

78th Lithium Battery Technical/Safety Group Meeting

Performance and Abuse Testing of Tadiran TLM-1550 Series Cells/Batteries

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- **Requirements Overview**
- **Battery Design**
 - **Tadiran TLM-1550 Series Specs**
- **Electrical Testing Results**
- **Abuse/Safety Testing Results**
- **Shock and Vibration Testing Results**
- **Summary**
- **Future Plans**



Mechanical & Environmental Requirements

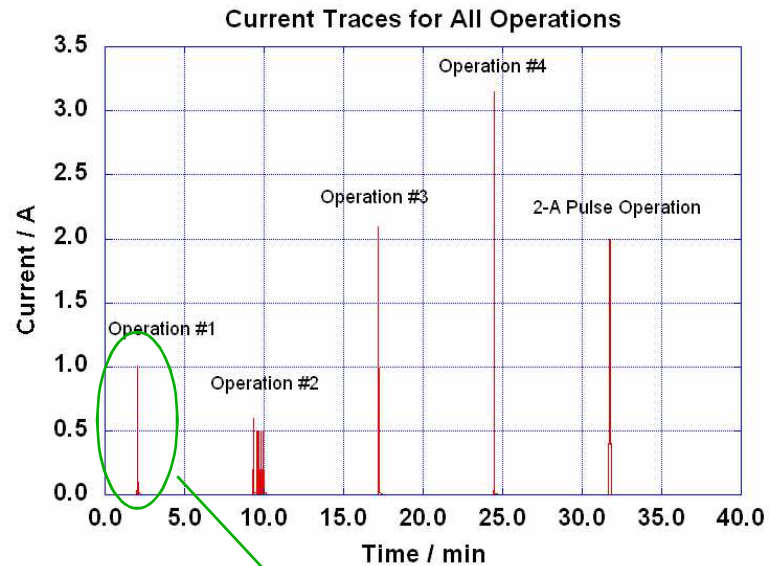
- **Package Size**
 - **No larger than:**
 - **3.00” Long by 3.75” Wide by 2.25” Deep**
 - **Dimensions of entire package including batteries**
 - **Package also contains ancillary circuitry**
 - **Space for cells is approximately 2.5” X 3.5” X 2”**
- **Mechanical Shock/Vibration**
 - **Capable of withstanding transportation type loads**
- **Temperature**
 - **Operating Environment**
 - **High: 60 °C**
 - **Low: -10 °C**
 - **Non-Operating Environment**
 - **High: 60 °C**
 - **Low: -25 °C**
- **Safety**
 - **Present no safety hazards to operating personnel**

Electrical Requirements

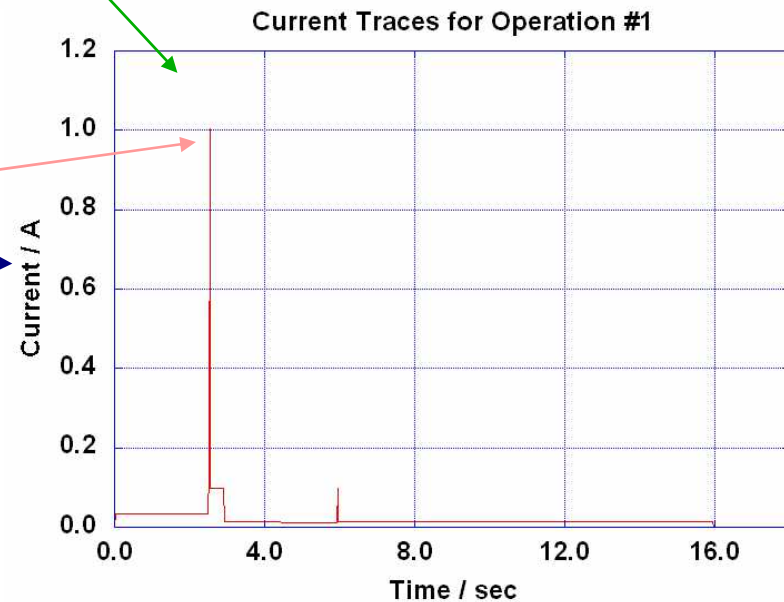
Load Profiles of Operations

- Voltage requirements at open circuit and under load
 - Upper: 32.5 V
 - Lower: 24.7 V
- Five load profiles

Operation #1	
Duration	Load
2.5 s	1066 mW
2 ms	143 mA
34 ms	30 Ω
366 ms	98 mA
3 s	373 mW
12 ms	30 Ω
23 ms	98 mA
10 s	426 mW



