PASSCAL Battery Update

Paul Carpenter

4/12/2016
# Power Storage

<table>
<thead>
<tr>
<th></th>
<th>LiFePO$_4$ Secondary</th>
<th>AGM Secondary</th>
<th>Li-SOCl$_2$ Primary</th>
<th>Air Alkaline Primary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gravimetric Energy Density</strong></td>
<td>37 Wh/lbs 36 Wh/lbs @ -20C</td>
<td>21.5 Wh/lbs 15 Wh/lbs @ -20C</td>
<td>311 Wh/lbs 304 Wh/lbs @ -20C</td>
<td>200 Wh/lbs TBD Wh/lbs @ -20C</td>
</tr>
<tr>
<td><strong>Volumetric Energy Density</strong></td>
<td>1.94 Wh/in$^3$ 1.90 Wh/in$^3$ @ -20C</td>
<td>2.07 Wh/in$^3$ 1.45 Wh/in$^3$ @ -20C</td>
<td>16.4 Wh/in$^3$ 16.1 Wh/in$^3$ @ -20C</td>
<td>11.5 Wh/in$^3$ TBD Wh/in$^3$ @ -20C</td>
</tr>
<tr>
<td><strong>Cost</strong></td>
<td>1.13 $/Wh 1.16 $/Wh @ -20C</td>
<td>0.187 $/Wh 0.27 $/Wh @ -20C</td>
<td>0.27 $/Wh 0.28 $/Wh @ -20C</td>
<td>0.11 $/Wh TBD $/Wh @ -20C</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>Rechargeable</td>
<td>Rechargeable</td>
<td>Not rechargeable</td>
<td>Not rechargeable</td>
</tr>
<tr>
<td><strong>Cold de-rate</strong></td>
<td>Very Low</td>
<td>Medium</td>
<td>Very Low</td>
<td>High to Medium</td>
</tr>
</tbody>
</table>
| **Notes** | • Very large number of charge cycles  
• Haz Cargo  
• New Technology | • Years of experience using | • Haz cargo  
• Long lead time  
• Replaced on regular schedule | • DC–DC Converter  
• Very temperature sensitive |
# Battery Chemistries at Taku Glacier

<table>
<thead>
<tr>
<th>Station</th>
<th>Chemistry</th>
<th># Batteries</th>
<th>SIU</th>
<th>Sensor</th>
<th>Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter 1</td>
<td>Alkaline</td>
<td>30x MN918</td>
<td>External</td>
<td>Compact</td>
<td>20W</td>
</tr>
<tr>
<td>Winter 2</td>
<td>Aircell</td>
<td>3x 6V 4AS10</td>
<td>External</td>
<td>Compact</td>
<td>20W</td>
</tr>
<tr>
<td>Winter 3</td>
<td>LTC</td>
<td>2x Custom Pack</td>
<td>External</td>
<td>Compact</td>
<td>20W</td>
</tr>
<tr>
<td>Winter 4</td>
<td>AGM</td>
<td>4x 108Ah</td>
<td>Internal</td>
<td>Compact</td>
<td>45W</td>
</tr>
<tr>
<td>Winter 5</td>
<td>LiFePO4</td>
<td>3x 100Ah</td>
<td>Internal</td>
<td>Compact</td>
<td>45W</td>
</tr>
<tr>
<td>Winter 6</td>
<td>AGM</td>
<td>8x 108Ah</td>
<td>Internal</td>
<td>120</td>
<td>45W</td>
</tr>
<tr>
<td>Winter 7</td>
<td>LiFePO4</td>
<td>6x 100Ah</td>
<td>Internal</td>
<td>120</td>
<td>2x 45W</td>
</tr>
</tbody>
</table>
Battery Results at Taku Glacier

Voltage

AGM, Meridian 120 2015 276 17:45 ZQ.GW6.VEI
Alkaline with DC-DC 2015 276 18:51 ZQ.GW1.VEI
LiFePO4, Meridian 120 2015 276 20:34 ZQ.GW7.VEI
AGM 2015 276 21:04 ZQ.GW4.VEI
Aircell with DC-DC 2015 276 22:34 ZQ.GW2.VEI
LiFePO4 2015 276 23:34 ZQ.GW5.VEI
LTC 2015 277 00:01 ZQ.GW3.VEI

Regulated Power

SOH Bug
Media
Taku Glacier
Air Alkaline Batteries

Due to increasing demand/interest in Air Alkaline Batteries, PASSCAL has been testing cells in a variety of conditions to verify characteristics.

**Pros**
- High energy density
- Inexpensive
- Non-hazardous (easy to ship)

**Cons**
- High Impedance (can’t source large amounts of current)
- Poor cold weather performance
- Require air supply
Air Alkaline Batteries

**DC-DC convertor:** In an attempt to bypass the cold weather limitations of Aircells, PASSCAL developed a DC-DC convertor to “trickle charge” a secondary battery capable of sourcing more current in the cold.

- Wide input range (13-50V)
- Can be programmed for max output of 50 to 600mA
- ~94% efficient when pulling from a 17V source to charge a 12.6V battery (AGM)
DC-DC Field Results

GIW1 (winter, with a LiFePO4 battery, and an alkaline external power box)
- Over ~29 days of low sunlight
- Maintained ~12.7V

GIW2 (winter, with a LiFePO4 battery, and an aircell external power box)
- Over ~29 days of low sunlight
- Maintained ~12.7V

GI01 (summer, with an AGM battery)
- Over ~5 days of low sunlight
- Dropped from ~12.4V to ~11.6 V.
- About half of the other comparable summer stations LVD’d.
Acknowledgements

NSF: National Science Foundation
IRIS: Incorporated Research Institutions for Seismology
NMT: New Mexico Tech