Power Sources - Storage devices

• Two primary types;
  – Batteries
  – Capacitors
Power Sources - Batteries

• A battery is a device where two different metals (usually) are placed a specific distance apart and are chemically connected with an “electrolyte”.
Power Sources - Batteries

• The number of electrons this unit will store depends on;
  – The chemical nature the metals used to make the “plates”.
  – The type, temperature & concentration of the electrolyte.
  – Surface area of the metal exposed.
Power Sources - Batteries

• Typically more surface area means more electrons.
• But the voltage will be determined by the chemical nature of the metals and electrolyte and their internal resistance.
• Resistance is due to the time it takes for reactions to occur as well as the temperature and contamination of the plates.
Power Sources - Batteries

- In a lead acid battery porous lead (- anode) and lead peroxide (+ cathode) are the two metals.
- $\text{H}_2\text{SO}_4$ is mixed with $\text{H}_2\text{O}$ for the electrolyte.
- This mix has a higher density than water.
Power Sources - Batteries

- The Pb can become PbSO$_4$ if it loses the hydrogen by sending two electrons through the circuit.
- The PbO$_2$ can become PbSO$_4$ if it gains the two electrons and hydrogen.
- The electrolyte loses the H$_2$SO$_4$ and gains 2 H$_2$Os.
Power Sources - Batteries

• As the battery discharges the plates become lead sulfate and the electrolyte becomes water.

• It will get weaker, and if it goes too low it will be impossible for it to completely reconvert back, when recharged.
Power Sources - Batteries

• As they colder this works less.
• As they get discharged the electrolyte freezes at higher temperatures.
• Since $\text{H}_2\text{SO}_4$ is denser than water the state of charge can be measured by checking the density of the electrolyte.
• This is done with a hydrometer.
Power Sources - Batteries

- At fully charged battery should be about 37% $\text{H}_2\text{SO}_4$ and the rest is pure water.
- This will equate to a specific gravity of 1.275-1.300
- The maximum voltage of each cell will be 2.113 with 6 cells for a maximum of 12.68 volts static charge.
Power Sources - Batteries

• If the charging voltage exceeds 14.2 volts the electrolyte will start producing oxygen and hydrogen gasses.

• The source of the gasses is the water, not the acid.

• Replenish fluid with pure water.
Power Sources - Batteries

- If over charged it at a high rate the cells will heat enough to flake off the $\text{H}_2\text{SO}_4$.
- This will drop to the bottom of the cell no longer participating in the reaction.
- It will eventually build up enough to short across the plates.
Power Sources – Batteries

• A hydrometer is a glass tube with a glass float in it.
• The float is a long thin piece with a scale and a thermometer.
• It is calibrated for the relative density scale to be accurate at 70°F.
• If the temperature varies from this then the scale reading is adjusted.
Power Sources – Batteries

- As the density increases the float will sit and read higher.
- More acid or colder temperature will increase temperature.
Power Sources – Batteries

• Standard lead acid batteries should be charged slowly, with 1-2 amps never exceeding 14.2V

• This rarely happens.
Power Sources – Batteries

• Several rating factors to consider.
• Amp-Hour = number of amps of current flow for a given amount of time.
  – 27AH = 1 amp of current for 27 hours.
Power Sources – Batteries

• Cold Cranking Amps = the maximum amps it can put out under full drain. Amps per 30 sec >> 7.2V @ 0°F
  – Typically they can only put out so much at one time due to internal resistance.
  – This gets worse as it is discharging.
  – This gets worse as the battery gets older (sulfated)
  – A load tester is used to see max output performance.
Power Sources – Batteries

• Load tester is used with battery at full charge.
• Full charge = 12.68V after surface charge depleted.
• Electrolyte density 1.275 or higher.
• Battery should be able to stay in green (voltage) for ten seconds.
Power Sources – Batteries

- Batteries most often fail their plates due to shorting and sulfating.
- Plates or posts can break internally.
- Posts can corrode severely.
- Dirty battery can conduct current through grease and dirt.
- It is normal for a sitting battery to slowly loose its charge over extended time.
Power Sources – Batteries

• It is not uncommon for batteries to come dry, with box of electrolyte.
• Don’t save electrolyte to top off other batteries.
• Dispose of properly, diluting greatly with water.
Power Sources – Batteries

