COTS Li-ion Cells; How rugged are new designs?

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Preliminary Draft

Outline

- Introduction and purpose
- COTS cell designs tested
- Test Plan
- Cell Quality Assessment
  - Capacity cycling pre & post vibration
  - Cell DPA
- Summary Conclusions

Current Batteries Supporting Space Walks

Pistol Grip Tool (PGT) Battery
Nickel Metal Hydride (NiMH)

Helmet Light (EHIP) Battery
Nickel Metal Hydride (NiMH)

Long Life Battery (LLB) for EMU
Lithium ion (Li-ion)

Rechargeable EVA Battery Assembly (REBA)
Nickel Metal Hydride (NiMH)

Simplified Aid For EVA Rescue (SAFER) Battery
Lithium Manganese Dioxide (Li-MnO_2)

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All made with commercial cylindrical cell designs, none are pouch construction

Objective & Rationale

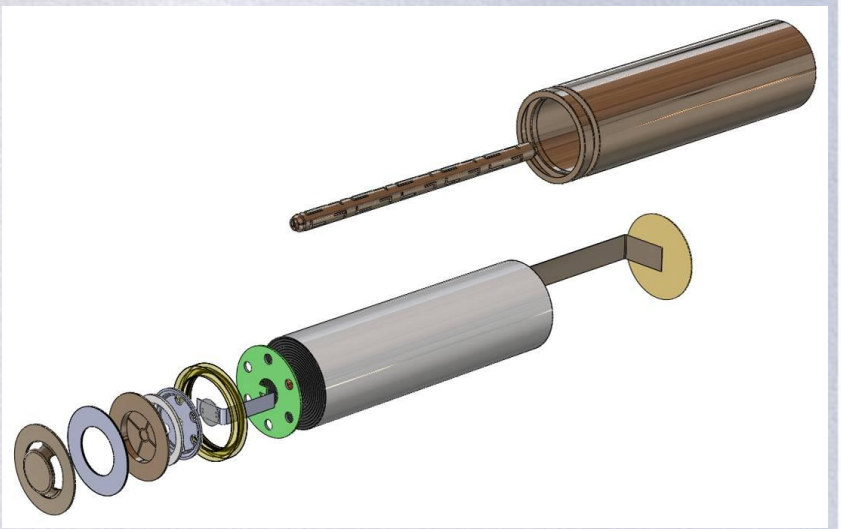
- Introduction
  - Orion LAS found shock & vibration limitations with a COTS 18650 cell design from Sanyo
  - Several new NASA applications have very high vibration requirements
- Objective
  - Can current high energy COTS Li-ion cell designs tolerate rigorous random vibration levels?
- Rationale
  - COTS Li-ion cell designs offer high performance, reliability, and consistency at a low cost
  - The Aerospace battery community will benefit from knowing the mechanical environment limitations of COTS Li-ion cell designs

