Bragg / Johnson
10/29/91

J r i s e n Space Center - Houston, Texas

Propulsion and Power Division

Preliminary Test Results for Li-SOCl₃ High-Rate "D" Cells

by
B.J. Bragg

and
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NASA Johnson Space Center

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AGENDA

- Background
- Test Results
  - Weight, OCV, and Load Check
  - Shock Test
  - Vibration Test
  - Capacity Performance
  - Uninsulated Short Circuit
  - High Temperature Exposure
  - Overdischarge
- Conclusions
Preliminary Test Results for Li-SOCl2 High-Rate "D" Cells

<table>
<thead>
<tr>
<th>Propulsion and Power Division</th>
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BACKGROUND

- Objective - Evaluate the performance and abuse characteristics of 55 D-Size lithium-thionyl chloride (Li-SOCl2) cells at relatively high rates.
- Cells developed by Electrochem Industries, Inc. under contract to the Jet Propulsion Laboratory.
- Cells manufactured in October 1989.
  - Li wt, - 3.44 g
  - Li anode area - 530 sq. cm
  - 1 anode tab - 0.25" w X 0.005" thk.
  - Electrolyte - 1.8M LiAlCl4 in SOCl2 - 44-45 g
- Cathode (carbon) wt. - 5.2 g
- Cathode thk. - 0.025"
- 2 cathode tabs - 0.125"w X 0.005"thk.
- 55 cells delivered to JSC
  - 39 used in this test program
  - 14 cells discharged in calorimetry testing
  - 2 held as spares
TEST RESULTS

- Weight Check: 121.31 - 122.79 grams

- Open Circuit Voltage: 3.658 - 3.662 VDC

- Load Check Voltage (5 ohm load for 90 sec.): 3.045 - 3.176 VDC
  - None of the cells met 3.50 VDC minimum.
  - Cells were almost two years old.

- Shock Test (2 Cells)
  - Sawtooth shock pulse, 20 g peak with a $11 \pm 1$ millisecond rise and a $1 \pm 1$ millisecond decay.
  - Results: No change in OCV
• Vibration Test (3 Cells)
  • Random vibration for 15 minutes in each of 3 mutually perpendicular axes according to the following spectrum:

<table>
<thead>
<tr>
<th>Frequency (Hz)</th>
<th>Level</th>
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</thead>
<tbody>
<tr>
<td>20 to 80</td>
<td>+3 dB/octave</td>
</tr>
<tr>
<td>80 to 350</td>
<td>0.1 g^2 / Hz</td>
</tr>
<tr>
<td>350 to 2000</td>
<td>-3 dB/octave</td>
</tr>
</tbody>
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• Results: No change in OCV.
### Preliminary Test Results for Li-SOCl\(_2\) High-Rate "D" Cells

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**Capacity Performance (32 Cells)**
- Ah to 1.5 VDC

<table>
<thead>
<tr>
<th>-40°F, 2 ohm load</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Cells</td>
</tr>
<tr>
<td>4.10 - 4.98 Ah</td>
</tr>
<tr>
<td>Avg. 4.52 Ah</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Room Temperature, 1 ohm load</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 Cells</td>
</tr>
<tr>
<td>10.38 - 10.75 Ah</td>
</tr>
<tr>
<td>Avg. 10.57 Ah</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>160°F, 1 ohm load</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 Cells</td>
</tr>
<tr>
<td>9.48 - 9.61 Ah</td>
</tr>
<tr>
<td>Avg. 9.55 Ah</td>
</tr>
</tbody>
</table>

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<tr>
<th>Room Temperature, 2 ohm load</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Cells</td>
</tr>
<tr>
<td>10.42 - 11.11 Ah</td>
</tr>
<tr>
<td>Avg. 10.7 Ah</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>160°F, 2 ohm load</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 Cells</td>
</tr>
<tr>
<td>9.45 - 9.75 Ah</td>
</tr>
<tr>
<td>Avg. 9.61 Ah</td>
</tr>
</tbody>
</table>
Li-SOCl₂ High Rate "D" Cell
One ohm discharge at room temperature to 1.5 volt
Li-SOCl$_2$ High Rate "D" Cell

