_4$  in battery acid or gassing or impurities.

# Other General Troubles ...

## **Open Circuit:**

- ▶ Poor burning of connectors to posts.
- ▶ Terminals broken off.
- ▶ Acid on soldered joints.
- ▶ Defective posts.
- ▶ Plates improperly burned.

## **Battery Discharged:**

- ▶ Due to excessive use of starting motor.
- ▶ Failure of generator.
- ▶ Defective switches.
- ▶ Defective regulator.
- ▶ Addition of accessories or use of too large lamps.
- ▶ Defective wiring.
- ▶ Insufficient charging rates.
- ▶ Batteries allowed to remain idle.

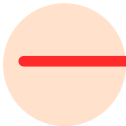
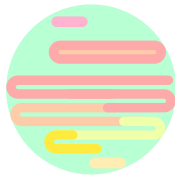
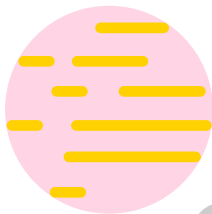
### **Dead cells:**

- ▶ Worn out separators.
- ▶ Foreign material.
- ▶ Accumulation of sediments.
- ▶ Badly sulphated plates & separators.
- ▶ Impurities which attack the plates.

### **Loss of capacity:**

- ▶ Impurities in the electrolyte.
- ▶ Sulphation.
- ▶ Loose active material.
- ▶ Incorrect Sp.gr. of electrolyte.
- ▶ Separators clogged.
- ▶ Shedding.
- ▶ Low level of electrolyte.
- ▶ Reversal of plates.
- ▶ Effect of age.

# Analysis of Degradation



# Analysis Tools:

Tools such as **causal tree and fault tree analysis** offer an inductive & deductive analysis to evaluate safety & reliability of a complex system such as lead acid battery.

The analysis of the causality chain of lead-acid battery is based on two stages:

- ▶ 1st stage interested in development of causal tree presenting possible combination of events generated by **physicochemical** phenomena.
- ▶ 2nd stage completes causality chain with fault tree analysis(FTA) with **electrical equivalent circuit** & experimental determination of **parameters** in the circuit, according to each mode of degradation.



# What Causes Degradation ?

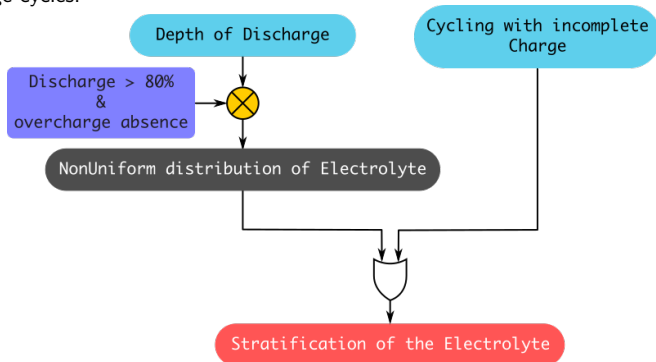
The aging mechanisms of batteries are the actual chemical & mechanical events that cause its degradation, depending on the condition which it is operated. All the types of lead acid batteries suffer from same damage mechanisms but with different degrees.

## Major aging process are:

- ▶ Stratification of electrolyte.
- ▶ Sulfating of the electrodes.
- ▶ Corrosion of the electrodes.
- ▶ Non cohesion of the active mass.

# Causality - Stratification of Electrolyte

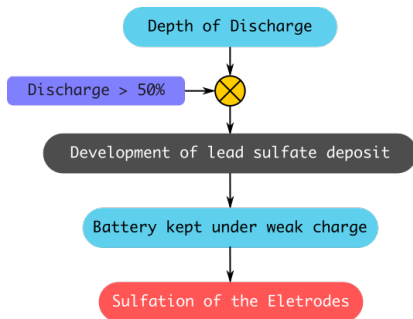
Battery tends to stratify if it did not receive a complete charge or kept under weak charge. With such conditions, distribution of electrolyte is not uniform with charge & discharge cycles.



The ions heavier than water tend to accumulate at the bottom of the battery, creating a **stratification of electrolyte**. Leads to reduced battery capacity by concentrating chemical reaction to specific parts of electrodes.