New COTS Cell Designs Evaluated

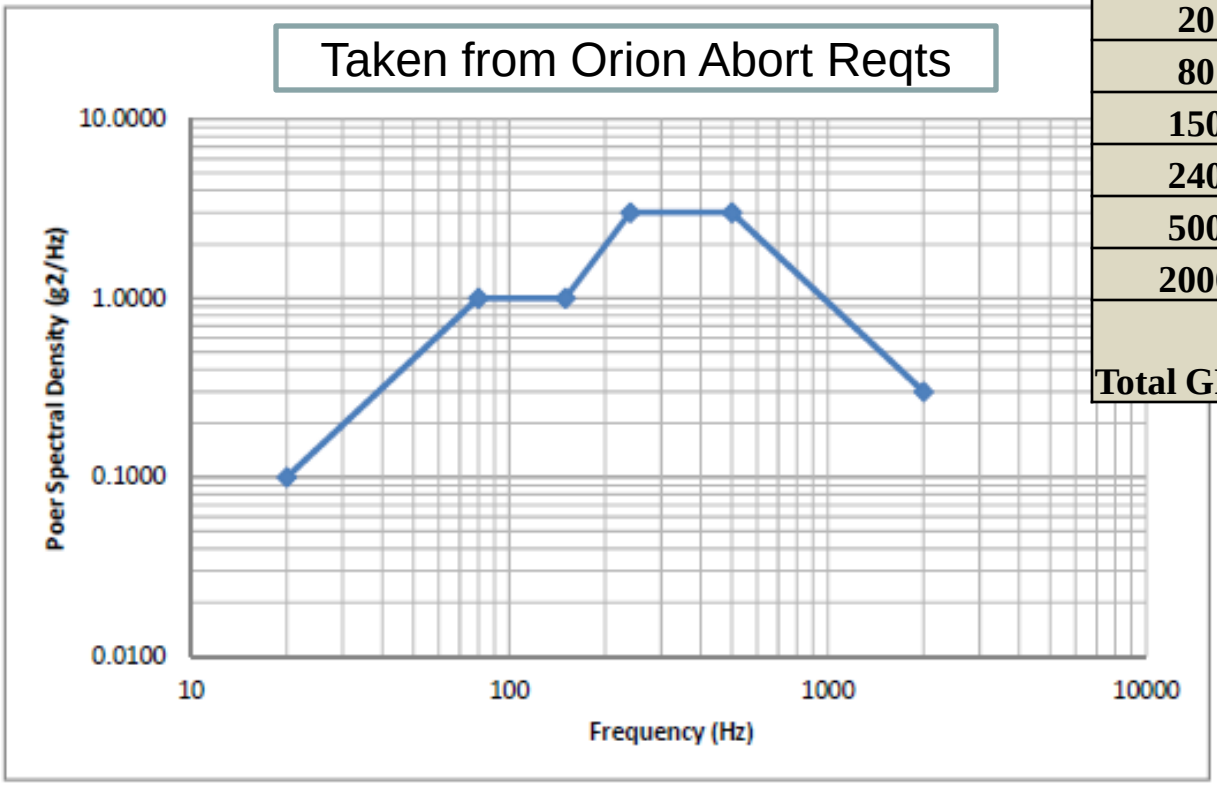
Cell Manufacturer	Cell Model	Cell Capacity (mAh)	Virtual Cell Capacity (Ah)	Heritage & Rationale
LG Chem	ICR18650 B4	2600	39	Highest Wh/L with SS can
E-One Moli Energy	ICR18650J	2400	36	LLB cell
Panasonic	NCR-18650A	3100	46.5	SpaceX cell, Highest Wh/L of all
Samsung	ICR-18650-26F	2600	39	Very high Wh
Sony	18650V3	2250	33.75	Good mix of power/energy, no PTC
Boston Power	Swing 5300	5300	39.75	Larger format, good mix of Wh/W, no PTC

Test Plan

- Procure lots of 20 cells for each cell design
- Use existing, proven 18650 vibration fixture
- Design & fabricate BP vibration fixture
- Receiving Inspection of all cells (120 in total), 20 per design
- Perform capacity cycling on all 120
- Vibrate 3 cells per design at each level
  - Level 1: Baseline Level
  - Level 2: Repeat with 3 fresh cells per design to Baseline + 3 dB
  - Level 3: Repeat with 3 fresh cell per design to Level 2 + 3 dB
- Perform post vibration capacity cycling
- Perform fully DPA on one cell from each design
- Perform abbreviated DPA on every cell
  - Cut open the tops and bottoms only to verify electrical connectivity of jellyroll to Enclosure
- Document results in Task History



