UGM519 Batarya ve Batarya Sistemleri

Lead Acid Battery

Eskişehir Teknik Üniversitesi
Uçak Gövde Motor Bakım ABD
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Cell Reaction Of Lead Acid Battery

❖**Discharging**

(+) electrode: $PbO_{2(s)} + 4H^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^- \rightarrow PbSO_{4(s)} + 2H_2O_{(L)}$ E˚=1.70 V

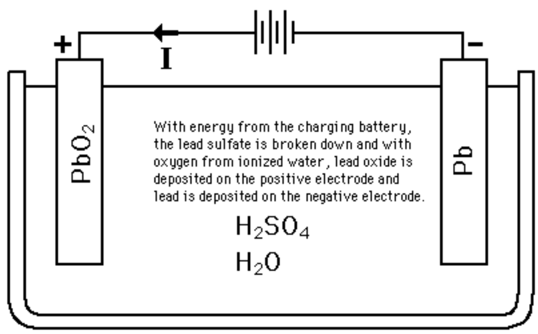
(–) electrode: $Pb_{(s)} + SO_4^{2-}{}_{(aq)} \rightarrow PbSO_{4(s)} + 2e^-$ E˚=-(-0.31) V

E˚= 2.01 V

❖**Charging**

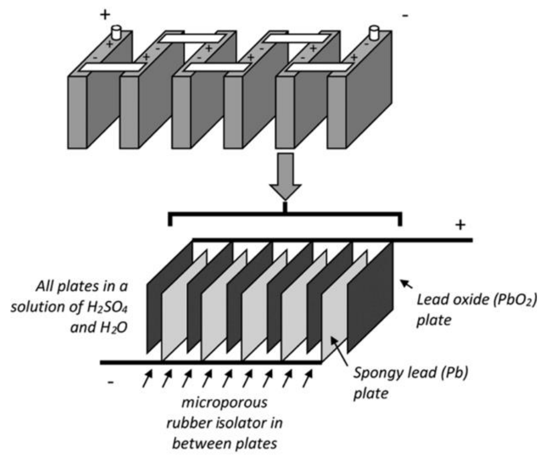
(+) electrode: $PbSO_{4(s)} + 2H_2O_{(L)} \rightarrow PbO_{2(s)} + 4H^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2e^-$

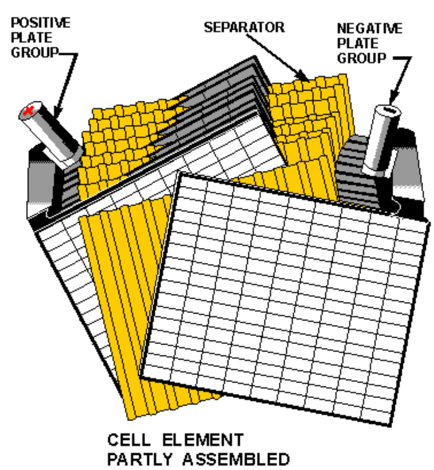
(+) electrode: $PbSO_{4(s)} + 2e^- \rightarrow Pb_{(s)} + SO_4^{2-}{}_{(aq)}$

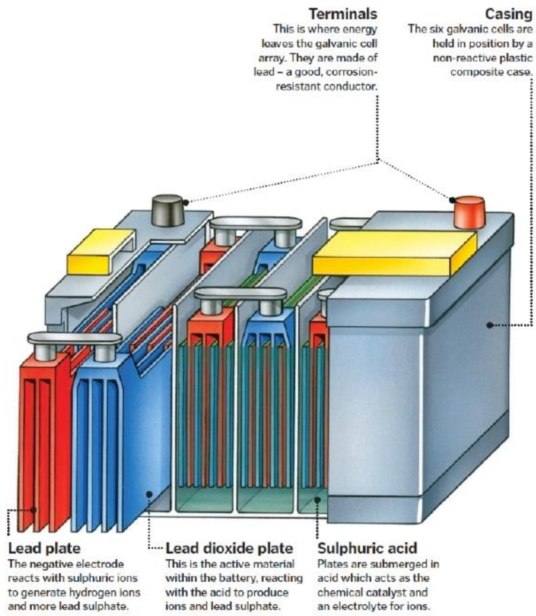


Lead-acid Battery Key features

- Positive electrode of lead oxide, blended with carbon and a binder, pasted and cured onto a lead current collector.
- Negative electrode of lead powder, blended with carbon and a binder, pasted and cured onto a lead current collector.
- Separator used depends on battery construction
- Electrolyte is 33% sulfuric acid and 66% water.