# Causality - Sulfating of Electrodes

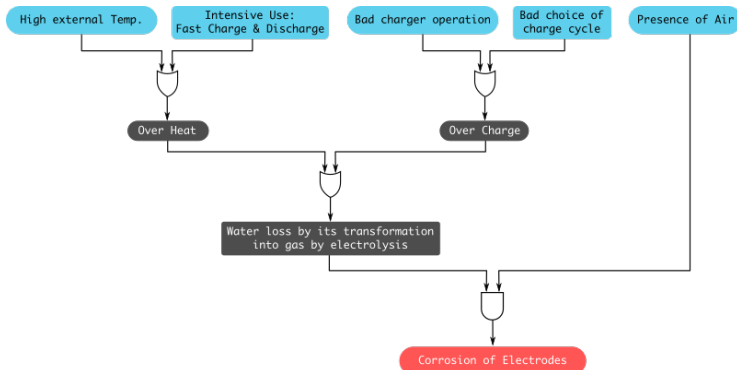
When battery is discharged, sulfate crystals are formed at both the electrodes. When charged, the sulfate crystals dissolve and form  $PbO_2$  &  $Pb$  respectively on +ve and -ve electrode respectively. If left at a low state of charge for longer period of time, sulfate crystals do not dissolve easily when charged. This leads to hard or irreversible **sulfating**.



It creates an insulating layer that slows down the diffusion of the acid. Thus it is recommended not to discharge below 50% and recharge back to 100%.

# Causality - Corrosion of Electrodes

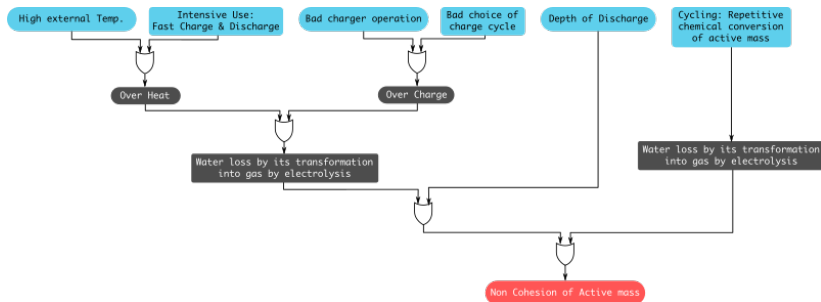
Battery voltage, acid concentration and temperature are the three main factors that drive corrosion. Generally high voltage and increased concentration of acid increases the rate of corrosion dramatically. Corrosion process is proportionately faster with rise in temperature.



As part of grid corrodes, active mass has reduced the electrical connection to the terminals. Because of increase in corrosion layer, reduced conductivity, reduced cross section of grid, internal resistance increases reducing the available capacity.

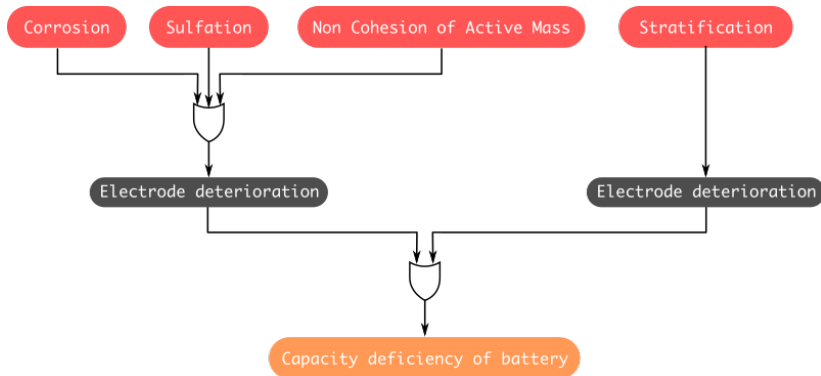
# Causality - Non Cohesion of Active Mass

Non cohesion of active material is usually caused by shedding. Enough shedded material at the bottom of the jar can cause an electrical short.



Gassing bubbles due to overcharging can also cause shedding. Depth of discharge and repetitive chemical transformation during charge & discharge are responsible for non cohesion. Over time active mass on battery plates, degrades, changes structure - losing some of electric transfer properties, reducing the capacity.

