



# UN 38.3 TRANSPORT TESTING REPORT

## 4277031

**ProTechnologies, Inc.  
Lithium Manganese Dioxide Battery Pack  
(PTO0856)**

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The product has been tested to the procedures contained herein and the statements and data in this report are accurate and true to the best of our knowledge and belief. The test data contained within this report is confidential property of the client.

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Issue Date: March 22, 2018  
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**REVISION HISTORY**

<b>Revision</b>	<b>Date</b>	<b>Justification</b>
<b>0</b>	03.23.2018	Original Issue

Name and address of Client:

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Date(s) of Tests and Measurements: 02.27.2018 - 03.22.2018

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## GENERAL INFORMATION

### Product Description

The Equipment Under Test (EUT) is a 9.0 VDC, 950mAh Lithium Manganese Dioxide Battery Pack, Part Number: PTO0856.

## TESTS AND MEASUREMENTS

### Method

Test requirements were performed in accordance with the Recommendations on the TRANSPORT OF DANGEROUS GOODS Manual of Tests and Criteria, 6<sup>th</sup> Edition. The following tests were performed.

- T1: Altitude Simulation
- T2: Thermal Test
- T3: Vibration
- T4: Shock
- T5: External Short Circuit

### Test Equipment

All instrumentation is calibrated annually to NIST traceable standards. Test equipment used to evaluate the product is itemized in Table 7.

### Test Results

Testing completed with no failures observed.

## Initial Characteristics

### Method

Prior to subjecting samples to testing, all units were visually inspected to insure no physical damage present. Open Circuit Voltage and Mass measurements were taken. Required samples were discharged in accordance with customer specifications using a constant current discharge of 5.35 mA to 6.0 VDC.

### Results

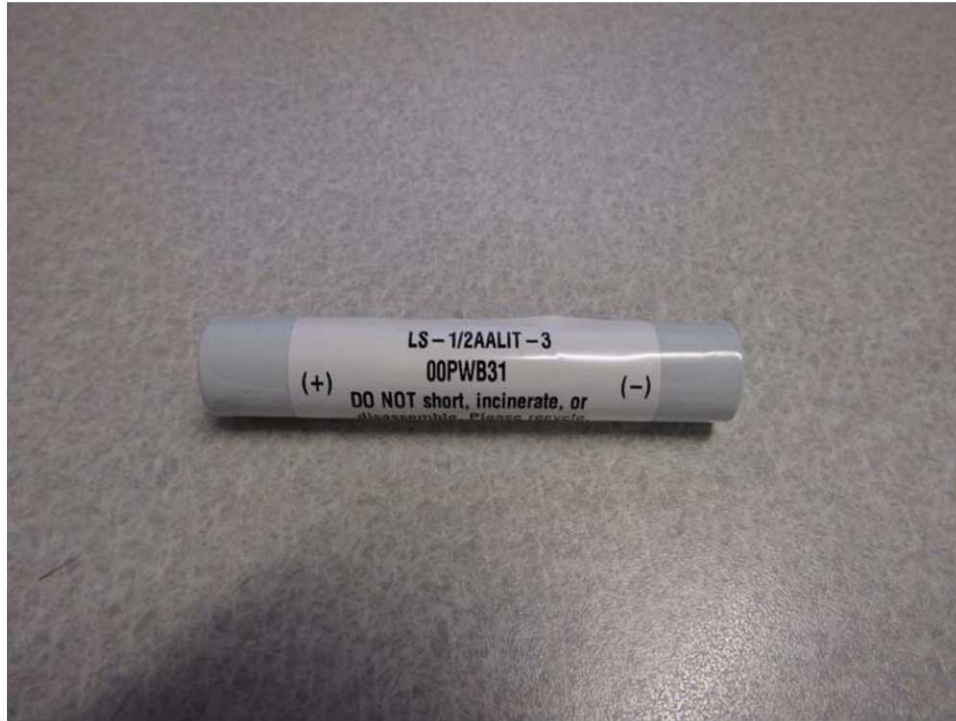
Initial measurements are recorded in Table 1. Sample picture of equipment under test is shown in Figure 1.