Peak Load



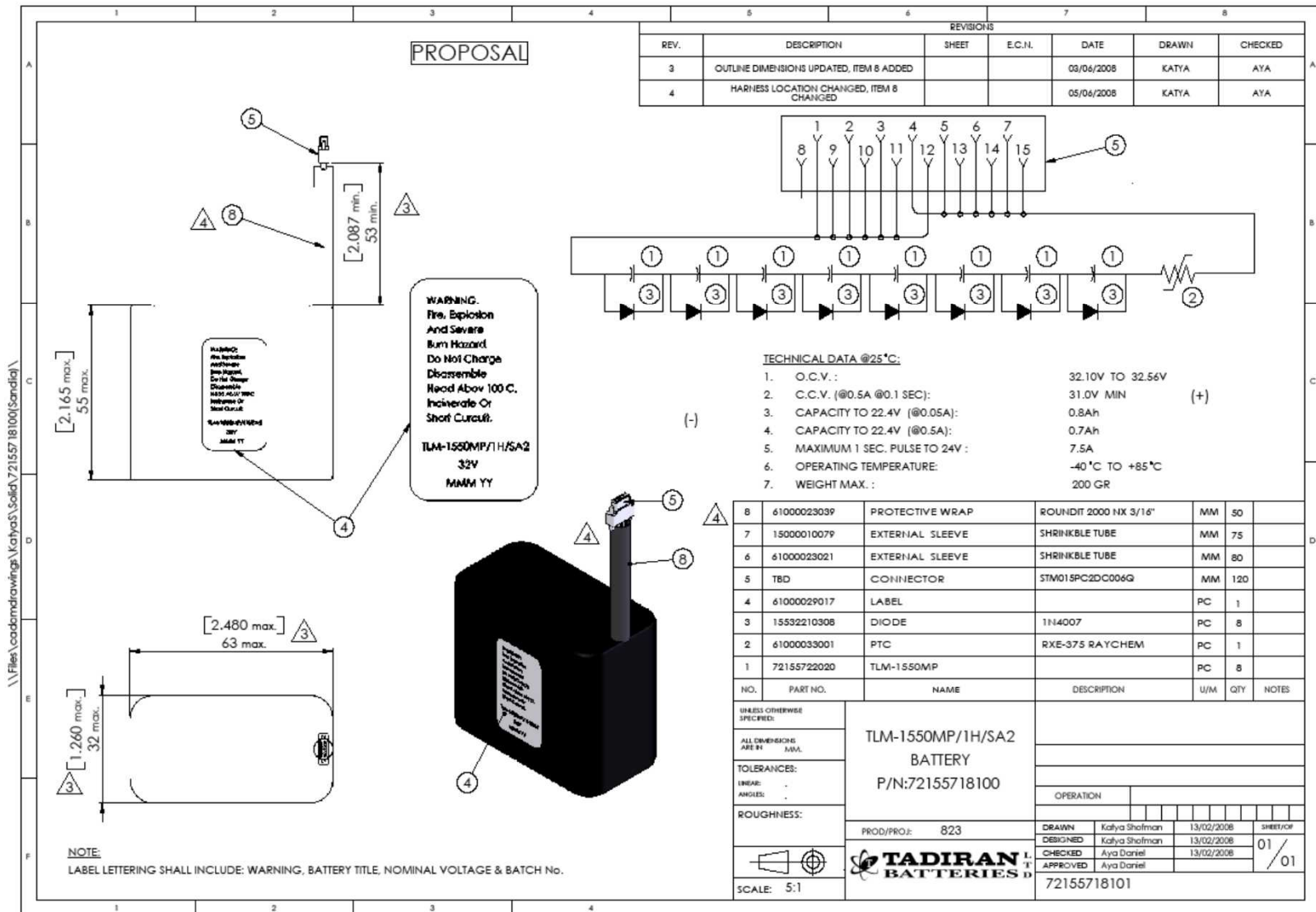
- **Baseline Cell**

- Tadiran TLM-1550 (AA size cell)
 - High Power (HP)
 - Medium Power (MP)
- Li-CoNiO₂ primary cells

- **Baseline Battery Design**

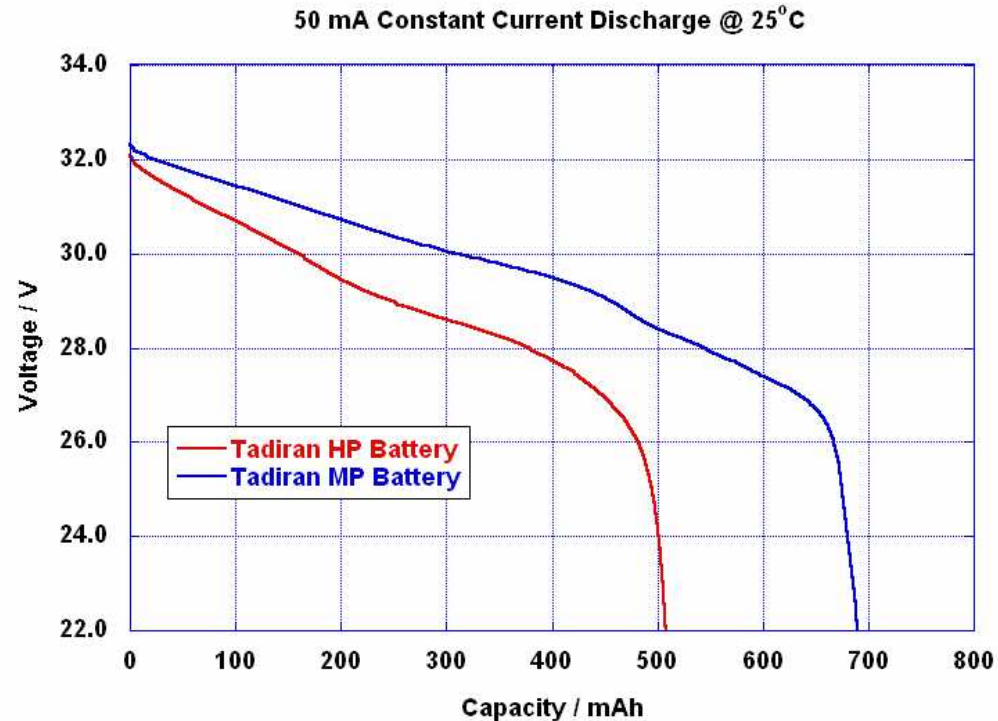
- 1x8 Series Configuration
 - 32 V
- Size of 1X8 Series Configuration
 - 2.17” Long by 2.48” Wide by 1.26” Deep