+
-
+
All plates in a solution of H_2SO_4 and H_2O
Lead oxide (PbO_2) plate
Spongy lead (Pb) plate
-
microporous rubber isolator in between plates

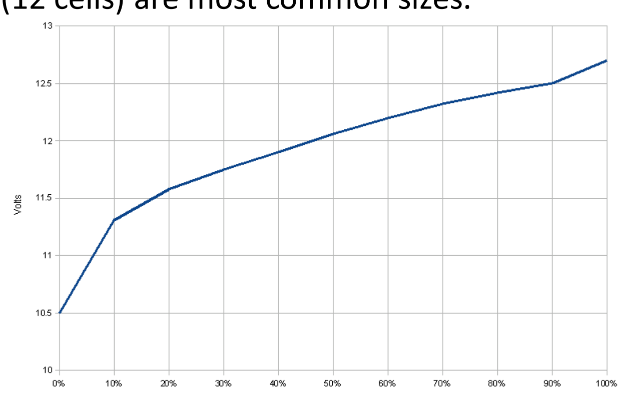

POSITIVE PLATE GROUP
SEPARATOR
NEGATIVE PLATE GROUP
CELL ELEMENT PARTLY ASSEMBLED



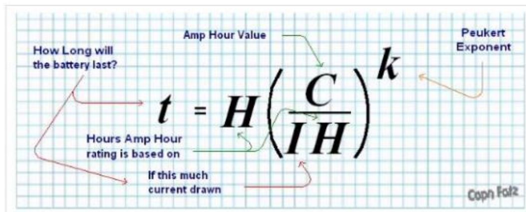
Key features

- Often assembled into multicell units, utilizing a common enclosure (monobloc)
- 6V (3 cells), 12V (6 cells), 24V (12 cells) are most common sizes.

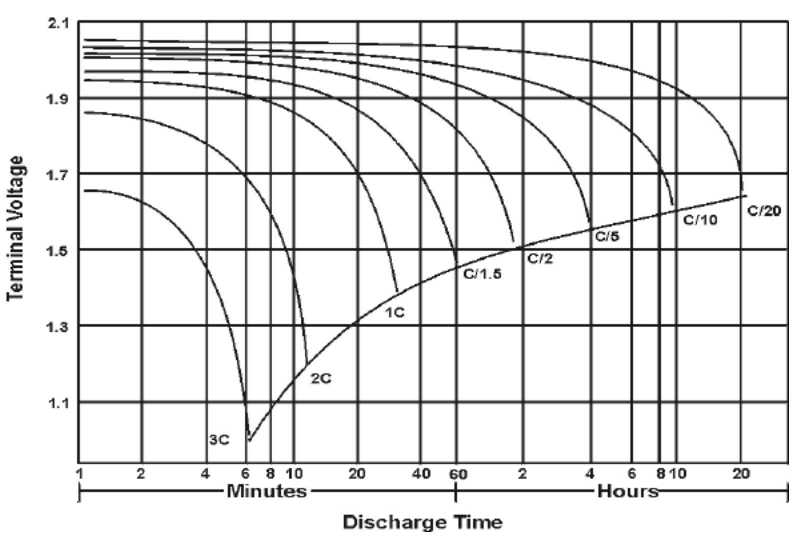
- 12.6V open cicuit
- 11.8V fully discharged
- 14.4V max voltage
- .0.022V/C˚ adjustment
- 20-40 Wh/kg
- 30-75 Wh/l
- 100-200w/kg
- 3-20%/mo self discharge



Peukert’s Law



- **t** - Time in hours. Its the time that the battery will last given a particular rate of discharge (the current).
- **H** – The discharge time in hours that the Amp Hour specification is based on. For example, if you had a 100 Amp Hour battery at a 20 hour discharge rate, H would equal 20.
- **C** – The battery capacity in Amp Hours based on the specified discharge time. For a 100 Amp Hour battery, this would be
- **I** – This is the current that we’re solving for. For example, if we wanted to know how long a battery would last while drawing 7.5 amps, we would enter it here.
- **k** – the Peukert Exponent. Every battery has its own Peukert exponent. Sometimes the manufacturer will provide it and other times we may need to figure it out.