**TABLE 1  
INITIAL CHARACTERISTICS**

Sample#	OCV (V)	Mass (g)	Comments
U1	9.820	31.503	No physical damage observed as received
U2	9.824	31.490	No physical damage observed as received
U3	9.823	31.584	No physical damage observed as received
U4	9.823	31.475	No physical damage observed as received
D1	9.812	31.500	No physical damage observed as received
D2	9.817	31.484	No physical damage observed as received
D3	9.820	31.578	No physical damage observed as received
D4	9.824	31.532	No physical damage observed as received

*Note: 'D' designation is for fully discharged batteries & the 'U' designation is for undischarged batteries.*

### FIGURE 1 TEST SAMPLES



## Altitude Simulation

### Method

Eight (4 discharged / 4 fresh) batteries were subjected to Altitude Simulation Testing. Samples were stored at a pressure of 11.6 kPa or less for at least six hours at ambient temperature (20±5°C).

### Requirement

No mass loss beyond allowable limits, no leakage, no venting, no disassembly, no rupture, no fire and the open circuit voltage of each battery after testing is not less than 90% of its voltage immediately prior to the test procedure. OCV measurement for discharged samples are not considered for pass/fail criteria and therefore not recorded.

### Results

Results for Altitude Simulation testing are given in Table 2.

**TABLE 2  
ALTITUDE SIMULATION RESULTS**

Sample#	Initial		Final		Result (Pass/Fail)	Comment
	OCV (V)	Mass (g)	OCV (V)	Mass (g)		
U1	9.820	31.816	9.820	31.816	Pass	--
U2	9.824	31.769	9.823	31.770	Pass	--
U3	9.822	31.843	9.822	31.842	Pass	--
U4	9.822	31.754	9.823	31.753	Pass	--
D1	N/A	31.832	N/A	31.831	Pass	--
D2		31.822		31.820	Pass	--
D3		31.885		31.881	Pass	--
D4		31.844		31.842	Pass	--

## Thermal Test

### Method

Upon successful completion of Altitude Simulation Testing, the eight batteries were subjected to the Thermal Test. Samples were stored for at least six hours at a test temperature equal to  $72\pm 2^{\circ}\text{C}$ , followed by storage for at least six hours at a test temperature equal to  $-40\pm 2^{\circ}\text{C}$ . The maximum time interval between test temperature extremes is 30 minutes. Procedure is repeated a total of 10 times, after which all samples are stored for 24 hours at ambient temperature ( $20\pm 5^{\circ}\text{C}$ ).

### Requirement

No mass loss beyond allowable limits, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each battery after testing is not less than 90% of its voltage immediately prior to the test procedure. OCV measurement for discharged samples are not considered for pass/fail criteria and therefore not recorded.

### Results

Results for Thermal Test are given in Table 3.

**TABLE 3  
THERMAL TEST RESULTS**

Sample#	Initial		Final		Result (Pass/Fail)	Comment
	OCV (V)	Mass (g)	OCV (V)	Mass (g)		
U1	9.820	31.816	9.824	31.817	Pass	--
U2	9.823	31.770	9.827	31.766	Pass	--
U3	9.822	31.842	9.827	31.840	Pass	--
U4	9.823	31.753	9.827	31.752	Pass	--
D1	N/A	31.831	N/A	31.830	Pass	--
D2		31.820		31.820	Pass	--
D3		31.881		31.883	Pass	--
D4		31.842		31.842	Pass	--



## Vibration

### Method

Upon successful completion of Thermal Testing, the eight batteries were subjected to Vibration Testing. Samples are firmly secured to the platform of the vibration machine. Samples were then subjected to a sinusoidal waveform with a logarithmic sweep between 7Hz and 200Hz and back to 7Hz traversed in 15 minutes. The cycle was repeated 12 times for a total of 3 hours for each of three mutually perpendicular axes. One of the directions of vibration must be perpendicular to the terminal face.

### Requirement

No mass loss beyond allowable limits, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each battery after testing is not less than 90% of its voltage immediately prior to the test procedure. OCV measurement for discharged samples are not considered for pass/fail criteria and therefore not recorded.

### Results

Results for Vibration Test are given in Table 4.

**TABLE 4  
VIBRATION RESULTS**

Sample#	Initial		Final		Result (Pass/Fail)	Comment
	OCV (V)	Mass (g)	OCV (V)	Mass (g)		
U1	9.828	31.819	9.828	31.819	Pass	--
U2	9.831	31.769	9.831	31.769	Pass	--
U3	9.831	31.842	9.831	31.841	Pass	--
U4	9.831	31.752	9.831	31.755	Pass	--
D1	N/A	31.832	N/A	31.833	Pass	--
D2		31.821		31.823	Pass	--
D3		31.882		31.882	Pass	--
D4		31.842		31.843	Pass	--

## Shock

### Method

Upon successful completion of Vibration Testing, the eight batteries were subjected to Shock Testing. Samples were secured to by a means of a rigid mount which will support all mounting surfaces. Each sample subjected to a half-sine shock of peak acceleration of 150 g<sub>n</sub> and pulse duration of 6 milliseconds. Each sample subjected to three shocks in the positive direction followed by three shocks in the negative direction of three mutually perpendicular mounting positions for a total of 18 shocks.

