

**Ultralife Corporation – UN Transportation Test Report**  
**United Nations Recommendations on the Transport of Dangerous**  
**Goods, Manual of Tests and Criteria.**  
(Seventh Revised Edition Amendment 1 - ST/SG/AC.10/11/Rev.7/Amend.1 Dated 2021)

**For “Rechargeable” Battery Type:**

Manufacturer: Excell Battery

Battery Chemistry: Li-Ion

Mass: ≈ 214 g

Nominal Voltage: 14.4 V

Rated Capacity: 3.0 Ahr / 43.2 Whr

Model #: 2EXL7560


Cell Configuration: 4S1P (Samsung INR18650-30Q Cell)

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## REVISION HISTORY

Revision	Summary of Change	Tested & Prepared By	Approved By	Date of Change
-	Initial Revision	J. Schuldt	J. Nielsen	5/19/2022
A	Updated document template	J. Schuldt	J. Nielsen	6/13/2022
B	Updated customer address	J. Schuldt	J. Nielsen	6/13/2022

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## TEST MATRIX: for “Rechargeable” Battery

UN Test Number	Test	1 Cycle	25 Cycle
T1	Altitude		
T2	Thermal Shock		
T3	Vibration	4 (Small) 2 (Large)	4 (Small) 2 (Large)
T4	Shock		
T5	External Short Circuit		
T6	Impact	N/R	N/R
T7	Overcharge	4 (Small) 2 (Large)	4 (Small) 2 (Large)
T8	Force Discharge	N/R	N/R
Total Qty.		8 (Small) 4 (Large)	8 (Small) 4 (Large)
		16 (Small) 8 (Large)	

**Note:**

N/R = Testing “Not Required” (per UN Testing Specification)

**Table 38.3.1: Mass loss limit**

Mass M of cell or cell	Mass loss limit
M < 1 g	0.5%
1 g ≤ M ≤ 75 g	0.2%
M > 75 g	0.1%

$$\text{Mass loss (\%)} = (M1 - M2) / M1 \times 100$$

M1 = mass before the test

M2 = mass after the test

**KEY DEFINITIONS:**

“**Fully Charged**” means a rechargeable cell or cell which has been electrically charged to its design rated capacity.

“**Small Battery**” means a lithium metal battery or lithium ion battery with a gross mass of not more than 12 kg.

“**Large Battery**” means a lithium metal battery or lithium ion battery with a gross mass of more than 12 kg.

“**Leakage**” means the visible escape of electrolyte or other material from a cell or battery or the loss of material (except battery casing, handling devices or labels) from a cell or battery such that the loss of mass exceeds the values in table 38.3.1.

“**Venting**” means the release of excessive internal pressure from a cell or battery in a manner intended by design to preclude rupture or disassembly.

“**Disassembly**” means a vent or rupture where solid matter

“**Rupture**” means the mechanical failure of a cell container or battery case induced by an internal or external cause, resulting in exposure or spillage but not ejection of solid materials.

“**Fire**” means that flames are emitted from the test cell or battery.

“**Open circuit voltage (or OCV)**” means the voltage across the terminals of a cell or battery when no external current is flowing.

## SUMMARY:

This document summarizes the results of testing of Excell Battery (Model #: 2EXL7560 / Nominal Voltage: 14.4 V / Rated Capacity: 3.0 Ahr / 43.2 Whr) in accordance with the *United Nations Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria seventh revised edition Amendment 1. ST/SG/AC.10/11/Rev.7/Amend.1 dated 2021.*

A total of sixteen (16) “rechargeable” batteries were received from Excell Battery to complete this testing. Eight (8) batteries were cycled once and eight (8) batteries were cycled 25 times using a charge rate of 1.50A, with a voltage limit of 16.6V, until (0.150A) was reached. The discharge rate was 1.50A to 12.0V. Batteries all left at 100% charged, using a Maccor Battery Test System at Ultralife Batteries.

All batteries have **PASSED** UN Specification Requirements for T1 to T5, and T7 of the referenced UN document. All test results are attached.

## PICTURE OF SAMPLE TESTED:



**TECHNICAL DATA SHEET (if available from manufacturer):**

UN T1 (38.3.4.1)

Finish Date: 05/02/2022 Results: Pass

**T-1: Altitude Test Data Sheet****Test Purpose:** This test simulates air transport under low-pressure conditions.**Test Procedure:** Test batteries shall be stored at a pressure of 11.6 kPa or less for at least six hours at ambient temperature (20 ±5°C).**Test Requirement:** Batteries meet this requirement if there is no leakage (mass loss is ≤ 0.1%), no venting, no disassembly, no rupture, and no fire and if the open circuit voltage of each test battery after testing is not less than 90% (OCV loss is ≤10%) of its voltage immediately prior to this procedure.