Tadiran Manufacturing



Tadiran TLM-1550 Specs

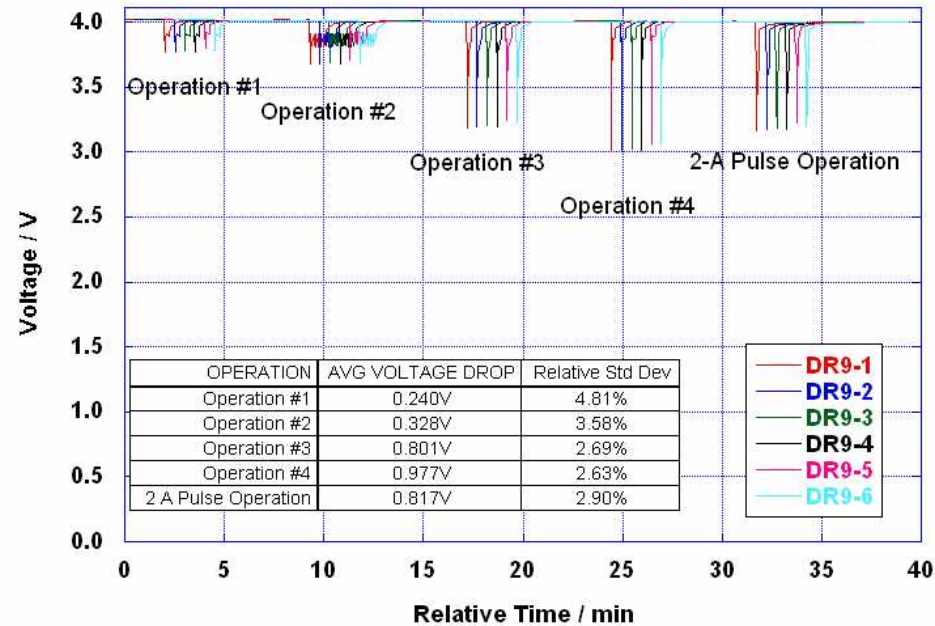
- **Physical Characteristics - AA-size**
 - Length: 51 +0/-1 mm
 - Diameter: 14.8 ± 0.3 mm
 - Weight: 20 g max
- **Electrical Characteristics**
 - OCV of 3.95 - 4.07 V
 - Operating voltage of 4.00 - 2.80 V
 - Max discharge current
 - Continuous: 5 A
 - Pulse: 15 A
 - Nominal Discharge Capacity at 50 mA @ RT to 2.8 V
 - HP Series: 550 mAh
 - MP Series: 800 mAh
- **Safety Characteristics**
 - Internal shutdown separator
 - External PTC on MP series cells
- **Operating Temperature of -40 °C - 85 °C**



