Performance and Safety of COTS 18650 Li-ion Cells from Various Manufacturers

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Outline

• Cell Characteristics
• Performance of Panasonic Cells
• Safety of Panasonic Cells
• Performance of Moli STOBA cells
• Safety of Moli STOBA cells
• Performance of LG cells at Different Temperatures
18650 Lithium-ion cells

Panasonic 3.1 Ah

LG 2.8 Ah

Moli STOBA 2.0 Ah
Panasonic 3.1 Ah Li-ion 18650 Cell

Performance and Safety Test Data
Panasonic 3.1 Ah Li-ion 18650 Cell

- **Sample 1**
  - Ch: C/2
  - Disch: C/2
  - Cycle 1: 2.93 Ah
  - Cycle 300: 2.54 Ah
  - Cap. Change: -13.3%
  - Re Change: -5.8%

- **Sample 2**
  - Ch: C/2
  - Disch: C/5
  - Cycle 1: 3.0 Ah
  - Cycle 250: 2.62 Ah
  - Cap. Change: -12.7%
  - Re Change: -1.5%

- **Sample 3**
  - Ch: C/2
  - Disch: 1C
  - Cycle 1: 2.9 Ah
  - Cycle 300: 2.6 Ah
  - Cap. Change: -10.3%
  - Re Change: +0.88%
Panasonic Li-ion 3.1 Ah 18650 Cell

- Sample 1
  - Ch: C/5
  - Disch: 1C
  - Cycle 1: 2.92 Ah
  - Cycle 300: 2.64 Ah
  - Cap. Change: -9.6%
  - Re Change: +0.86%

- Sample 1
  - Ch: C/5
  - Disch: C/5
  - Cycle 1: 2.98 Ah
  - Cycle 200: 2.66 Ah
  - Cap. Change: -10.7%
  - Re Change: -14.4%

- Sample 1
  - Ch: C/5
  - Disch: C/2
  - Cycle 1: 2.95 Ah
  - Cycle 250: 2.63 Ah
  - Cap. Change: -10.8%
  - Re Change: -0.6%

- Sample 2
  - Ch: C/5
  - Disch: C/10
  - Cycle 1: 3.03 Ah
  - Cycle 125: 2.85 Ah
  - Cap. Change: -5.9%
  - Re Change: -16.4%
Panasonic 3.1 Ah Li-ion 18650 Cell

Cap. Change: -11.9%
Re Change: +0.54%

Cap. Change: -20.5%
Re Change: -1.8%

Sample 2
Ch: 1C
Disch: 1C
Cycle 1: 2.88 Ah
Cycle 300: 2.45 Ah

Sample 2
Ch: 1C
Disch: C/2
Cycle 1: 2.93 Ah
Cycle 300: 2.33 Ah
Panasonic 3.1 Ah Li-ion 18650 Cell

Performance Capabilities at 0°C

- Charge and Disch: C/5
- Cap Change: -5%
- -15% of RT

Performance Capabilities at -20°C

- Charge and Disch: C/5
- Cap Change: -80%
- -53% of RT

Performance Capabilities at -10°C

- Charge and Disch: C/5
- Cap Change: -54%
- -21% of RT

Performance Capabilities at 30°C

- Charge and Disch: C/5
- Cap Change: -3.9%
- 3.5% of RT
Panasonic 3.1 Ah Li-ion 18650 Cell

Performance Capabilities at 40°C

Cap Change: -3.2%
4.5% of RT
Panasonic 3.1 Ah Li-ion 18650 Cell
Panasonic 3.1 Ah 18650 Li-ion Cell

**Over-Charge 8 Series at 1 C current**

- Max Voltage = 41.13 V
- Cell #1, #3, #5, #7 CID activated creating open circuit

**Test C1: Over-Charge Test Cell 5 of 8 Cells in Series**

- Max Temp = 57.26 °C
- Max Voltage = 5.10 V
- CID activated
Panasonic 3.1 Ah Li-ion 18650 Cell

Over-Discharge to 0 V

Peak Temperature = 58.22 °C

Normal Cycle Charge

Normal Cycle Charge Failed

Discharge to 1 V

Discharge to 0 V

Time (h:mm:ss)
Panasonic 3.1 Ah Li-ion 18650 Cell

External Short (10 mohms)

2 hours

Max Current = 76.48 A
Max Temperature = 62.02 °C

4 hours

Max Current = 90.06 A
Max Temperature = 72.82 °C
Panasonic 3.1 Ah Li-ion 18650 Cell Series String External Short (10 mohms)
Panasonic 3.1 Ah Li-ion 18650 Cell

Simulated Internal Short with .125" Rod

Max Temp Prior to Fire = 44.15 °C

Voltage (V)

Time (h:mm:ss)

Voltage  Temperature
Panasonic 3.1 Ah Li-ion 18650 Cell

Heat-to-Vent

- Voltage
- Temperature

Fire at 188.63°C
Moli STOBA 2.0 Ah Li-ion 18650 Cell

Performance and Safety Test Data
Moli STOBA 2.0 Ah Li-ion Cell

- **C/2 Charge / C/1 Discharge**
  - Cap. Change: -6.3%
  - Re Change: +7.96%

- **C/2 Charge / C/5 Discharge**
  - Cap. Change: -9.7%
  - Re Change: +26.7%

- **C/2 Charge / C/10 Discharge**
  - Cap. Change: -11.6%
  - Re Change: +13.98%
Moli STOBA 2.0 Ah Li-ion Cell

C/5 Charge / 1C Discharge
Cap. Change: -6.3%
Re Change: +11.2%

C/5 Charge / C/5 Discharge
Cap. Change: -5.1%
Re Change: +1.5%

C/5 Charge / C/2 Discharge
Cap. Change: -6.8%
Re Change: +10.5%

C/5 Charge / C/10 Discharge
Cap. Change: -1.97%
Re Change: 0%
Moli STOBA 2.0 Ah Li-ion Cell

C/1 Charge / C/1 Discharge
Cap. Change: -8.8%
Re Change: 16.3%

1C Charge / C/2 Discharge
Cap. Change: -9.8%
Re Change: 11.23%
Moli STOBA 2.0 Ah Li-ion Cell

Performance Capabilities at 0°C

< 17.1% of RT

Performance Capabilities at -20°C

< 39.75% of RT

Performance Capabilities at -10°C

< 26.2% of RT

Performance Capabilities at 30°C

< 3.2% of RT
Moli STOBA 2.0 Ah Li-ion Cell

Performance Capabilities at 40°C

> 4.8% of RT

Internal Resistance

Depth of Discharge (%) vs. Internal Resistance (mΩ)
Moli STOBA 2.0 Ah Li-ion Cell
Moli STOBA 2.0 Ah Li-ion Cell
Moli STOBA 2.0 Ah Li-ion Cell

Temp Ramp Rate: 1.5 deg C/min.
Moli STOBA 2.0 Ah Li-ion Cell

Vent and Burst Pressure Test Data

Sample 14 vent opened at a pressure of 155 psi.
Sample 15 vent opened at a pressure of 145 psi.

Sample 10 burst at a pressure of 859 psi. Failure around crimp seal.
Sample 11 burst at a pressure of 645 psi. Failure around crimp seal.
LG 2.8 Ah Li-ion 18650 Cell

Performance at Various Temperatures
LG 2.8 Ah Li-ion 18650 Cell

Disch Capacity at
23 deg C: 1.53 Ah
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