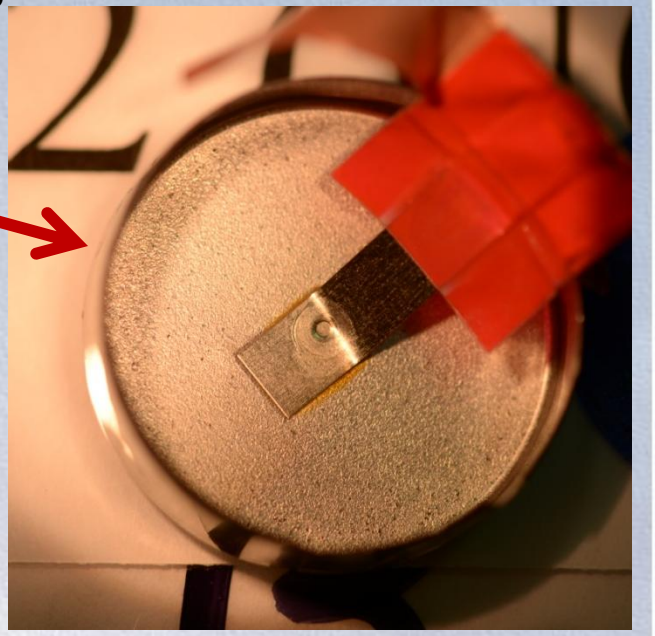
Level 2 Vibration Spectrum



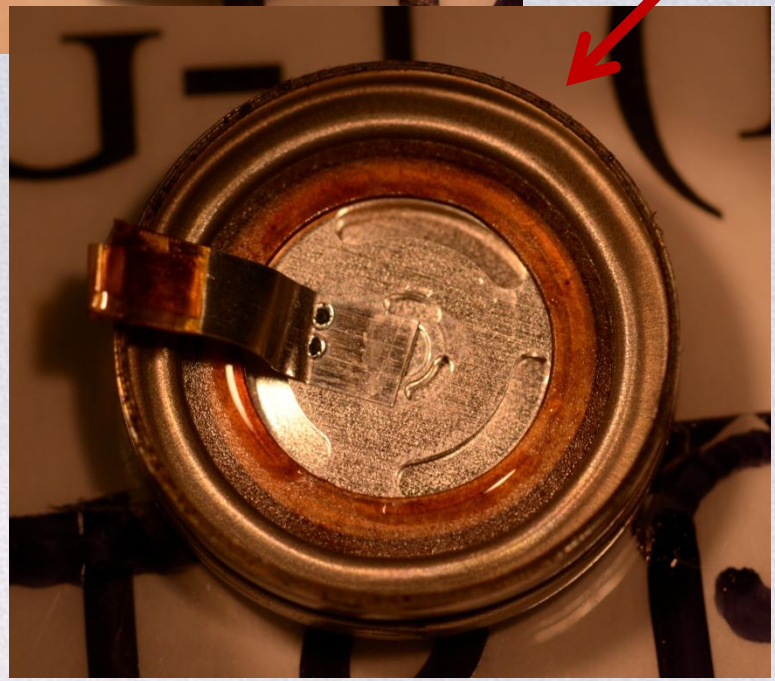
Vibration Spectrums			
Frequency (Hz)	Baseline PSD (g^2/Hz)	Level 2 (g^2/Hz)	Level 3 (g^2/Hz)
20	0.05	0.1	0.2
80	0.5	1	2
150	0.5	1	2
240	1.5	3	6
500	1.5	3	6
2000	0.15	0.3	0.6
Total GRMS	34.73	49.12	69.46

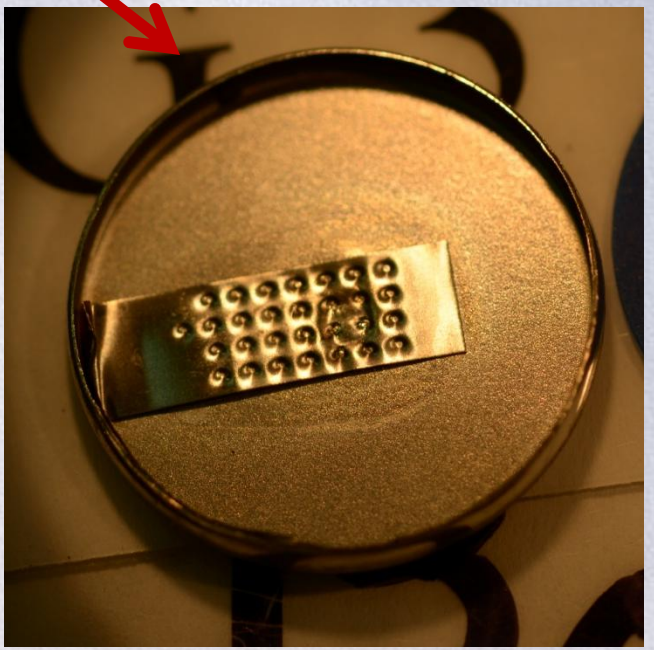
Post Vibration Cell DPA showing positive and negative tab connections

Panasonic NCR-18650A (3.1Ah)



LG ICR18650B4 (2.6Ah)





Summary

- All cells (54) passed the intensive vibration levels
  - Level 3 exposed cells to 69 grms over 20-20,000 Hz
  - OCV pre and post vibration did not vary > ± 5 mV
  - Capacity performance pre and post vibration did not vary > 1 %
  - Abbreviated cell DPA after vibration indicated that all internal tab connections from the electrode jellyroll to the top/bottom of cell enclosure show no signs of fatigue
- Full cell DPA revealed unique features of each cell design and overall quality of manufacturing

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