

# UNIT-1 BATTERIES

## Battery:

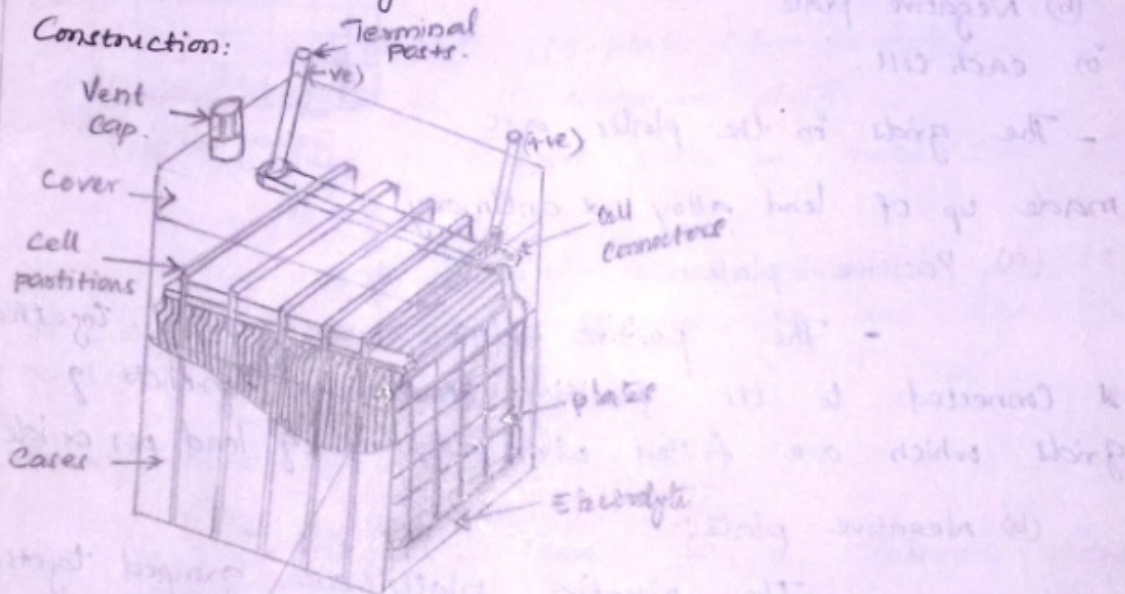
- Primary source of electrical energy on vehicles.
- Stores chemicals, not electricity

## Types:

- \* Lead Acid battery
- \* Nickel alkaline battery

## Lead Acid Battery:

### Construction:



### (i) Case

- holds & protects all battery components & electrolyte, separates cells, & provides space at the bottom for sediment (active materials washed off plates).

- Cases/containers are made of bituminous / hard rubber materials.



Battery Case/container

(ii) Covers:

- Permanently sealed to the top of the case.
- provides outlets for terminal posts, vent holes for venting of gases & for battery maintenance (checking electrolyte, adding water).

(iii) Plates:

- There are two types of plates,

(a) positive plate

(b) Negative plate

in each cell.

- The grids in the plates are

made up of lead alloy & antimony.

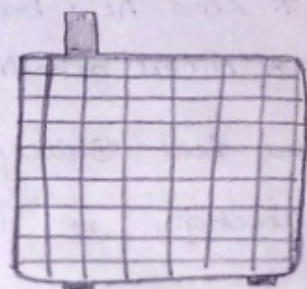
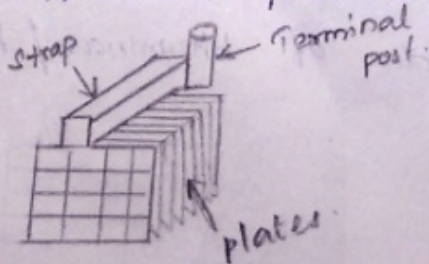
(a) Positive plate:

- The positive plates are grouped together & connected to the positive terminal consists of grids which are filled with a paste of lead per oxide ( $PbO_2$ )

(b) Negative plate:

- The negative plates are grouped together & connected to the negative terminal consists of grids which are filled with metallic <sup>spongy</sup> lead. (Pb)

- Each group of plates held together by post strap, to which individual plates are welded.



Battery plate grid.

## Charging:

- The chemical reaction is reversed & the specific gravity of the electrolyte rises.