• Wet Cell batteries can come with serviceable cells or sealed cells.
• Both of these types will gas if charged too high/fast.
• Cells are vented, sometimes with slight PRD and fluid trap.
• Fluid trap will have a drain, drain should go someplace non-critical, and stay clean.
Power Sources – Batteries

- Some brands will have a cheap hydrometer installed. (A/C Delco green eye is good)
- Sealed types should stay sealed.
- Typical life is 5 years regardless of use.
- Extensive discharging will shorten life due to excessive sulfation.
Power Sources – Batteries

• Too basic types of structure, deep cycle, and rapid cycle.
• Rapid cycle good for starting
• Deep cycle good for long low current use such as motor home or marine.
Power Sources – Batteries

- Gel Cell Batteries
- Geletinized (w/silica) electrolyte keeps battery from leaking.
- Good for deep cycle use.
- Non-vented
  - Valve Regulated Lead Acid = VRLA
- Sensitive to charging rates
Power Sources – Batteries

- Can discharge at a higher rate than flooded cells,
- Operate at pressure
- Cost = higher
- Non-serviceable other than charging
Power Sources – Batteries

• AGM = Absorbent Gas Mat batteries.
• Name describes it, compact compressed package of plates.
• Separated by electrolyte soaked mats.
• Will take a very high rate of charge.
• Non-vented
  – Valve Regulated Lead Acid = VRLA
Power Sources – Batteries

• Can discharge at a high rate, similar to flooded rapid cycle
• Operate at pressure, tends to cause gassing to reform into water.
• Cost = highest of lead acids
• Non-serviceable other than charging
Power Sources – Batteries

• Disposal, hazardous material, non-FAA issue, but other Fed, State and local laws apply.
• Are most often recyclable
Power Sources – Batteries

• Primary danger sources are pressure failure and flash explosion
• Secondary concerns:
  – is being zapped, but low chance.
  – Shorting, causing hot conductor, fire.
Power Sources – Batteries

• VRLAs are more efficient
  – Wet cells 15-20%
  – Gels 10-15%
  – AGMs 4%
  – Charging energy into heat
Power Sources – Batteries

• Wet Cells self discharge about 1% per day.
• Gels and AGMs self discharge about 2% per month.
Power Sources – Batteries

• Nickel-cadmium - Nicad batteries
• Use Nickel hydroxide for one plate and cadmium for the other, both in a porous state.
• Polymide or polymer separator.
• Uses a base usually 30% potassium hydroxide as the electrolyte, which doesn’t “convert” in the process.
Power Sources – Batteries

• The chemical flow in the electrolyte is to move a oxygen (hydroxyl) ion from plate to plate.

• Therefore electrolyte state does not equal charge state.
Power Sources – Batteries

- Like lead acid is a secondary cell (rechargeable)
- Anode and cathode form an oxidizing-reducing reaction if electrons allows to conduct from one plate to the other.
Power Sources – Batteries

• Very low internal resistance
• Can charge and discharge very fast
• If completely discharged, one or more cells may reverse.
• Is very sensitive to overcharging.
Power Sources – Batteries

• Once plates are full the charging starts oxidizing the electrolyte since the plates can no longer exchange oxygen ions.
• This generates a lot of heat.
• High rate charging must include temperature measuring.
• High temp is bad for all batteries.
Power Sources – Batteries

• Limit on current rate of charging is due to time required for oxygen to exchange across plates.
• Excessive rate will cause oxygen release rather than charging.
• Will also change the nature of the nickel hydroxide plate, ruining it.
Power Sources – Batteries

• Ni-cad Memory = voltage depression.
• Is due to changes in plate’s crystallized structure.
• Very slow charging or repeated cycling of charge/discharge causes material nucleation to form larger crystals which resist chemical interaction.
Power Sources – Batteries

- Properly discharging (no more than 95%) and then recharging can reform crystals properly.
- But every cycling does reduce battery lifespan so don’t cycle just because.
Power Sources – Batteries

• Trickle charging to keep full is ok if less than 5mA.
• Otherwise low current trickle charging can cause memory effect, and will overcharge, oxidizing the electrolyte.
• Medium current trickle charging based upon capacity is most common method.
Power Sources – Batteries

