

## LEAD-ACID BATTERY

Dr. Vahid Esfahanian  
An Introduction to Battery Technologies  
Lecture #6

1

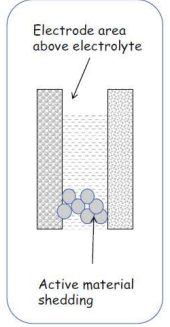
## FAILURE MODES

1-electrolyte loss:

Occurs in the **flooded** or non-sealed batteries  
Occurs at **Overcharge phase**  
Increases with temp. and high charging rates

**Overcharging and high charge in sealed batteries :**  
high charge rates cause an **increase in temperature and pressure**.  
If pressure exceeds certain preset value a valve opens and gas is released, **along with some Electrolyte**.

Solution : properly charge the battery and avoid overcharge




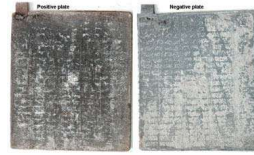
2

## FAILURE MODES

2-Sulfation or formation of  $PbSO_4$  :

As we introduced the reaction ,  $PbSO_4$  will be produced during discharge, but it decomposes in charging.  
**High temp. will increase the rate of sulfation.**  
**It Blocks active materials**

If a battery is left longer in the fully discharged state or close to fully discharged state, the lead sulfate crystals grow in size, making it impossible to breakdown such large crystals.

3

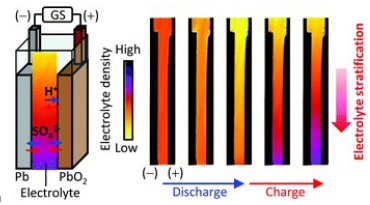
## FAILURE MODES

3-Electrolyte stratification :

**Cause :** the **specific gravity differentiation** between sulfuric acid and water

**Driving phenomenon :** **absence of mixing or agitation**, a denser sulfuric acid starts settling closer to the bottom

**Damage:**  
1-Uneven electrolyte concentration cause a **nonuniform current distribution** across battery plates can occur and have an effect on the **active masses**.  
2-Toward the bottom, high acid concentration, the **self-discharge** reaction leading to sulfate formation is faster; which then, over prolonged periods of time, may cause permanent sulfation and loss of capacity.



4

## FAILURE MODES

### 4-Plate Distortion:

**Cause :** Operating in high temperatures and overcharging

### Damage:

Once the plates are distorted, the puncture through the separator and cause an electrical short

### 5-Grid corrosion :

In flooded lead-acid batteries, roughly 85% of all failures, while in valve-regulated lead-acid batteries, grid corrosion is the cause of failure in about 60% of cases.

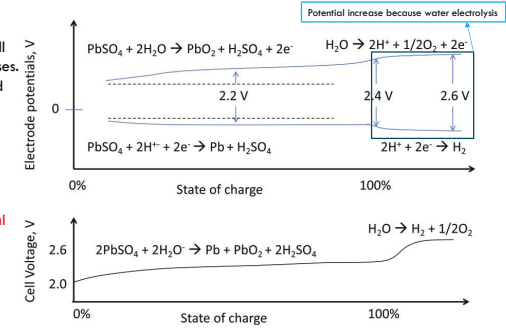
- ✓ Develops over time and it typically affects batteries that are **close to end of life**
- ✓ The only way to extend it is to develop new materials or processes.

5

## CHARGE PROCESS

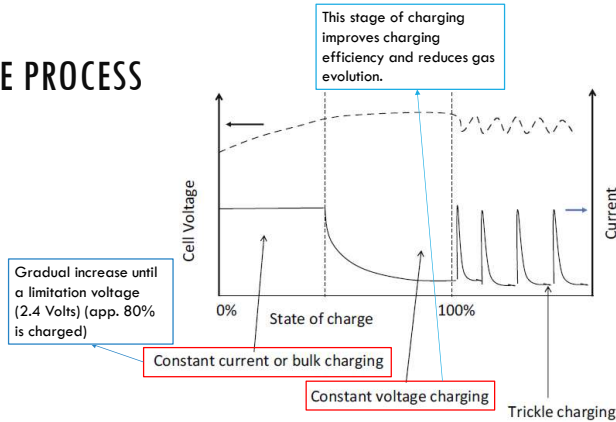
If the charging continues beyond the point of full charge, the cell potentials show step-like increases. This is transition between the potentials required for the lead-acid reactions and the water electrolysis reactions to start.

The dashed lines show the **thermodynamic or theoretical electrode potentials**. The difference between actual and thermodynamic potentials is called **overpotential** and it is higher for the positive or lead dioxide electrode.



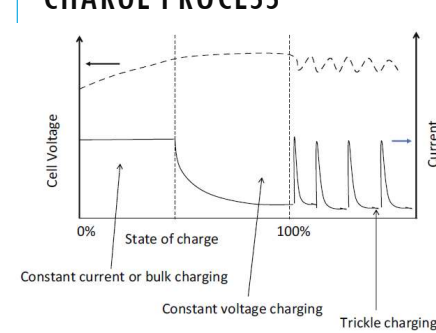
6

## CHARGE PROCESS



7

## CHARGE PROCESS



As we said, battery will lose electrolyte and face sulfation if it left fully charged

Charging must be controlled and battery voltage should be reduced from 2.25 or 2.27 to 2.15 V. This is happening by applying a pulse of 2.15 V.

8