- Battery is never discharged beyond a certain point because of the following reasons.

\* Lead Sulphate ( $PbSO_4$ ) occupies greater volume than lead peroxide ( $PbO_2$ ). and hence excessive sulphation is liable to set up mechanical stresses in the +ve plate, thereby causing shedding of active materials & cracking of plates.

\* Excessive sulphation doesn't permit the sulphate to get reconverted fully back to the active material during charging.

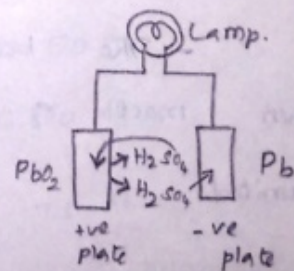
## Chemical Action in Cell.

- The active materials ( $PbO_2$ ) & that of the negative plate ( $Pb$ )

- The ~~is~~ sulphuric acid in the electrolyte ( $H_2SO_4$ )

- when a battery is being discharged, chemical reaction starts. The sulphuric <sup>acid</sup> molecules splits up into  $H_2$  &  $SO_4$

- One  $SO_4$  unites with the  $Pb$  of positive plate forming ( $PbSO_4$ ) while the other unites with the  $Pb$  of -ve plate



- Positive terminal is identified by a +ve sign or red colour. Some times the +ve terminal is larger than the -ve terminal.

#### (iv) Cells:

- An assembly of connected positive and negative plates with separators in between is called a cell/element.

\* 6V Battery - 3 cells (2V each)

\* 12V Battery - 6 cells (2V each).

- Battery cells are connected in series

When the cells are immersed in electrolyte, voltage of about 2.1 volts were produced.

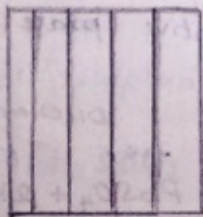
- Cells may contain 19-plates (for example).

9-positive plates ; 10 negative plates

- There is a negative plate on each side of the positive plate.

- Positive plates have more chemical activity so the plate-number is always less than the negative plate.

#### (v) Separators:



- There is a clearance maintained in b/w positive & negative plates for the placement of separators

- Thin, porous insulators (leaves glass or plastic envelopes), they allow passage of electrolyte, yet prevent the plates from touching each other to avoid short circuit.

### (vi) Vent plug/cap:

- The vent caps include individual filler plugs, strip type, or box type.

- They allow controlled release of hydrogen gas during charging.

- The vent plugs are provided with baffle plates. The gases emitted are likely to carry droplets of electrolyte along with them.

- The baffle plates trap the droplets of the electrolyte, thus avoiding the loss of electrolyte.

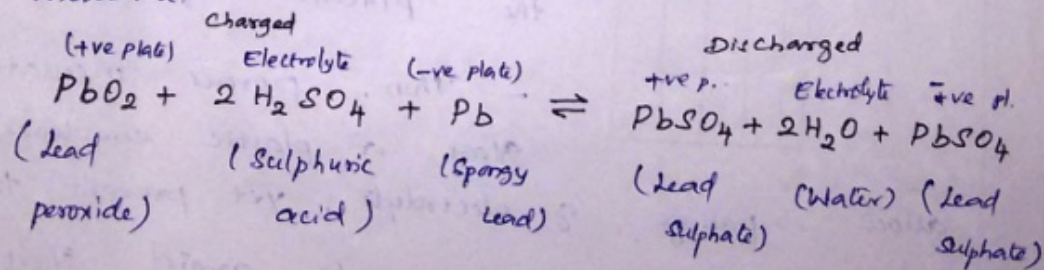
### Working Principle:

- When the positive & negative electrodes of a lead acid battery are immersed in dilute sulphuric acid

### Fully charged:

- Lead peroxide is on the +ve plate

- Spongy lead on the negative plate as the active material.



### Discharge:

- The chemical reaction forms lead sulphate on both the plates by liberating water.

## Battery Capacity:

- Capacity of battery can be defined as the amount of the current in amperes that it can be delivered for the specific period of time.

The amount of current depends upon

\* Number of plates

Electrolyte strength

\* Area of the plate

Current demanded.

\* Temperature

- About 930 sq. cm of plate area, which is in contact with the electrolyte will produce 1060 amps of current.