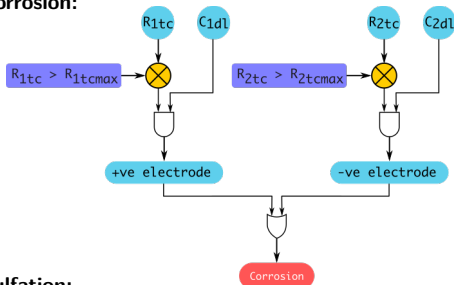
# Overall Causality - Loss of Capacity



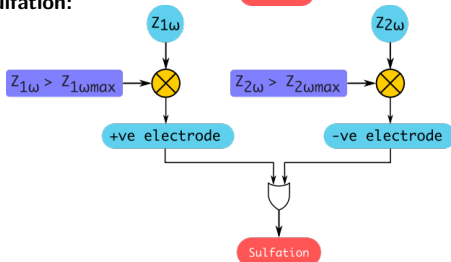
# Fault Tree - from electrical equivalent

► Goto Electrical Equivalent

## Fault tracing in Corrosion:

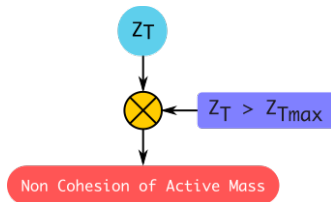


## Fault tracing in Sulfation:

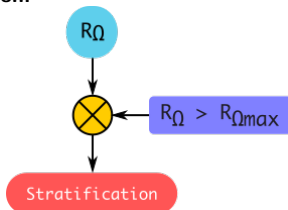


# Fault Tree - from electrical equivalent ...

Fault tracing in Non cohesion of active mass:

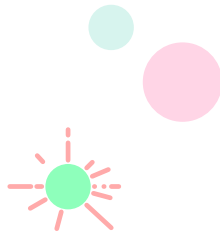
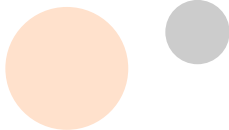
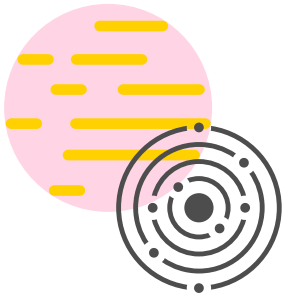


Fault tracing in Stratification:





# Instructions



# Kind of Charging

- ▶ Initial Filling & Charging:
  - ▶ @ 5% of Ah for 48hrs.
  - ▶ without rise in temperature.
  - ▶ final consistent Voltage and Sp.Gr. for 5hrs without heavy gassing.
- ▶ Bench Charging:
  - ▶ @ 7.5% of Ah.
  - ▶ rating is reduced when battery is heavily sulfated.
- ▶ Trickle Charging
- ▶ Regular Charging:
  - ▶ for farm lighting or inverter batteries.
  - ▶ to meet lighting and other demands.
- ▶ Over Charging:
  - ▶ extension of regular charging.
  - ▶ once a month to prevent inequalities in cells.
- ▶ Partial or Rapid Charging:
  - ▶ for farm lighting or inverter batteries, when there is not enough time for regular charging.
  - ▶ @ double the charging rate until all cells are gassing, then reduce to normal rate.

# Rating & Time for Charging

## Rating:

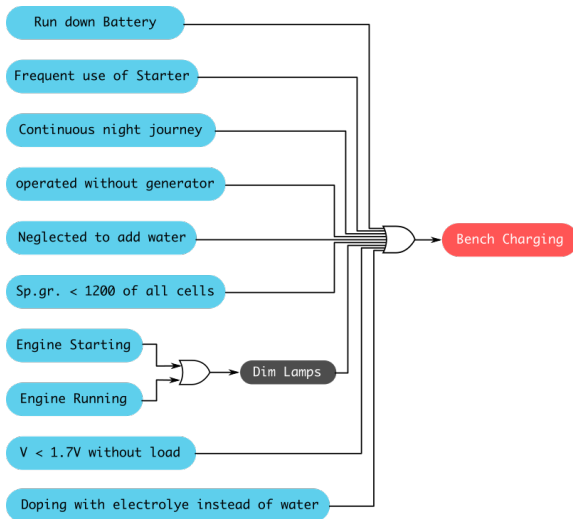
- ▶ As long as excessive temp. & too early gassing are avoided, any rate upto 7.5% of Ah can be used.
- ▶ Temperature and Gassing must be watched carefully during charging.
- ▶ As a general rule, do not use rate higher than 10A, 5A is better (but takes more time).
- ▶ For heavily sulfated battery, less than 5A for days together would comeup.

