High Specific Energy Primary Batteries for NASA Missions

National Aeronautics and Space Administration

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Technology

$Li + CF_x \rightarrow LiF + C + heat$

- Recent significant investments by Europa Lander project advanced the technology
- High capacity anode (Li) and cathode (CF_x)
- Standard D-cell format similar to heritage designs
- Low mass aluminum packaging
- Cell chemistry is highly exothermic, for cell self-heating in cold environments

EaglePicher

Rayovac

Applications

- Gas and ice giants atmospheric probes
- Mars, Small Body and Ocean Worlds landers, probes, impactors and penetrators
- Lunar probes and lunar night survival

Comparison of SOA vs. Advanced Cells

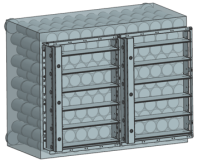
Cell Chemistry	Vendor	Part Number	Format	Specific Energy, Wh/kg (20ºC, 50 mA)
Li/SO_2	Saft	LO 26 SXC	D cell	420
$Li/SOCl_2$	Saft	LSH 20	D cell	421
Li/MnO_2	Ultralife	CR15270	D cell	250
Li/FeS_2	Energizer	L91	AA cell	350
Li/CF_x-MnO_2	EaglePicher	LCF-133 (COTS and modified)	D cell	514
Li/CF_x	Rayovac	Europa Lander Developmental	D cell	730
Li/CF_x	EaglePicher		D cell	741

Benefits

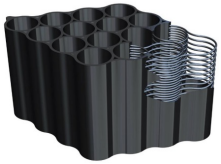
- **High specific energy (650-770 Wh/kg)**
  - For long run time / low mass power
- **Minimal voltage delay**
  - Potential to eliminate depassivation circuitry
- **Heat generation (~1:1 ratio of heat/power)**
  - Reduce or eliminate external heating

Low self-discharge (~1% annually)

- **High radiation tolerance with minimal loss in capacity up to 10 Mrad total ionizing dose levels**

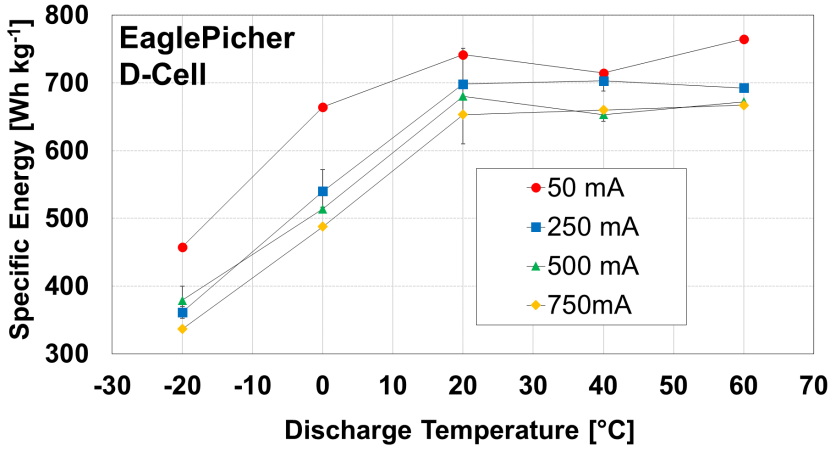


12.5 kWh battery module
~500 Wh/kg design



JPL additively manufactured battery module with heat pipes

Wide Temperature Operation



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