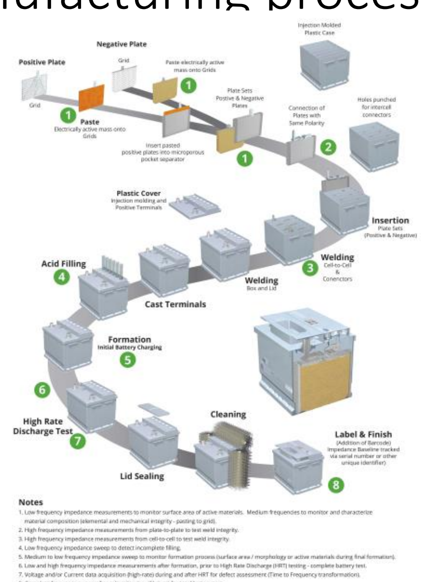
Types of Lead-Acid Battery

- Flooded Batteries
  - Utilize a free liquid electrolyte of sulfuric acid
  - Oxygen and hydrogen can be generated during a charge or deep discharge reaction and need to be removed
- Starting (sometimes called SLI for starting, lightning, ignition) batteries are commonly used to start and run engines
  - 30-150 deep cycles if deep cycled
  - Thousands of cycles in normal starting use (2-5% discharge)
- Deep cycle batteries
  - Designed to be discharged down as much as 80% time after time, and have much thicker plates
- Recombinant – Valve regulated lead-acid (VRLA)
  - Oxygen and hydrogen are held within the cell, and allowed to recombine
  - Gell batteries: acid is immobilized in a gel
  - Absorbent Glass Mat (AGM): Absorbs gasses within the cell
- Lead Carbon: utilizes carbon as a charge carrier on the negative electrode

Flooded Lead Acid

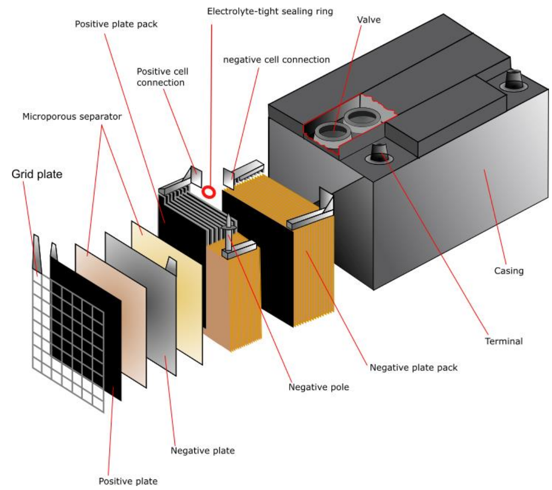
- Most common battery type
- Excess electrolyte filling battery cavities
- Serviced by managing water levels in electrolyte, caused by loss from gas generation and permeation

Lead acid manufacturing process



Valve regulated lead acid battery

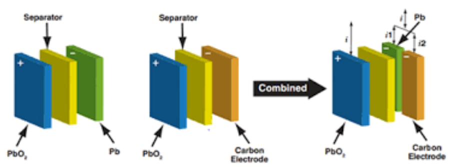
- Container is sealed and valve regulated
- Oxygen recombination cycle minimizes water loss
- Plates are kept under pressure for better performance
- AGM separator eliminates acid stratification

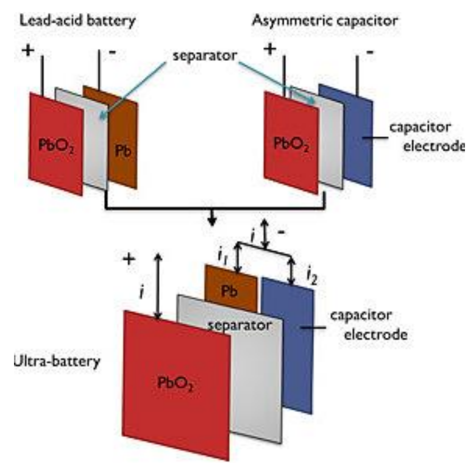


VRLA Battery

- Electrolyte “starved” (no free electrolyte)
- Separator is typically an absorbed glass mat (AGM)
  - Short glass fibers for a mat, which “wick” electrolyte
  - Allows gas pathways for transport of hydrogen and oxygen from electrolyte plates
  - This permits gas recombination, preventing water loss
- Excessive gas generation can be released through a one-way rubber valve
  - Sealed lead acid batteries permit gas build-up and recovery
- Orientation independent
- Maintenance free
- Slower charge rate than flooded lead-acid
  - Twice the price of flooded lead-acid
- More capable of deep discharges