## Timing:

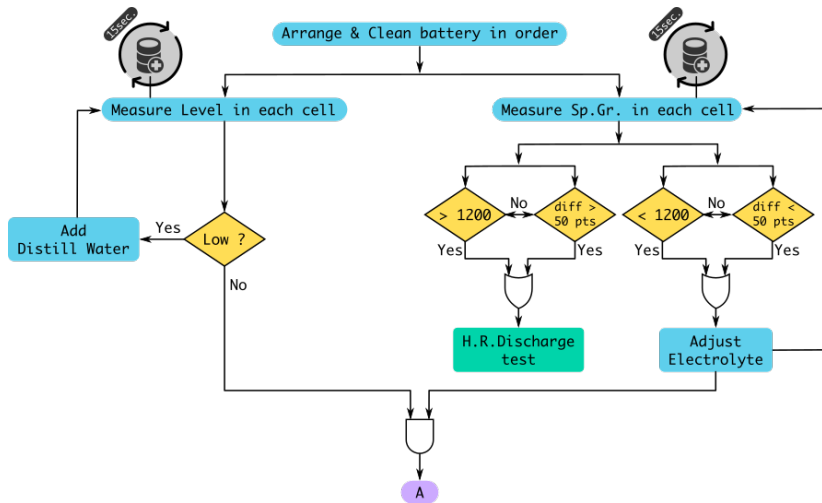
- ▶ It is not determined by clock, but by cells, plates, electrolyte ...
- ▶ Continue charging until each cell is gassing freely (not violently), for 5hrs. after Sp.Gr. has stopped rising, with constant voltage.
- ▶ Charging depends upon the conditions of the battery.

# When to Bench Charge ?

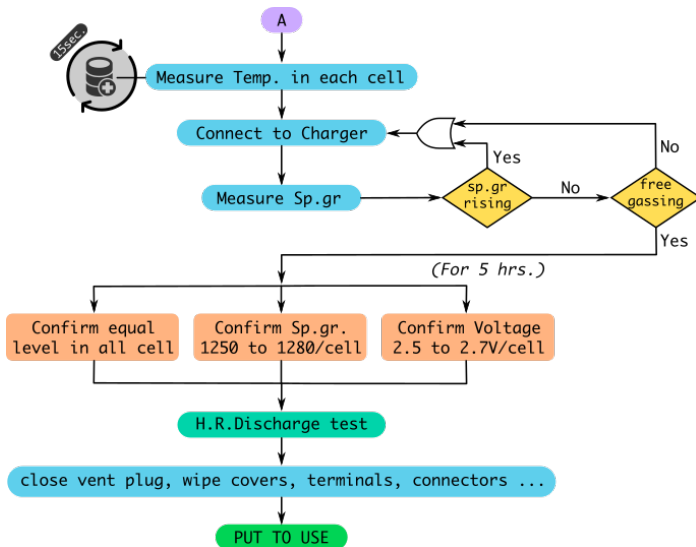
## Conditions for Bench Charging:



# How to Bench Charge ?



# How to Bench Charge ? ...



# Troubles while Bench Charging ...

- ▶ Battery kept long time in discharging condition.
- ▶ Neglected to add water.
- ▶ Battery overheated by excessive charging rate.
- ▶ Shedded sediments causing short circuit of plates.
- ▶ Impurities attacking the plates and changes active materials to other substances.
- ▶ Separators may be clogged.
- ▶ Spongy lead may be bulged.
- ▶ Positive plates may be buckled.
- ▶ Sp.Gr. will not rise because of sediments - not enough to schort circuit.
- ▶ Sp.Gr. will not rise when impurities are added.
- ▶ Sp.Gr. will not rise when spilled electrolyte is replaced with water.
- ▶ Sp.Gr. will not rise when too much water is added.
- ▶ Battery will not hold charge due to impurities(ex: impure water).
- ▶ Battery will not hold charge due to shlow short circuit because of defective separators or excessive sediments.

# Probable Cause

- ▶ **IF** : Sp.Gr. not raising to 1280  
**THEN** : make cadminum test; ascertain condition of plates
- ▶ **IF** : one cell fails to charge  
**CAUSE** : may be due to internal defect
- ▶ **IF** : cells not take half a charge  
**THEN** : battery is defective
- ▶ **IF** : Sp.Gr. is  $> 1280$   
**CAUSE** : doping of electrolyte  
**THEN** : refill with distilled water; charge for 10hrs twice; Fill back with 1250 Sp.Gr.
- ▶ **IF** : Hot on normal charging  
**CAUSE** : badly sulfated; has partial short circuit
- ▶ **IF** : electrolyte is milky white  
**CAUSE** : presence of impurities



# Battery Tests



# Tests conducted on Batteries

**Lighting ability Discharge test / CAPACITY TEST:** Continuing for 5hrs. to a final voltage of 1.75V/cell, after charging for 24hrs. the battery discharges to 20% of its capacity - while readings are measured at 30min. interval.

