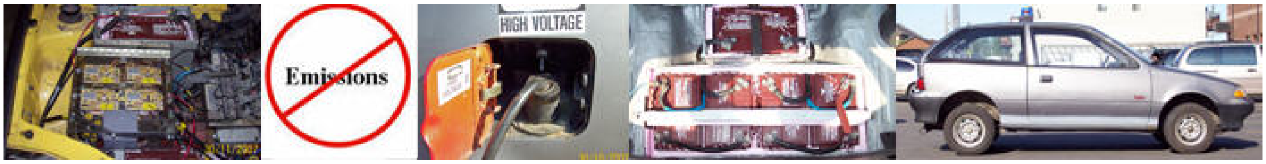


Lead Acid Battery Report - Issue 1, by Robert Weekley October 10, 2009

Lead Acid Batteries are commonly chosen for use in Electric Vehicles because of their readily available sources, relatively low cost, and considered abuse tolerance. Let us examine those issues - using data from manufactures of various Lead Acid Batteries.

First - Abuse Tolerance: For me - this means the ability to take (for a given battery) high levels of currents for more than a few moments or a few seconds. Manufactures tables suggest otherwise.

First example is the EnerSys 12V, 17.2AH SLA Battery Specs for starters:
NOMINAL CAPACITY:
20 hr. rate of 0.86A to 10.5V 17.2Ah
10 hr. rate of 1.6A to 10.5V 16.0Ah
5 hr. rate of 2.9A to 10.2V 14.5Ah
1 hr. rate of 10.3A to 9.60V 10.3Ah

This shows - that the battery - can only deliver 10.3 Amps for 1 hour, yielding just 59.88% of the rated (at a 20 hour duration) 17.2 Ah, or just 10.3 Ah - This is for a 13.7 pound or 6.2 Kg Battery.

Further data on life expectancy show cycle use is very dependant on level of discharge:
CYCLE USE (approx.):
100% depth of discharge 250 cycles
50% depth of discharge 550 cycles
30% depth of discharge 1200 cycles

Taking these two tables together - a user might get 250 cycles at a 10.3 Amp Draw yielding just 10.3 Ah per cycle, which means a total life delivery of just 2,575 Ah before replacement. Considering the average voltage from full at 12.7 Volts to discharged (1 hour rate) at 9.6 Volts, equals 11.15 Volts, times the total life Ah = **just 28,711 Watt Hours.**

Noting the max and pulse power limits:
MAXIMUM DISCHARGE CURRENT WITH STANDARD TERMINALS: 150 amperes
MAXIMUM SHORT-DURATION DISCHARGE CURRENT: 450 amperes

Would suggest a robust battery, but these are not tied to, or reported in relation to total discharge energy or cycle life calculations.

Keep in mind that the 10.3 Amp Current Draw, versus the rated 17.2 Ah energy rating = a discharge 'C' Rating (Energy charged or discharged compared to the rated power) of 0.5984 or less that 0.6C over it's short 250 Cycle life.

Thinking of Relatively Low Cost, examining that: these Specs are for a battery as described at the www.totalcomputing.com web site for sale at $95.84 USD. See: http://tinyurl.com/yks7qdh for the Reference Details.

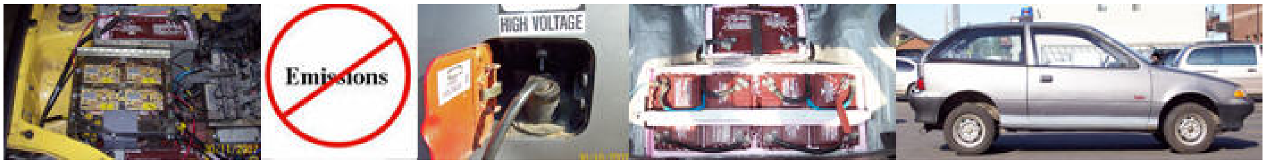
Taking a comparison non Lead-Acid Cell formed from Lithium Iron Phosphate, or LiFePO4 for short, the **40Ah ThunderSky Cell** if purchased currently from www.evcomponents.com would be at a cell cost of $44.00 so four (4) of them would cost $176.00, but that is still less than the 2.32 EnerSys 17.2 Ah Batteries would cost to equal the same Ah total at $222.88, for starters.

This just takes into account the rated Ah of the Battery - which for the Lead Acid (PbA) type is rated over a 20 Hour cycle - but specs do show the 1 hour cycle which we will be comparing yields only 10.3 Ah for the PbA EnerSys 17.2 Ah (Rated) Battery, which means that it would actually take 3.884 such Batteries at $95.84 to equal the energy (not counting cycle life yet), which equals $372.19 USD. So - when actually looking at this comparison - it would seem that the PbA Batteries are going to be more expensive.