Lead-carbon Battery



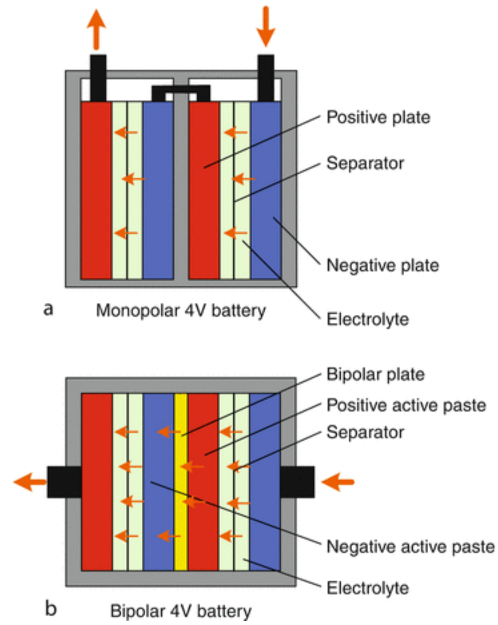


Lead-carbon Battery

- Based off of AGM battery
- Combine the electrode of an ultra capacitor with lead on the negative electrode
- Improved charge acceptance over normal PbA
- Improved cyclability and cycle life (total energy throughput)
- Significant improvement in calendar life over PbA
- Potentially improved temperature performance over AGM
- Reduced energy density
- E°=1.69V

Bipolar battery

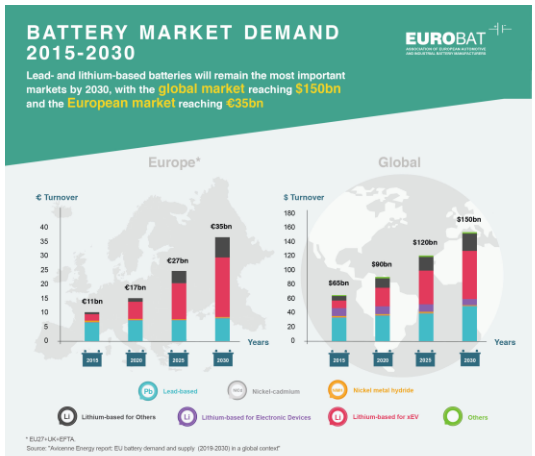
- Stack all components of multiple cells in series
- Elimination of tabs and simplification of inter-cell connections
- Shorter conductive pathways through the battery
- Lower impedance and improved utilization of electrode materials
- Challenges to seal battery



Failure modes

- Shorting between plates, due to deformation/swelling of electrodes
- Shedding of material, leading to shorting between plates
- Corrosion of tabs, leading to tab failure
- Corrosion of current collectors, leading to plate failure
  - Positive electrode oxidizes
  - Negative electrode sulfates
- Sulfation of negative electrodes
  - Crystallization of lead sulfate, removing active material from lead
- Electrode exhaustion and dry-out

Lead-acid vs other chemistries



Lead-acid pros and cons

- Pros
  - Low cost
  - Simple handling
  - No extensive controls required
  - Readily recyclable
  - Good instantaneous power density
- Cons
  - Poor energy density/specific energy
  - Short cycle and calendar life
  - Toxic materials
  - Capacity is highly sensitive to rate and temperature

Ders içeriği

Konular
Giriş
Enerji depolama metodları
Batarya elektrokimyalarına giriş
Kurşun asit bataryalar
Lithium ion bataryalar
Süper kapasitörler
Nikel Metal Hydrid bataryalar
Batarya sistem entegrasyonu
Otomotiv batarya uygulamaları
Şebekeye bağlı enerji depolama sistemleri ve uygulamaları
Havacılık uygulamaları
Bataryaların modelleme ve simülasyonu
Gelecek elektrik enerjisi depolama uygulamaları

Ders içeriği -2

Konular
Enerji depolama sistemleri araştırmaları
Bataryaların ölçümü, tahmini ve korunması
Şarj üniteleri
Batarya geri dönüşümü
Batarya standartları ve testleri
Süper kapasitörler

- **Sorular ??**