No. of plates:

6v batteries - 15, 17, 19, 21 / cell. } depends upon the  
12v batteries - 7, 9, 11, 13 / cell } size of the battery.

Some details about batteries used in vehicles.

(i) Cars (1000 cc engine) - 40-Ah at 20h rating.

1500 - 2000 cc - 43 to 50 Ah.

upto 3000 cc - 50 to 70 Ah.

American cars 300-400 Bhp - 70 - 75 Ah

↓ 200 to 300 Bhp - 45-55 Ah.

(ii) Commercial Vehicles - 90 to 240 Ah at 10h rating.

Diesel Engines - upto 300 Ah (due to the need of higher starter currents)

## Battery Efficiency:

- Efficiency of a battery is generally defined in terms of ampere-hours or Watt hours.

$$\text{Battery Efficiency} = \frac{A_1 \text{ (Amp hr for full discharge)}}{A_2 \text{ (Amp hr for full charge)}}$$

- When the battery discharges current at slower rate, then it is more efficient than discharging rapidly.

- At lower temperature, the battery efficiency was lowered due to the time taken for chemical activity.

## Temperature Effect on Battery:

- At low temperature the resistance of the electrolyte increases, and also the

- The quantity of electrolyte also increases & this cannot diffuse effectively into the pores of the battery plate.

- During cold weather, the viscosity of the cylinder increases, which requires greater starting torque to crank the motor.

- At 27°C of engine oil SAE-20 <sup>if</sup> the power required is 100%.

then,

at 0°C - 155%.

-18°C - 250%.

## Battery Rating:

- Measure of energy stored in it.
- Expressed in terms of the period during which the battery will give rated current before it reaches the specified final voltage.
- Quantity of current that a battery can deliver depends upon
  - (i) Amount of electrolyte present in the battery
  - (ii) Strength of electrolyte

Most commonly used ratings are

- (a) 20-h rate
- (b) 25-A rate
- (c) Cold rate
- (d) 4-h rate.

### (a) 20-h rate:

- The amount of current, battery can deliver in a period of 20 hours, holding the cell voltage above 1.75 V at electrolyte temperature of 27°C.

- During the test, the temp of battery approx 80°F (26°C). This is usually given in ampere hour.

### (b) 25-A rate:

- The time in minutes from which the battery can supply 25 Amps at 25°C without the cell voltage falling below 1.75 V.

- Which indicates as to how long the battery can run the car if the charging system stops working.



(c) Cold rate:

- Termed as short time rate
- This rating is the number of minutes a battery can deliver 300 A of current at starting temperature of  $-18^{\circ}\text{C}$ , before the cell voltage drops below 1.0 volt.

- A 100 Ah battery with a 20-hr rate may be in a position to deliver 300 A for a period of 36 min., starting at  $-18^{\circ}\text{C}$ , before the voltage drops below 1.0 V per cell.

(d) 4-h Rate:

- Rating is often used for heavy vehicles. (coaches, buses, lorry, etc.,)

- It represents the ampere hour rating of a battery discharged in 4h.

- Battery supplying 25 A for 4h will have 100 Ah on the 4-h rate.

## Charging Methods

### Battery Charging:

- The charging of the battery should be followed by instructions of the mfg.
- A battery with a low state of charge will require a large amount of charging current than a fully charged one.
- The charging current in automobiles were adjusted by means of a regulator depending upon the <sup>state</sup> charge of the battery.
- Batteries which are laid <sup>up</sup> ~~out~~ after removing it from the vehicle or A.B. batteries which are kept idle or out of action, should be charged with the help of a battery charger working on mains supply.
- Charging a battery by DC is essential, if AC is the only source in case then rectifiers can be used for the conversion of AC to DC.
- Rectifier should have a rheostat to regulate the charging current & an accurate V.m & A.m for checking current & voltage.

**Rheostat** - An electrical instrument which is used to control the current by varying resistance

## Methods of Charging Battery

- \* Constant - Current Charging
- \* Constant - Voltage Charging

Some of other methods of charging the battery are

- \* Booster or high rate charging
- \* Trickle charging or slow rate charging.

### Constant Current Charging:

- These chargers are generally with a rectifier which ~~are~~ may be of a glass filled bulb type or a series of copper oxide or other chemical disks.