**Starting ability Discharge test / HIGH RATE DISCHARGE TEST:** After 24hrs. of fully charging in cold bath at  $-15^{\circ}\text{C}$ , battery is discharged as per standard of 30sec. To reach 9.1V and extends upto 6V of battery voltage at intervals of 5sec or 10sec. (@ 30sec. 9.1V is passed OK).

**Cycling Discharge test:** New batteries are cyclically charged and discharged at the normal rates to come up the battery.

**Backup test:** Conducted for inverter batteries after checking voltage, Sp.Gr. in each cell. Discharging at 200W or 400W as per standard of 13.2V for 100Ah or 150Ah for 2hrs.

**Life Cycle test:** For all batteries (automotive/inverter) for 400 cycles 5hrs. charge at normal charging and 1hr discharge at 20A. For every 25 cycles batteries should be charged fully and capacity test to be conducted.

**Torque test:** For automobile battery upto 400 cycles, 1.15hrs charge at 20A and 15min discharge at 80A. For every 50cycles battery fully charged and the capacity test to be conducted.

# General Tests

**General Inspection:** Helps in deciding what must be done.

- ▶ Is battery loose ?
- ▶ Are cables loose ?
- ▶ Is there corrosion at terminals ?
- ▶ Is top of battery wet ?
- ▶ Is top of case acid soaked ?
- ▶ Is lower part of case acid soaked ?
- ▶ Are ends of case bulged out ? - may be due to battery having been frozen.

**Operation Tests:** Turn on the lights & continue

- ▶ If its dim : then battery is run down or defective, may be put to bench charge.
- ▶ With lights burning and started switch to be closed, – if the light is very dim, the battery is run down or may be defective.

## Questioning the Driver/Battery man:

- ▶ Has water been added regularly ?
- ▶ Has impure water or river water ever been added to battery ?
- ▶ Has too much water been added ?
- ▶ Has electrolyte replaced by water ?
- ▶ Has battery been idle or stored without regular charging ?
- ▶ Is the vehicle operated at night than in day ?
- ▶ Is starter used frequently ?
- ▶ What is the average driving speed ?
- ▶ How long engine is usually cranked before starting ? (must not exceed 10 seconds).

# General Remedy

ALL CELLS SHOW LOW GRAVITY OR LOW VOLTAGE		
<i>Reason</i>	<i>Problem</i>	<i>Remedy</i>
Loose/Dirty terminals	Reduced charging rate or open charging circuit	Tighten & clean connections
Corrosion on terminals	Reduced charging rate or open charging circuit	Clean corroded parts & vaseline coated
Broken terminals	Reduced charging rate or open charging circuit	Replace new terminals
Generator not charging	–	Replace the alternator
Charging rate too low	–	Replace the alternator
Acid/moisture on top of battery	Causes corrosion and current leakage	Remove the things
Short circuits in wiring	–	Repair wiring

# General Remedy ...

GRAVITY READINGS UNEQUAL		
<i>Reason</i>	<i>Problem</i>	<i>Remedy</i>
Acid/moisture on top of battery	Causes current leakage	Remove cause
Tools/wires on battery	Causing short circuits	Remove things
Electrolyte or acid added to cells	—	—
Electrolyte spilled and replaced by water	—	
Grooved side of separators placed against negatives	—	
Cracked/leftout Separators	—	
Old plates used in some cells and new in others	—	—
Impurities in cells	Low Gravity	—
Shorted Cell	—	—
Cracked Jar	—	—

# Care to be taken by Electrician

- ▶ Alternator must be checked frequently for output. Worn out bearings, carbon brushes must be replaced.
- ▶ Fan belt checkup and to be replaced on scheduled manner.
- ▶ Fan belt tension must be checked in frequent intervals.
- ▶ After fan belt replacement or end routes breakdown or alternator breakdown - a bench charge is advisable.
- ▶ If fault is ascertained with starter - would run down the battery - replace immediately.
- ▶ Damaged braided copper strip may be replaced.
- ▶ It is advisable that whenever FC or half FC all connections should be checked and replaced when required.
- ▶ Whenever starter or alternator received for reconditioning, essentials like bearings, carbon brushes must be replaced without fail.
- ▶ A perfect record of topup, bench charging and replacement of alternator or starter should be maintained for each vehicle.
- ▶ Whenever the vehicle is kept idle for more than 2 days, the battery may be charged in bench.
- ▶ It is best practice to make bench charging every 6 months.

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# Thank you !