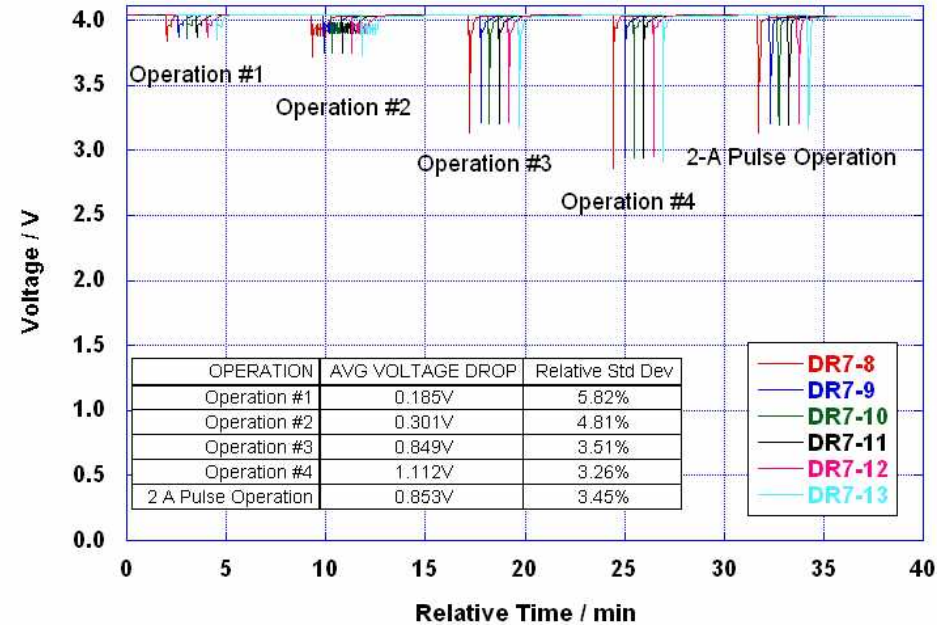
Reproducibility of Tadiran Cells

Tadiran TLM-1550-MP/HP Cells

Tadiran TLM-1550-HP Cell -10°C



Tadiran TLM-1550-MP Cell -10°C
PTC Included in Measurement - Spot Welded

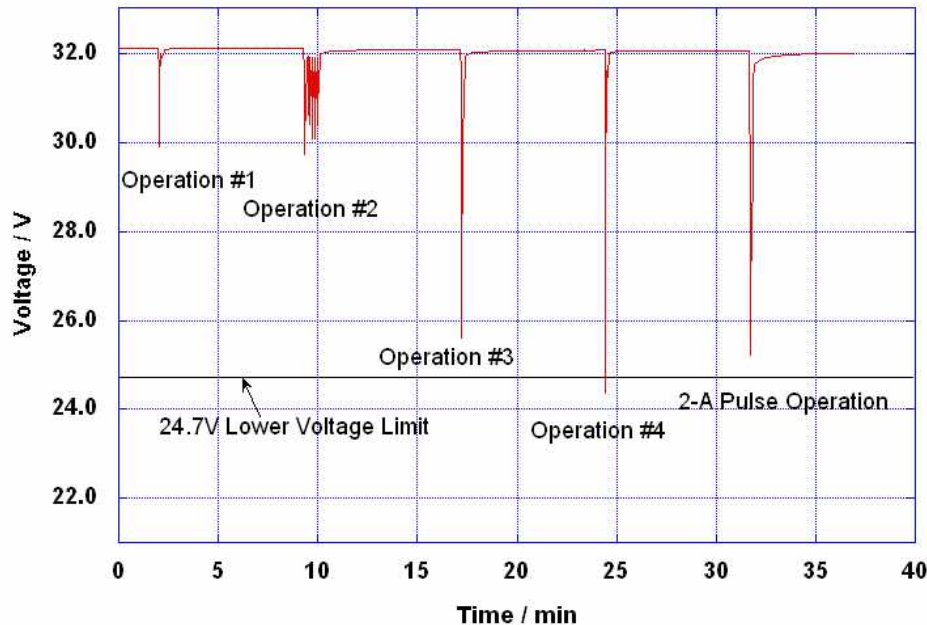


- Evaluation of six cells @ -10 °C
 - All five operations were conducted
 - Allows for assessment of battery voltage drop
- Small relative standard deviation