- High rate charging methods = Constant V or Constant C
- Constant voltage or voltage monitoring.
- Relies on not exceeding cell temperature as current reduces when close to full.
- Voltage state is kept fairly constant. But there is a slight drop when reaching full charge.
Power Sources – Batteries

• Sensing circuit measures this drop and shuts down charging.
• System should monitor temperature.
• Allows for higher rate charging, quicker.
• Down side of using voltage drop sensing is a defective cell could fool sensing system which may then fry other cells.
Power Sources – Batteries

- Constant current
- Is cheapest method = wall chargers
- Typically called trickle charging = slow rate, long time.
- Charges at a rate that does not exceed gassing.
- User is expected to not over-charge
Power Sources – Batteries

- Pulse and burp charging
- One second on, 5 ms off
- Burp actually does high discharge during 5 ms period.
- Allows diffusion of oxygen in electrolyte.
- Promotes better micro-nucleation of plate crystals.
Power Sources – Batteries

• Allows for short voltage measurement period between pulses
• NiCads using this technology tend to last up to twice as long.
Power Sources – Batteries

- DON'T deliberately discharge the batteries to avoid memory
- DO let the cells discharge to 1.0V/cell on occasion through normal use.
- DON'T leave the cells on trickle charge for long times, unless voltage depression can be tolerated.
Power Sources – Batteries

• DO protect the cells from high temperature both in charging and storage.
• DON'T overcharge the cells. Use a good charging technique.
Power Sources – Batteries

• Full discharging should be done with individual cells only to prevent cell reversal. (called Equalizing)

• Electrolyte is very corrosive, use proper safety gear.

• Never mix tools, facilities and equipment with lead acid tools. Might prove big bang theory.
Power Sources – Batteries

• Terminal corrosion is potassium carbonate.

• Clean with water and fiber brush, (metal brush can cause arcing)

• Excessive terminal corrosion may be a sign of overcharging. (gassing and venting fluid)
Power Sources – Batteries

• Electrolyte level may change with state of charge.
• Service with distilled water at full charge only unless plates are exposed.
Power Sources – Batteries

• Plate reforming during charging can cause material to form dendrites in a manner that shorts through separator.
• Is grounds for removal from service.
• A reversed cell if recharged in a pack will get hot and may thermally run away when charged.
Power Sources – Batteries

- Thermal runaway is when cell gets hot, maybe during charging, then shorts internally and gets really hot discharging and melts or goes BOOM.
Power Sources – Batteries

- Nickel metal hydride
- Similar to ni-cad
- 30% more capacity, less memory effect, less toxic
- But lower number of charging cycles, discharge current lower, charging temp higher and more sensitive
- Will often include temp probe in case.
Power Sources – Batteries

- Lithium Ion
- 300-500 cycles, highest capacity per pound.
- Deep discharge bad for them as well as NiMH.
- Worst case, like above, is high charge high temp.
- Long storage, store at 40% charge.
Power Sources – Batteries

- Cell voltage 3.6V
- Lithium metal is lightest of metals, but unstable when charging/discharging.
- Hence the need for lithium ions place upon a substrate.
- DOT standards apply to transport of lithium due to unstable nature.
Power Sources – Capacitors

- Capacitors
- Very similar to batteries in construction.
- Usually has two plates, these may be rolled or folded in a case.
- They do not really produce power but they store it.
- They traditionally don’t use “chemical” reaction to function.
Power Sources – Capacitors

• external power source charges plates
• Plates are separated by thin dielectric material that keeps plate separated but promotes electrostatic flux.
• Tension from flux will cause electrons on one plate to push away electrons on opposite plate.
Power Sources – Capacitors

- Can act like a “shock” absorber as in case of the condenser used with ignition points.
- Can be used as short term battery for things like timer electronics.
- Can be used to filter out AC, DC or various frequencies. (More later on this)
Power Sources – Capacitors

• some species use electrolyte, some are polarized.
• All will have two leads like a battery.
• Capacitance measured in Farads = 1 Columb at 1 volt.
• This is very big as capacitors go, common to see micro-, nano-, and pico-farads.
Power Sources – Capacitors

• But very small as batteries go.
• Dielectric strength determines voltage limit.
• Barrier breaks down and unit shorts if delta V gets too high.
• Advantage over battery is they move electrons much faster.