- The rectifier also incorporates some form of rheostat to adjust the amount of charging current as per battery rating.

- The battery with a lowest rating was given preference <sup>for charge rate,</sup> when a series of batteries <sup>are</sup> were charged.

- Battery charging should be continued till all the cells of battery are gassing freely & no sp. gvtg risk of electrolyte takes place.

## Constant voltage charging :

Principle:

- When a battery reaches its charge, the terminal voltage increases.

ie... motor generator set.

- When a battery in a discharged condition is connected to the generator, high rate of current will flow into the battery

- As the battery reaches its fully charged condition, its terminal ~~terminal~~ voltage will increase in opposition to charging current.

ie...

charging current tapers off as the battery approaches charged condition.

- If there is excessive battery temp., the terminal voltage will not increase as much as expected.

- This will continue the high current into the battery resulting in overcharging unless the battery is removed in time from the charger.

## Booster or High-rate charging :

- These devices can supply high charging currents of the order of 40-100 A, depending upon the size

of the battery

- It is possible to recharge a battery almost full charge within 1 hr.

Before using this type of charging, the battery should meet the following conditions.

- Battery should be in good condition or otherwise plates will be damaged.
- Electrolyte temp shouldn't  $\uparrow$  above  $50^{\circ}\text{C}$ .
- Badly Sulphated battery should not be used in this process, because the lead sulphate takes more time to convert into active material (over heating can be occurred).
- Badly over charged battery which are kept idle for a long time shouldn't be charged this way.
- To bring the battery in a fully charged condition the battery should be charged at normal rate.

- This action sets free two atoms of oxygen from the +ve plate & the get united with the hydrogen left behind in the electrolyte.

- The Union of Hydrogen & oxygen forms  $H_2O$ , which means that during discharge, lead sulphate is formed on both the plates while sulphuric acid is replaced by water.

### Current Flow:

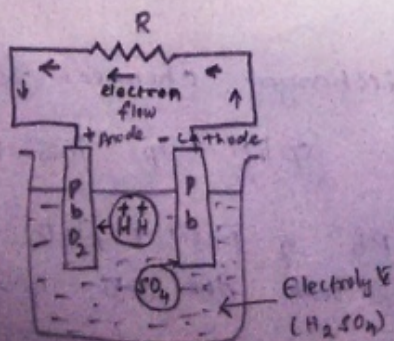
- Current flow - movement of electrons.

- Current flow / movement of electrons are produced by shifting  $SO_4$  &  $O_2$  to and from the plates where these parts of molecules are called ions.

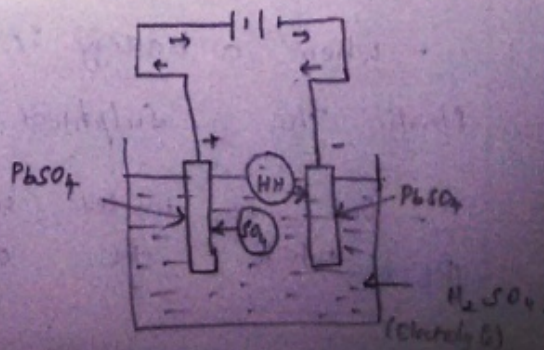
- The electrons are carried by these ions from the positive plates & placed on the negative plates.

- The battery is considered to be discharged when most of these molecules have split up & reunited.

### Discharging



### charging



## VARIOUS TESTS ON BATTERY CONDITION.

- Battery testing is necessary to assess the quality of the battery

- To ensure satisfactory results, the battery should be charged & discharged at least twice before the test readings are taken.

### (a) Checking Specific Gravity of a Battery:

- The Battery hydrometer was used to measure the specific gravity of electrolyte inside the battery.

- One of the ways/methods of knowing the state of charge of battery is to know the amount of sulphuric acid left in the electrolyte, which can be found out by battery hydrometer.