Let us compare Weight: now here is another different picture - the ThunderSky Cell weight is 1.5 Kg, so 4 of them = 6.0 Kg. Whereas the EnerSys Battery = 6.2 Kg for just 1, but we need 4 of them (3.884) = 4 times the Weight, and 2.147 Times the Cost ($377.96). For details on the on the ThunderSky Cell: http://tinyurl.com/yjaly3p.

Now - looking at Durability, comparing is a bit more difficult - as both manufacturers do not report the same level of discharge for cycle life,

Continued Overleaf



Lead Acid Battery Report Issue 1, Continued.

however, a good sense can still be gotten. The ThunderSky Specs found at this site: http://www.thunder-sky.com/pdf/TS-LFP40.pdf Show a cycle life at a standard Discharge Current rate of 0.5C or 20 Amps, to a level of 80% Depth of discharge (DOD) yielding a cycle life of more than 3,000 times and to a discharge of 70% DOD for a cycle life of Greater than 5000 times.

Charts also show a 100% DOD cycle life of 1,000 times, or 4 times the life of the EnerSys 12V, 17.2AH SLA, which is 250 times.
Just factoring this capacity in to the cost equation, equals another 4X cost penalty for PbA over the life of the ThunderSky TS-LFP40AHA Cell built Set of 4, Meaning the PbA Battery now would cost $1,511.84 over the same life cost of $176 for the ThunderSky Cells. This is at 20 Amps or ~ 2X the EnerSys' 10.3 Amps!

It also means changing the batteries out four times, for 4 times the labour time or cost, more chances for the Toxic Lead Acid Batteries not getting recycled, and more energy costs related to manufacturing the additional batteries. From this it can be reasonably seen that there is not much to back up the logic that Lead Acid Batteries are Cheaper and therefore better, to use in an Electric Vehicle.

Voltage Sag Issues
Also - there are other points - the set of 4 ThunderSky Cells, replacing the 12V Lead Acid Battery, hold up better to higher current drains, comparing the chart - from 0.5C (20 Amps) to 3C (120 Amps) and to 5 C (200 Amps) Shows a total sag difference of approximately just 0.2 Volts when increasing the load from 20 Amps to 200 Amps, in other words - whereas a Lead Acid Battery - over such an increase in load, shows a very large Voltage Drop or 'Sag' and can be said to be quite 'soft' in supplying higher current drains, the ThunderSky Cell, can be shown to be 'stiffer' under load when changing from 20 Amps to 40 Amps (0.5C to 1C) only drops from about 3.3V down to3.2 Volts by 80% DOD. Changing from a load of 1C (40 Amps) to a load of 3C (120 Amps) causes a voltage drop from 3.2 Volts down to just 3.0 Volts at 80% DOD, but from 0% DOD to 40% DOD the Voltage Sag is just about .06 Volts less than at 1C. Moving from 3C (120 Amps) to 5C (200 Amps) causes a slightly faster voltage sag as we move from 20% DOD to 80% DOD, starting at just slightly below 3.2 Volts with a fresh charge at that load, and progressing gradually down to about 3.05V at 60% DOD, and then increasing its sag down to 3.0V at about 70% DOD, and to 2.9V or greater at 80% DOD.

The Cells Weight on the Specs is listed at 1.6 kg +/- 100 g, so it could (in theory) vary from 1.5 to 1.7 Kg., for a maximum 4 cell set weight of 6.8 Kg. or just 0.6 Kg over a single 17.2 Ah PbA!

Another factor of Hardiness, or Durability, or Resistance to Abuse - is the Charge - Discharge Operating Temperature - listed at -45 Degrees Celsius for the low end, to 85 Degrees Celsius at the High End for the TS-LFP40AHA ThunderSky Cell, versus -20 C for the PbA Cold Temps, and 60 C for the high Temps Limits.

Lifetime Energy Delivery:
Using the ThunderSky 80% DOD Cycle Life Figures shows that 32 Ah (40 Ah X 80%) multiplied by 3,000 Cycles = 96,000 Ah, and for the 4-Cell Pack at a 0.5C (20 Amp) discharge voltage of 13.2V with the cycle life of 80% DOD X 3000 Cycles = 1,267,200 Watt Hours Delivered over it's life. However - Dropping back to just a 70% DOD Cycle for the pack changes the total energy output by another 45% at 1,848,000 Watt Hours!

Compare this with the PbA Results on page 1, at 28,711 Watt Hours over it's life, and it can be seen that it would take 64 PbA Batteries worth of energy, a drastic difference in energy output!

In Conclusion: It can be seen as meaning only one thing: Using Lead Acid Batteries in An Electric Vehicle Today, is just for proving your wiring!

Next Report - Larger PbA BCI Formats Compared to LiFePO4 & More Non-PbA Chemistries.

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