Start Test: 05/02/2022 (07:52)	End Test: 05/02/2022 (13:53)
Initial Data Recorded: 05/02/2022	Final Data Recorded: 05/02/2022

Battery Number	Cycle(s)	Initial OCV (volts)	Final OCV (volts)	%OCV Loss (≤10%)	Initial Weight (grams)	Final Weight (grams)	%Wt. Loss	Cosmetic List if applicable: Venting, Disassembly, rupture, fire.	Pass or Fail
1	1	16.396	16.393	0.02%	214.458	214.449	0.00%	No	Pass
2	1	16.401	16.399	0.01%	213.740	213.732	0.00%	No	Pass
3	1	16.398	16.396	0.01%	214.669	214.660	0.00%	No	Pass
4	1	16.405	16.403	0.01%	213.928	213.920	0.00%	No	Pass
5	25	16.404	16.401	0.02%	214.111	214.103	0.00%	No	Pass
6	25	16.407	16.403	0.02%	214.347	214.339	0.00%	No	Pass
7	25	16.406	16.403	0.02%	214.451	214.443	0.00%	No	Pass
8	25	16.398	16.396	0.01%	214.078	214.071	0.00%	No	Pass

UN T2 (38.3.4.2)

Finish Date: 05/09/2022 Results: Pass

**T-2: Thermal Shock Test Data Sheet**

**Test Purpose:** This test assesses batteries seal integrity and internal electrical connections. This test is conducted using rapid and extreme temperature changes.

**Test Procedure:** Test batteries are to be stored for at least six hours at a test temperature equal to  $72 \pm 2$  °C, followed by storage for at least six hours at a test temperature equal to  $-40 \pm 2$  °C. The maximum time interval between test temperature extremes is 30 minutes. This procedure is to be repeated until 10 total cycles are complete, after which all test batteries are to be stored for 24 hours at ambient temperature ( $20 \pm 5$ °C). For large batteries the duration of exposure to the test temperature extremes should be at least 12 hours.

**Test Requirement:** Batteries meet this requirement if there is no leakage (mass loss is  $\leq 0.1\%$ ), no venting, no disassembly, no rupture, and no fire and if the open circuit voltage of each test battery after testing is not less than 90% (OCV loss is  $\leq 10\%$ ) of its voltage immediately prior to this procedure.

Start Test: 05/02/2022 (16:16)	End Test: 05/09/2022 (02:46)
Initial Data Recorded: 05/02/2022	Final Data Recorded: 05/09/2022

Battery Number	Cycle(s)	Initial OCV (volts)	Final OCV (volts)	%OCV Loss ( $\leq 10\%$ )	Initial Weight (grams)	Final Weight (grams)	%Wt. Loss	Cosmetic List if applicable: Venting, Disassembly, rupture, fire.	Pass or Fail
1	1	16.393	16.301	0.56%	214.449	214.432	0.01%	No	Pass
2	1	16.399	16.302	0.59%	213.732	213.718	0.01%	No	Pass
3	1	16.396	16.301	0.58%	214.660	214.642	0.01%	No	Pass
4	1	16.403	16.303	0.61%	213.920	213.903	0.01%	No	Pass
5	25	16.401	16.304	0.59%	214.103	214.087	0.01%	No	Pass
6	25	16.403	16.305	0.60%	214.339	214.322	0.01%	No	Pass
7	25	16.403	16.304	0.60%	214.443	214.424	0.01%	No	Pass
8	25	16.396	16.303	0.57%	214.071	214.053	0.01%	No	Pass

UN T3 (38.3.4.3)

Finish Date: 05/16/2022 Results: Pass

**T-3: Vibration Test Data Sheet**

**Test Purpose:** This test simulates vibration during transport.

**Test Procedure:** Batteries are to be firmly secured to the platform of the vibration machine without distorting the test sample in such a manner to faithfully transmit the vibration. The vibration is a sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours for each of the 3 mutually perpendicular mounting positions of the test sample. One of the directions of vibration must be perpendicular to the terminal face.

The logarithmic frequency sweep shall differ for batteries with a gross mass of not more than 12 kg (small batteries), and for batteries with a gross mass of more than 12 kg (large batteries).

For small batteries: from 7 Hz a peak acceleration of 1  $g_n$  is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 8  $g_n$  occurs (approximately 50 Hz). A peak acceleration of 8  $g_n$  is then maintained until the frequency is increased to 200 Hz.