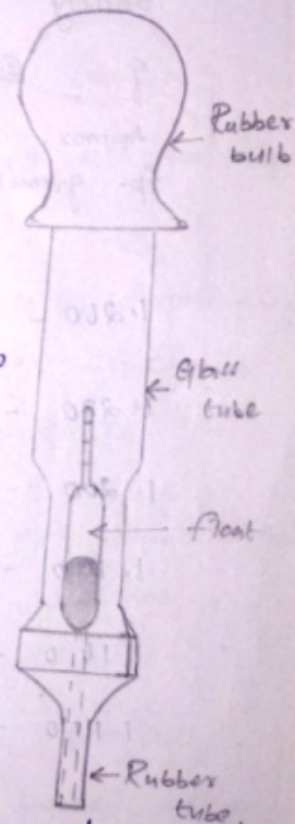
\* Fully charged - 39% Acid ; 61% water by wt.

\* Discharged - 15% Acid ; 85% water

- Battery hydrometer is made up of a glass tube containing a weighted float with markings on its stem

- Rubber bulb was fitted at one end of the glass tube & on the other end a flexible suction tube was fitted.

- When the electrolyte is drawn inside the tube, the float rises or sinks, depending upon the gravity of the electrolyte



- The specific gravity reading can be taken from the markings on the float stem.

- Test should not be checked while the battery is gassing (passing air bubbles)

- When the water has been added to adjust the electrolyte level in order to avoid errors while testing.

Battery Conditions according to the specific gravity of Electrolyte.

Approx. sp. gravity	State of charge of battery.
---------------------	-----------------------------

1.260 - 1.280	Fully charged
---------------	---------------

1.230 - 1.260	3/4 charged
---------------	-------------

1.200 - 1.230	Half charged
---------------	--------------

1.170 - 1.200	1/4 charged
---------------	-------------

1.140 - 1.170	Run down
---------------	----------

1.110 - 1.140	discharged.
---------------	-------------

(\*) High rate - Discharge Test:

- During starting (cranking motor) heavy current was drawn, so that cell voltage falls critically.

- The high rate discharge test was carried out by means of a cell voltage tester



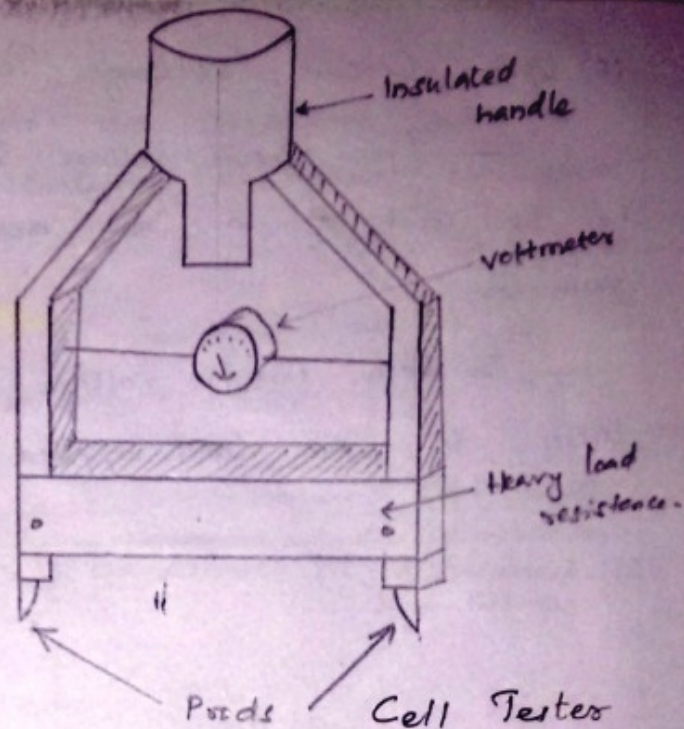
INTERNAL ERROR - FALSE

POSITION : 041163188 (18231688)

SYSTEM : BOPWSIM/xl\_image

LINE : 605

VERSION : QPDL 1.26 04-14-2005



- It consists of a voltmeter connected to two legs with a resistance placed across them.

- As the prods are placed on the cell terminals the resistance places the cell under high discharge and at the same time voltmeter indicates the cell voltage.

- The duration of test should be very short (5 sec) because of the current flow across the resistance is high (100-200 A).

- For 12v battery if each cell is fully charged, the test should not show battery voltage as 10v.

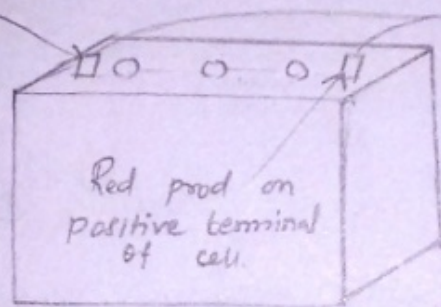
- Cells of the battery should give same reading.