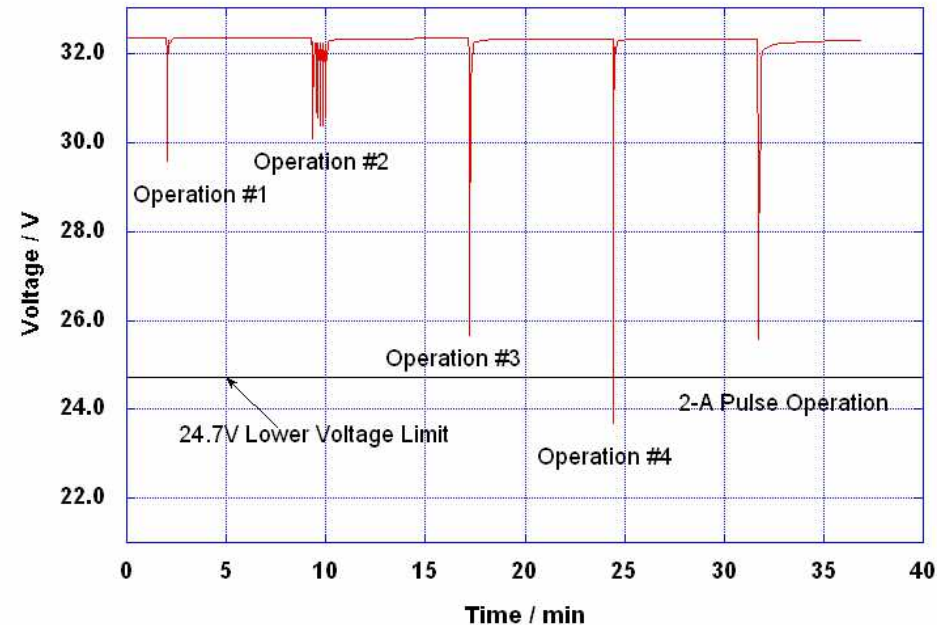
Behavior of Tadiran Battery Packs

Tadiran TLM-1550-MP/HP Batteries

Tadiran TLM-1550-HP Battery @ -10°C



Tadiran TLM-1550-MP Battery w/PTC @ -10°C

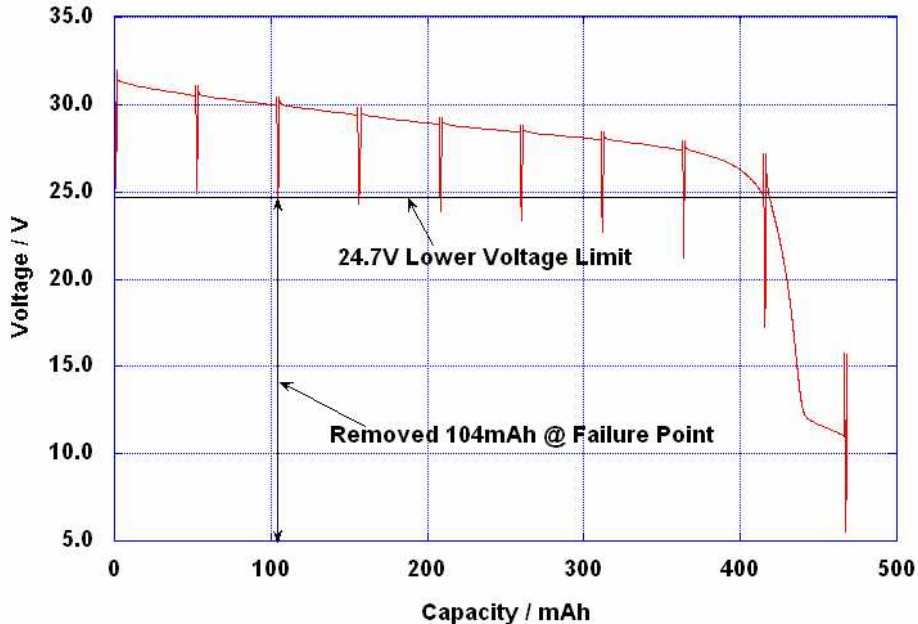


- Evaluation of two battery packs @ -10 °C
 - Battery packs consist of 8 MP or HP type cells in series
 - MP Battery packs incorporate an individual PTC on each cell
 - All five operations were conducted

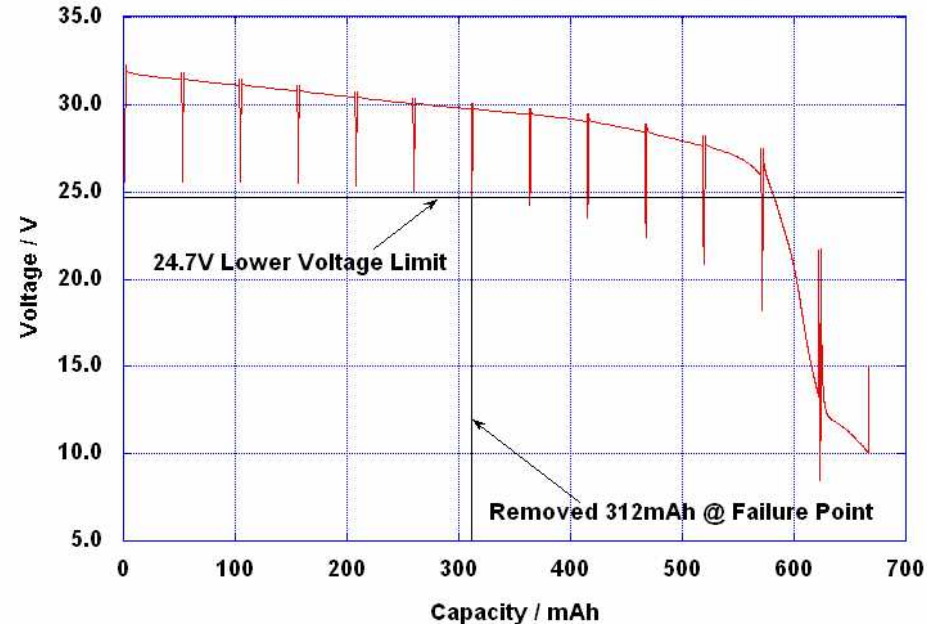
Behavior of Tadiran Battery Packs

Tadiran TLM-1550 HP & MP Batteries

Tadiran TLM-1550-HP Battery @ -10°C
Discharge Test with Periodic 2-A Pulse Profile



Tadiran TLM-1550-MP Battery w/PTC @ -10°C
Discharge Test with Periodic 2-A Pulse Profile



- 50 mA constant current discharge with periodic 2-A Pulse Operation @ -10 °C
- Allows for assessment of max number of operations