For large batteries: from 7Hz to a peak acceleration of 1  $g_n$  is maintained until 18 Hz is reached. The amplitude is then maintained at 0.8 mm (1.6 mm total excursion) and the frequency increased until a peak acceleration of 2  $g_n$  occurs (approximately 25 Hz). A peak acceleration of 2  $g_n$  is then maintained until the frequency is increased to 200 Hz.

**Test Requirement:** Batteries meet this requirement if there is no leakage (mass loss is  $\leq 0.1\%$ ), no venting, no disassembly, no rupture, and no fire and if the open circuit voltage of each test battery after testing is not less than 90% (OCV loss is  $\leq 10\%$ ) of its voltage immediately prior to this procedure.

Start Test: 05/09/2022	End Test: 05/10/2022
Initial Data Recorded: 05/09/2022	Final Data Recorded: 05/16/2022

Battery Number	Cycle(s)	Initial OCV (volts)	Final OCV (volts)	%OCV Loss ( $\leq 10\%$ )	Initial Weight (grams)	Final Weight (grams)	%Wt. Loss	Cosmetic List if applicable: Venting, Disassembly, rupture, fire.	Pass or Fail
1	1	16.301	16.278	0.14%	214.432	214.426	0.00%	No	Pass
2	1	16.302	16.279	0.14%	213.718	213.713	0.00%	No	Pass
3	1	16.301	16.277	0.15%	214.642	214.637	0.00%	No	Pass
4	1	16.303	16.280	0.14%	213.903	213.899	0.00%	No	Pass
5	25	16.304	16.280	0.15%	214.087	214.082	0.00%	No	Pass
6	25	16.305	16.281	0.15%	214.322	214.318	0.00%	No	Pass
7	25	16.304	16.281	0.14%	214.424	214.418	0.00%	No	Pass
8	25	16.303	16.280	0.14%	214.053	214.049	0.00%	No	Pass



UN T4 (38.3.4.4)

Finish Date: 05/16/2022 Results: Pass

**T-4: Shock Test Data Sheet**

**Test Purpose:** This test assesses the robustness of batteries against cumulative shocks.

**Test Procedure:** Test batteries shall be secured to the testing machine by means of a rigid mount with will support all mounting surfaces of each test battery.

Each battery shall be subjected to a half-sine shock of peak acceleration depending on the mass of the battery. The pulse duration shall be 6 milliseconds for small batteries and 11 milliseconds for large batteries. The formulas below are provided to calculate the appropriate minimum peak accelerations.

Battery	Minimum peak acceleration	Pulse duration
Small batteries	150 g <sub>a</sub> or result of formula	6 ms
	$Acceleration(g_a) = \sqrt{\left(\frac{100850}{mass^a}\right)}$ <p>whichever is smaller</p>	
Large batteries	50 g <sub>a</sub> or result of formula	11 ms
	$Acceleration(g_a) = \sqrt{\left(\frac{30000}{mass^a}\right)}$ <p>whichever is smaller</p>	

<sup>a</sup> Mass is expressed in kilograms.

Each battery shall be subjected to three shocks in the positive direction and to three shocks in the negative direction in each of three mutually perpendicular mounting positions of the battery for a total of 18 shocks.

**Test Requirement:** Batteries meet this requirement if there is no leakage (mass loss is ≤ 0.1%), no venting, no disassembly, no rupture, and no fire and if the open circuit voltage of each test battery after testing is not less than 90% (OCV loss is ≤ 10%) of its voltage immediately prior to this procedure.

Start Test: 05/16/2022	End Test: 05/16/2022
Initial Data Recorded: 05/16/2022	Final Data Recorded: 05/16/2022

Battery Number	Cycle(s)	Initial OCV (volts)	Final OCV (volts)	%OCV Loss (≤10%)	Initial Weight (grams)	Final Weight (grams)	%Wt. Loss	Cosmetic List if applicable: Venting, Disassembly, rupture, fire.	Pass or Fail
1	1	16.278	16.278	0.00%	214.426	214.465	-0.02%	No	Pass
2	1	16.279	16.278	0.01%	213.713	213.749	-0.02%	No	Pass
3	1	16.277	16.277	0.00%	214.637	214.674	-0.02%	No	Pass
4	1	16.280	16.279	0.01%	213.899	213.936	-0.02%	No	Pass
5	25	16.280	16.280	0.00%	214.082	214.119	-0.02%	No	Pass
6	25	16.281	16.281	0.00%	214.318	214.353	-0.02%	No	Pass
7	25	16.281	16.281	0.00%	214.418	214.456	-0.02%	No	Pass
8	25	16.280	16.279	0.01%	214.049	214.087	-0.02%	No	Pass

UN T5 (38.3.4.5)

Finish Date: 05/18/2022 Results: Pass

**T-5: External Short Circuit @ 55°C Test Data Sheet**

**Test Purpose:** This test simulates an external short circuit.

**Test Procedure:** The batteries to be tested shall be heated for a period of time necessary to reach a homogenous stabilized temperature of  $57 \pm 4^\circ\text{C}$ , measured on the external case. This period of time depends on the size and design of the battery and should be assessed and documented. If this assessment is not feasible, the exposure time shall be at least 6 hours for small batteries, and 12 hours for large batteries. Then the battery at  $57 \pm 4^\circ\text{C}$  shall be subjected to one short circuit condition with a total external resistance of less than 0.1 ohm.