Two ohm discharge at room temperature to 1.5 volt
Li-SOCl₂ High Rate "D" Cell

Two ohm discharge at room temperature to 1.5 volt
Li-SOCl₂ High Rate "D" Cell

One ohm discharge at 160°F to 1.5 volt
Li-SOCl$_2$ High Rate "D" Cell

Two ohm discharge at 160°F to 1.5 volt
Preliminary Test Results for Li-SOCl2 High-Rate "D" Cells

- Uninsulated Short Circuit (3 Cells)
  - Cell S/N 048396
    - Load: 0.75 ohm
    - Maximums: 0.27 VDC, 30 Amp, 118°F
    - Duration: 11 seconds until internal lead fused.
    - Post-test: 0.396 V on 100 ohm load
  - Cell S/N 048422
    - Load: 1.20 ohm
    - Maximums: 1.21 VDC, 25.2 Amp, 198°F
    - Duration: 4 min 42 sec until internal lead fused.
    - Post-test: 0.18 V on 20 ohm load
Li-SOCl₂ High Rate "D" Cell
Uninsulated short circuit test
Cell S/N 048422 on 0.12 ohm load
Li-SOCl₂ High Rate "D" Cell
Uninsulated short circuit test
Cell S/N 048422 on 0.12 ohm load

Cylinder wall temperature (°F)

Time (sec)
Preliminary Test Results for Li-SOCl2 High-Rate "D" Cells

- Cell S/N 048439
  - Load: .120 ohm
  - Maximums: 1.21 VDC, 25 Amp, 130°F
  - Duration: 1 min 43 sec until internal lead fused.
  - Post-test: No OCV

- High Temperature Exposure
  - Cells tested for one hour at 225, 250, 275, and 300°F.
  - No leakage was found on any of the cells one week after high temperature exposure.
Preliminary Test Results for Li-SOCl2 High-Rate "D" Cells

- Overdischarge; 2 Weeks Post-Discharge (6 Cells)
  - With Shunt Diodes
    - 1.5 A at 160°F
    - No cells vented, max temperature 209.4°F
  - Without Shunt Diodes
    - 1.5 A at 160°F to 245°F: Chamber temp. control drifted during test.
    - One cell vented at 19 hours and 3 cells at 19.25 hours, max temperature 348.7°F
- Overdischarge; 4 Weeks Post-Discharge (6 Cells)
  - With Shunt Diodes
    - 1.5 A at 160°F
    - No cells vented, max temperature 226.4°F
  - Without Shunt Diodes
    - 1.5 A at 160°F
    - One cell vented at 1.6 hours, max temperature 328.8°F
Li-SOCl₂ High Rate "D" Cell

Two week post-discharge overdischarge without shunt diodes

1.5 A at 160°F
Li-SOCl₂ High Rate "D" Cell
Two week post-discharge overdischarge without shunt diodes
1.5 A at 160°F

Chamber temperature controller drifted from 160 to 250°F during testing
Li-SOCl$_2$ High Rate "D" Cell

Four week post-discharge without shunt diodes

1.5 A at 160°F
Li-SOCl₂ High Rate "D" Cell
Four week post-discharge overdischarge without shunt diodes
1.5 A at 160°F
CONCLUSIONS

- Take note of presented capacity to 1.5 volt end voltage.
  - RT data, in particular, shows gradual decline from 3 v to 1.5 v.
  - Final report will compare fresh capacities at higher end voltages.
- Overdischarge Tolerance
  - Data taken after a 2-week interval of OCV was very tolerant.
  - Data taken after a 4-week interval vented very quickly.
  - Susceptibility to venting on overdischarge increases with length of OCV interval after discharge.
  - By-pass diodes protect the cell from this effect.
Nickel-Cadmium Technologies Session

Organizers: Dean Maurer
AT&T

Larry Thaller
The Aerospace Corporation