### (c) Open Circuit Voltage Test:

- Open circuit voltage test was conducted by the aid of a very accurate & sensitive voltmeter.

- Open circuit voltage of each cell is taken i.e., no load applied.

Black prod  
on negative  
terminal  
of cell.



↑  
Battery  
Charge X  
Tester

- Open circuit voltage of fully charged battery cell is about 2.1 volts.

- In case of 12 v. battery, if voltmeter reading shows 12.6 v then it is fully charged, if the voltmeter shows 12.2 v then it is half charged, if it shows 11.9 v - Completely discharged.

- Normally each 0.01 v is equal to a difference of 0.010 sp. gr. point.

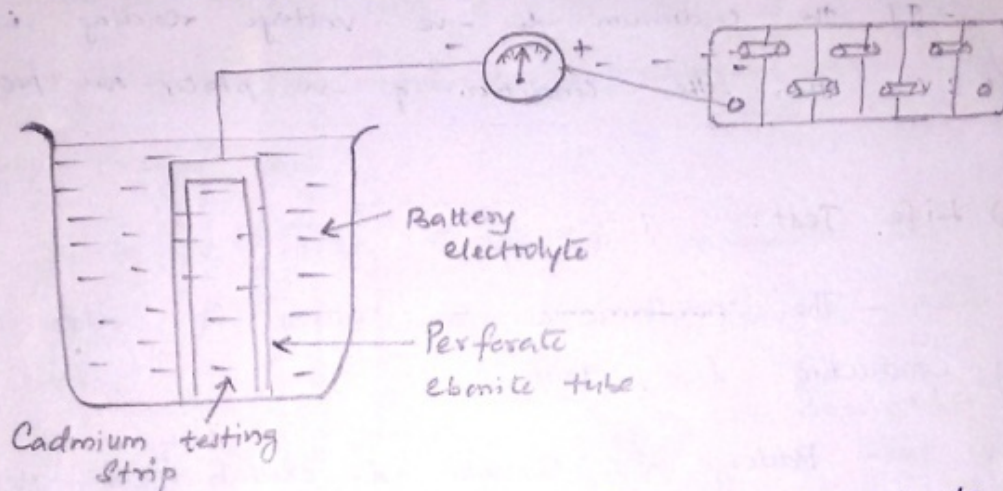
- Batteries which have been just charged should not be tested with V.M because the gases on the plate surface will cause high reading.

- Batteries should not be allowed to stand for a no. of hours for the dissipation of gasses before the test is conducted.

#### (d) Cadmium Test:

- Cadmium Tests are performed to know about the chemical condition of +ve & -ve plates in the battery.

- It consists of finding out the voltage b/w plates & the cadmium testing strip was immersed in the battery electrolyte.



- Perforated ebonite tube is generally used to enclose the cadmium strip.

- One end of the strip is connected by a insulated conductor to the -ve terminal of voltmeter, whereas the other end is connected to the -ve or +ve plate as reqd.

- Cell voltage is equal to the algebraic diff. of the cadmium to negative & cadmium to positive volt. readings.

- High resistance voltmeters having positive reading of 3v & a negative reading of 0.2 v was recommended to perform cadmium test.

- For a battery in good condition, the cadmium to +ve voltage should be 2.35-2.50 v & the cadmium to -ve voltage should be -0.1-0.14 v, giving a cell voltage of 2.45-2.64 v

- Cadmium to -ve voltage should not exceed +0.2v than that of Cadmium to +ve voltage not less than 2.0v, thus giving cell voltage of 1.8v for a battery in normal discharge rate.

- If <sup>the</sup> Cadmium to +ve voltage is less than 2.0v chemical condition of +ve group of plate is not upto the mark.

- If the Cadmium to -ve voltage reading is +0.3v, then the condition of -ve plates are poor.

#### (e) Life Test:

- The performance of battery is also determined by conducting life tests.

- Battery <sup>is</sup> charged & discharged at one-hr rate until the capacity of the battery is reduced to about 30-40% of its initial 20-hr rating.

- The total no of cycles before the capacity is reached is considered as the life of the battery.