Short Circuit Testing

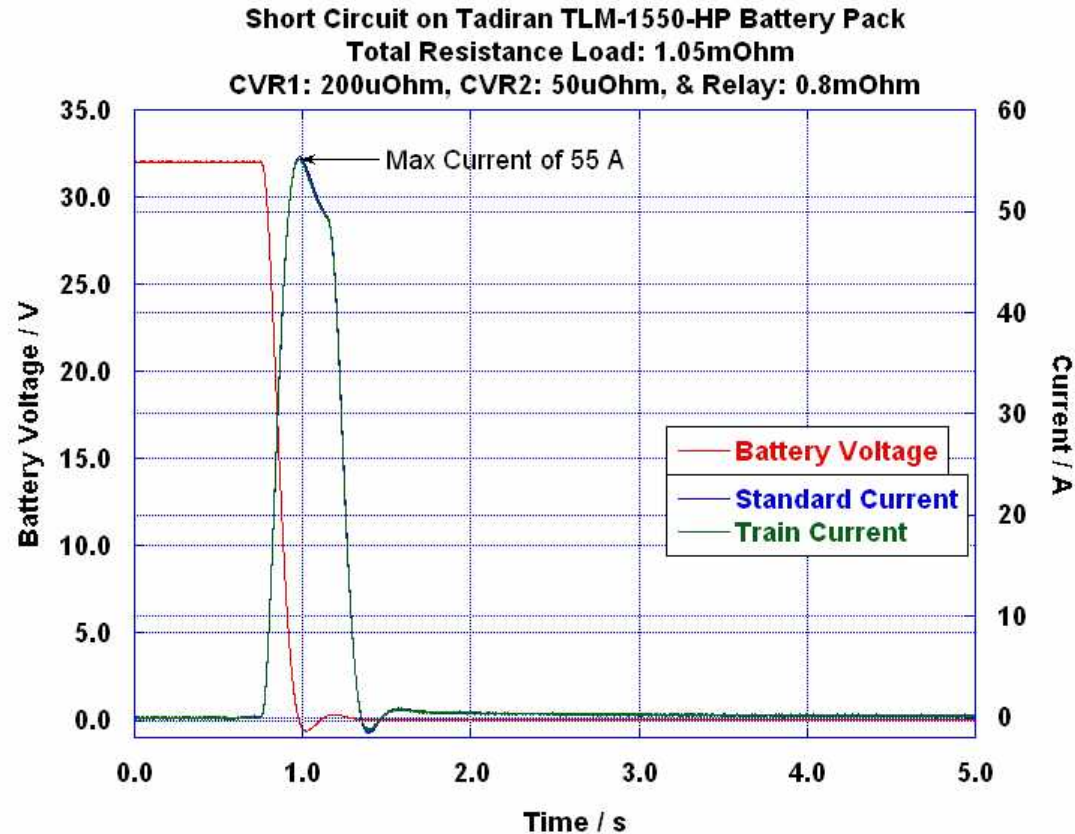
Tadiran HP Battery

- Short Circuit Test on Tadiran HP Battery Pack

- Total res. load of 1.05 mOhm
- Peak current of 55 A
- One cell Vented and Sparked
 - *No* fire or explosion
- Battery Voltage Recovered to ~30 V after removal of load
 - Signs of internal safety device

- Second Test was Performed on New Battery

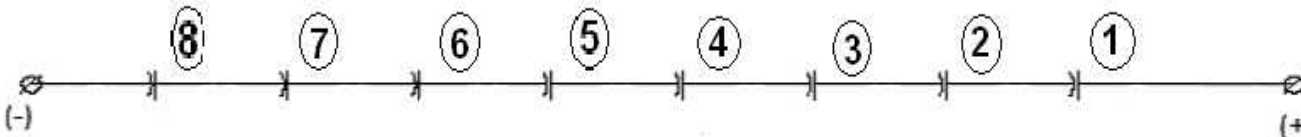
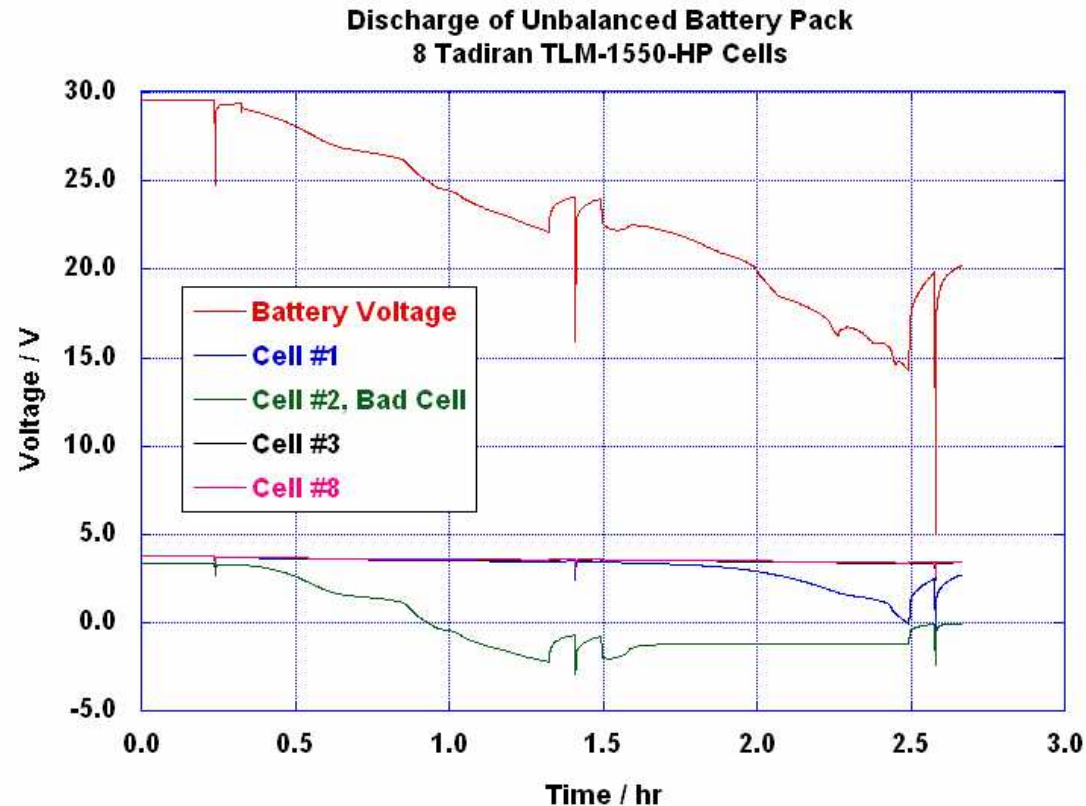
- Produced equivalent results
 - No cells vented or sparked