### Requirement

No mass loss beyond allowable limits, no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each battery after testing is not less than 90% of its voltage immediately prior to the test procedure. OCV measurement for discharged samples are not considered for pass/fail criteria and therefore not recorded.

### Results

Results for Shock Test are given in Table 5.

**TABLE 5  
SHOCK RESULTS**

Sample#	Initial		Final		Result (Pass/Fail)	Comment
	OCV (V)	Mass (g)	OCV (V)	Mass (g)		
U1	9.828	31.819	9.828	31.820	Pass	--
U2	9.831	31.769	9.830	31.768	Pass	--
U3	9.831	31.841	9.831	31.843	Pass	--
U4	9.831	31.755	9.831	31.755	Pass	--
D1	N/A	31.833	N/A	31.832	Pass	--
D2		31.823		31.823	Pass	--
D3		31.882		31.882	Pass	--
D4		31.843		31.843	Pass	--

## External Short Circuit

### Method

Upon successful completion of Shock Testing, the eight batteries were subjected to External Short Circuit Testing. Samples were stabilized to where the external case temperature reaches  $57 \pm 4^{\circ}\text{C}$  and then the sample is subjected to a short circuit condition with a total external resistance of less than  $0.1\Omega$  at  $57 \pm 4^{\circ}\text{C}$ . The short condition is continued for a minimum of one hour after the external case temperature has returned to  $57 \pm 4^{\circ}\text{C}$ . The sample is then observed for an additional six hours.

### Requirement

External temperature does not exceed  $170^{\circ}\text{C}$  and there is no disassembly, no rupture and no fire within six hours of testing.

### Results

Results for External Short Circuit Test are given in Table 6.

**TABLE 6  
EXTERNAL SHORT CIRCUIT RESULTS**

Sample#	Short Circuit Resistance ( $\Omega$ )	Maximum Temperature ( $^{\circ}\text{C}$ )	Disassembly or fire within 6 hrs of testing	Result (Pass/Fail)	Comment
U1	0.069	63.40	No	Pass	--
U2	0.073	61.80	No	Pass	--
U3	0.082	63.90	No	Pass	--
U4	0.074	62.30	No	Pass	--
D1	0.081	59.10	No	Pass	--
D2	0.069	60.10	No	Pass	--
D3	0.073	60.80	No	Pass	--
D4	0.082	61.30	No	Pass	--

**TABLE 7  
TEST INSTRUMENTS**

Test	Equipment	Manufacturer	Model	Control #
All	Digital Multimeter	Agilent	34410A	BAT-DMM-02
All	Electronic Balance	Ohaus	EP4130	BAT-EBL-01
Discharging	Battery Test System	Arbin	BT2000	BAT-BTS-01
Altitude Simulation	Vacuum Chamber	Yamato	DP63	BAT-VDO-01
Altitude Simulation	Data Logger	Omega	OM-CP-TC101A	L275
Thermal Test	Environmental Chamber	Thermotron	SE-2000-15-15-RAC	BAT-ETC-04
Vibration	Dynamic Vibration System Table	Dynamic Solutions	DS-2200VH/9-10	L239
Vibration	Dynamic Vibration System Amplifier	Dynamic Solutions	SA-10	L240
Vibration	Controller	Vibration Research	VR-9500	BAT-VCU-01
Vibration	Accelerometer	PCB Piezotronics	352C33	BAT-ACL-06
Shock	Free Fall System	Lansmont	--	--
Shock	Accelerometer	PCB Piezotronics	353M288	BAT-ACL-10
Shock	Signal Conditioner/Display Unit	Lansmont	Test Partner	BAT-SCU-01
External Short Circuit	Chamber	Espec	PHH-202	BAT-OVN-01
External Short Circuit	Data Acquisition System	Agilent	34972A	BAT-DLG-04
External Short Circuit	Impedance Meter	Tegam	252	BAT-IMP-01
External Short Circuit	Current Shunt	Crompton	50mV / 100A	BAT-CST-06 BAT-CST-07 BAT-CST-08 BAT-CST-09