This short circuit condition is continued for at least one hour after the battery external case temperature has returned to  $57 \pm 4^\circ\text{C}$ , or in the case of large batteries, has decreased by half of the maximum temperature increase observed during the test and remains below that value.

The short circuit and cooling down phases shall be conducted at least at ambient temperature.

**Test Requirement:** Batteries meet this requirement if their external temperature does not exceed  $170^\circ\text{C}$  and there is no disassembly, no rupture and no fire during the test and within six hours after the test.

Start Test: 05/16/2022	End Test: 05/18/2022
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Battery Number	Cycle(s)	Soak Time to $57 \pm 4^\circ\text{C}$ *	Max Ext. Temp. ( $^\circ\text{C}$ )	Disassembly "Y" or "N"	Rupture "Y" or "N"	Fire "Y" or "N"	Pass or Fail
1	1	17:05:00	58.040	N	N	N	Pass
2	1	17:05:00	57.896	N	N	N	Pass
3	1	17:05:00	57.667	N	N	N	Pass
4	1	17:05:00	57.125	N	N	N	Pass
5	25	16:14:30	57.084	N	N	N	Pass
6	25	16:14:30	57.259	N	N	N	Pass
7	25	16:14:30	57.133	N	N	N	Pass
8	25	16:14:30	57.060	N	N	N	Pass

\*HH:MM:SS

**UN T7 (38.3.4.7)****Finish Date: 05/10/2022 Results: Pass****T-7: Rechargeable Battery Overcharge Test Data Sheet**

**Test Purpose:** This test evaluates the ability of a rechargeable battery to withstand an overcharge condition.

**Test Procedure:** The charge current shall be twice the manufacturer's recommended maximum continuous charge current. The minimum voltage of the test shall be as follows:

- (a) when the manufacturer's recommended charge voltage is not more than 18V, the minimum voltage of the test shall be the lesser of two times the maximum charge voltage of the battery or 22V.
- (b) when the manufacturer's recommended charge voltage is more than 18V, the minimum voltage of the test shall be 1.2 times the maximum charge voltage.

Tests are conducted at ambient temperature. The duration of the test shall be 24 hours.

**Test Requirement:** Rechargeable batteries meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.

Start Test: 04/28/2022	End Test: 05/10/2022
Charge Rate Applied (for 24 hours): 6.0A	Charge Voltage: 22.0V

Battery Number	Cycle(s)	Disassembly (after 7 days) "Y" or "N"	Rupture (after 7 days) "Y" or "N"	Fire (after 7 days) "Y" or "N"	Pass or Fail
9	1	N	N	N	Pass
10	1	N	N	N	Pass
11	1	N	N	N	Pass
12	1	N	N	N	Pass
13	25	N	N	N	Pass
14	25	N	N	N	Pass
15	25	N	N	N	Pass
16	25	N	N	N	Pass

**EQUIPMENT LIST:**

<b>Instrument</b>	<b>ID #</b>	<b>Last Calibration Date</b>	<b>Calibration Due Date</b>
Cycling System (Maccor)	A50007	5/13/2021	5/13/2022
Scale	C105085654	2/17/2022	8/17/2022
Voltmeter	2703A04097	2/8/2022	2/08/2023
Vacuum Gauge (T1)	U001V	9/15/2021	9/15/2022
Chamber (T2)	0142751B	11/9/2021	11/9/2022
Temperature Monitor (T2) (Maccor)	A50019	7/6/2021	7/6/2022
Vibration Controller (T3)	10055771	1/13/2022	1/13/2023
Signal Conditioner (T3)	1268	1/11/2022	1/11/2023
Accelerometer (T3)	6284	9/17/2021	9/17/2022
Oscilloscope (T4)	US37090637	5/17/2021	5/17/2022
Voltage Amplifier (T4)	285	2/3/2022	2/3/2024
Accelerometer (T4)	71426	11/23/2021	11/23/2022
Oven (T5)	0200197	4/20/2022	4/20/2023
Datalogger (T5)	MY49001565	10/19/2021	10/19/2022
Datalogger (T7)	MY49022677	7/6/2021	7/6/2022