Discharge of Unbalanced String

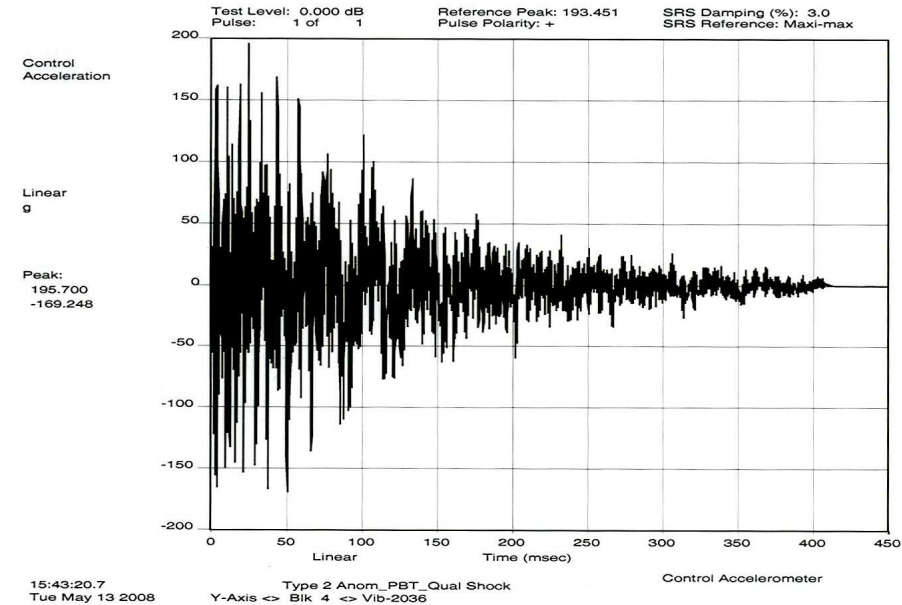
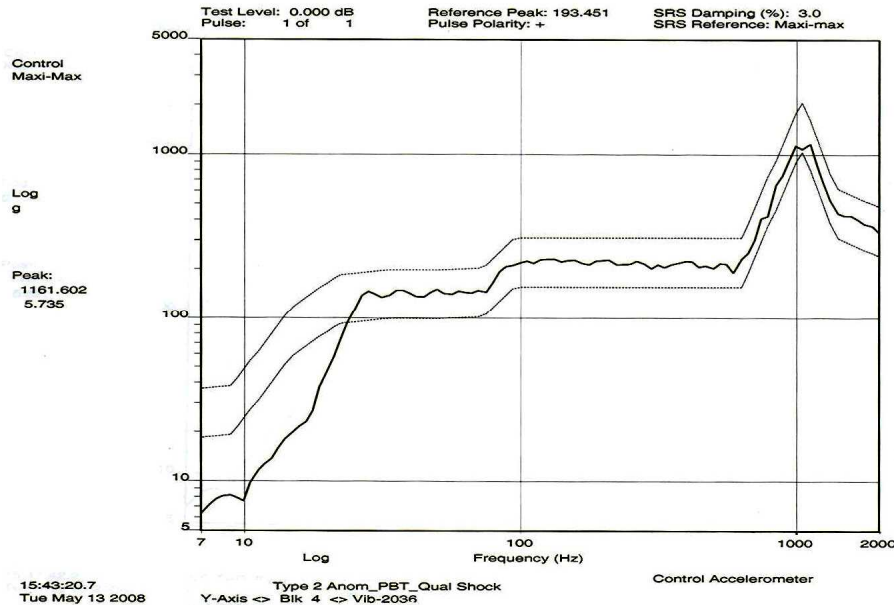
Tadiran HP Battery

- Discharge of Unbalanced Battery String
 - 50 mA discharge with periodic 2-A Pulse Operation
 - 2nd Cell was ~ 90 % discharged
 - Remaining 7 cells were ~ 10 % discharged
- 2nd cell went into reversal
 - -2.9 V
- Battery pack showed no signs of venting



Vibration Testing

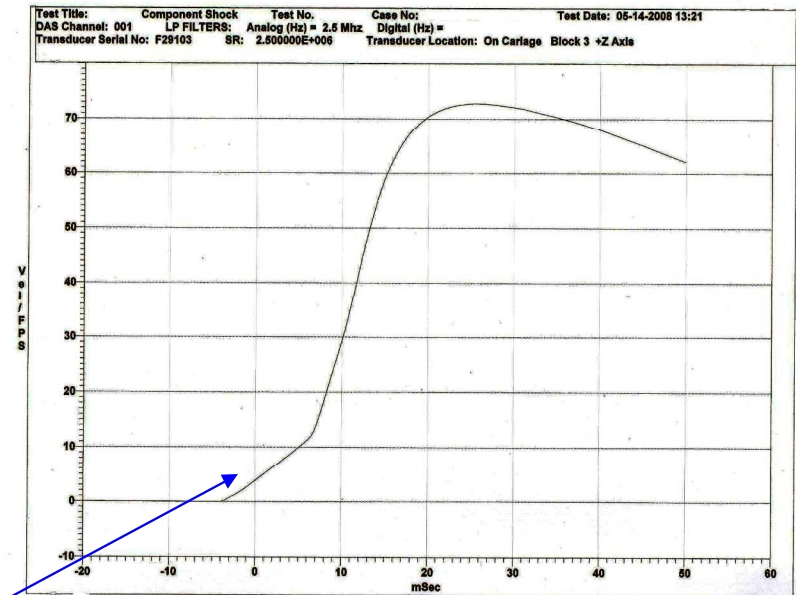
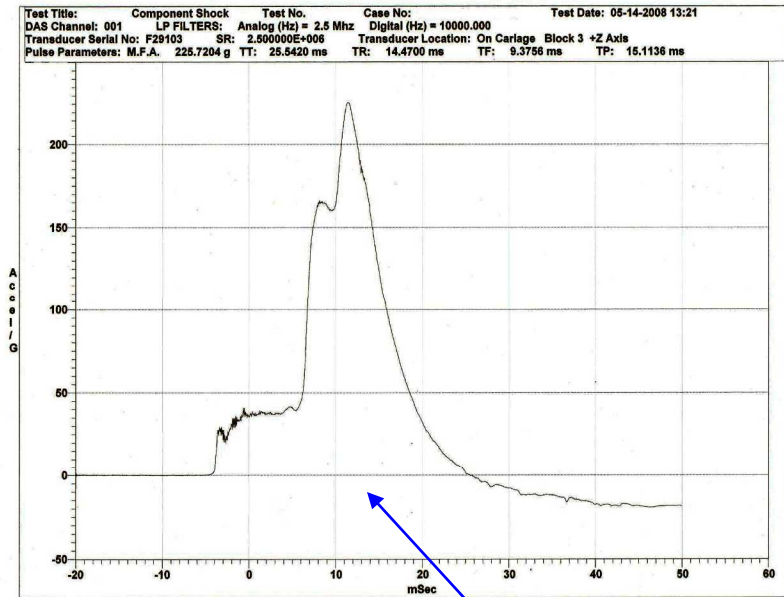
Tadiran HP Battery



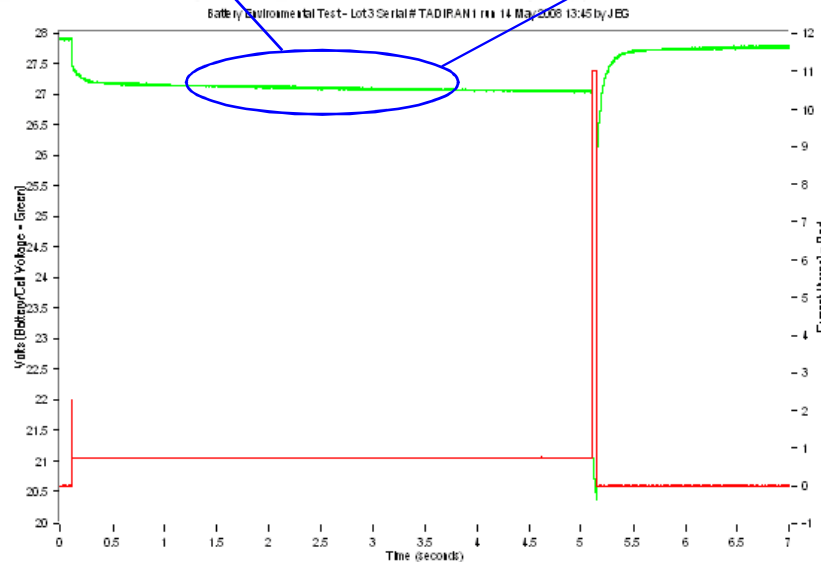
- Peak Vibration: 1161 G
- Performed electrical testing after vibration
- Battery performed as expected

Shock Testing

Tadiran HP Battery

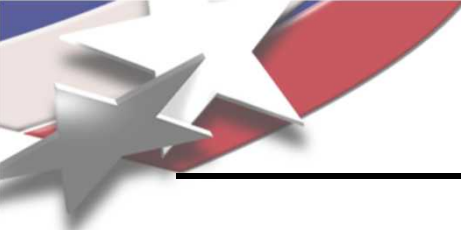


- Amplitude of Shock: 225.7 G
- Duration of Shock: 25.5 ms
- Max Velocity: 72.5 FPS



- **Behavioral Characteristics of Tadiran TLM-1550 Cells**
 - Both types of Tadiran cells show characteristics of high reproducibility
 - **Relative standard Deviation of TLM-1550 HP cells**
 - 4.8 % at -10 °C
 - 2.3 % at 25 °C
 - **Relative standard Deviation of TLM-1550 MP cells with PTC**
 - 5.8 % at -10 °C
 - 2.2 % at 25 °C
- **Both types of Tadiran cells/batteries are capable of supporting the three required operations at all temperatures**
 - Operations #1, #2, and #3
- **Useable Discharge Capacity @ -10 °C**
 - ~105 mAh for HP Battery
 - ~310 mAh for MP Battery

- **Tadiran cells/batteries showed excellent safety characteristics during abuse testing**
 - **The shutdown separator was the major influencing factor in the short circuit tests**
 - **No cells vented while in reversal**
- **Tadiran cells/batteries were capable of supporting the shock and vibration loads at transportation levels**
 - **No signs of voltage dropouts**



- **Continue testing at higher temperature**
- **Expand abuse/safety tests**
 - **Over discharge**
 - **Impact**
- **Evaluate electrical performance of battery packs built by Tadiran**
 - **Perform abuse/safety tests on these battery packs**