



**LIETUVOS  
NACIONALINIS  
AKREDITACIJOS  
BIURAS**

**BANDYMAI  
ISO/IEC 17025**

**Nr. LA.197-01**

**UN 38.3**

**Test report No. 2023\*1109**  
***Bandyų protokolas Nr. 2023\*1109***

**United Nations Manual for Tests and Criteria 7<sup>th</sup> edition. 38.3 Lithium metal and lithium ion batteries: ST/SG/AC.10/11/Rev.7**

*Jungtinių Tautų Vadovas Bandyams 7-o leidimo Kriterijai. 38.3 Litio metalų ir Ličio jonų baterijos: ST/SG/AC.10/11/Rev.7*

**Name and address of applicant**

*Užsakovas, jo adresas*

UAB Green Express  
Eišiškių pl. 8A, LT-02184 Vilnius,  
Lithuania

**Make (trade name of manufacturer)**

*Gamyklinė markė*

B2-Li-001

**Tested object type, tested object ID**

*Bandinio tipas, bandinio ID*

Rechargeable Li-ion battery HRB2,  
HRB2 #1 - #16

**Test date**

*Bandyų data*

2023-10-09 – 2023-11-09



<b>Test Summary</b> <i>Bandymų santrauka</i>	
T1. Altitude Simulation	Pass
T2. Thermal Test	Pass
T3. Vibration	Pass
T4. Shock	Pass
T5. External Short Circuit	Pass
T6. Impact or Crush	N/A
T7. Overcharge	Pass
T8. Forced Discharge	N/A

The test report shall not be duplicated without the written permission of the test laboratory  
*Be raštiško laboratorijos sutikimo bandymų protokolo dalys negali būti dauginamos.*

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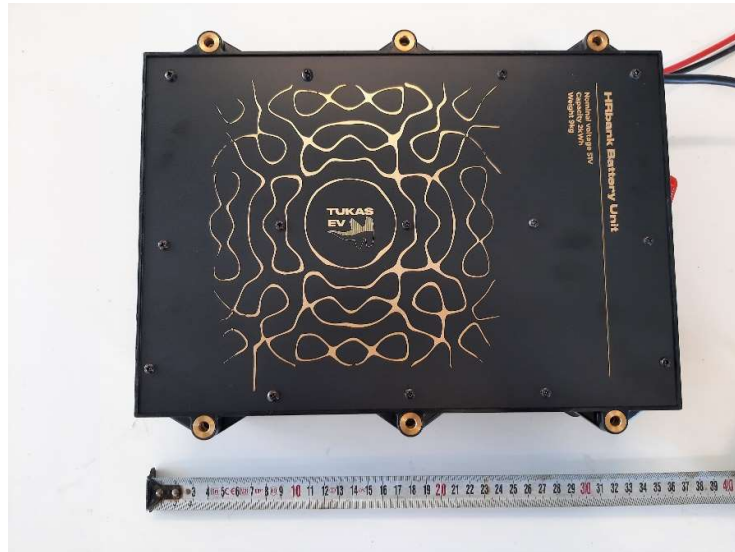
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<b>1. Information about the tested object /</b> <i>Informacija apie bandinį</i>		
1.1	Battery category according to UN38.3	Small rechargeable Lithium Ion battery <12 kg
1.2	Battery weight	9.4 kg
1.3	Battery dimensions	321 x 248 x 80mm
1.4	Nominal voltage	51.66 V
1.5	Capacity	38.4 Ah
1.6	Maximum charge current	20A
1.7	Manufacturer recommended continuous charge current	12A
1.8	Maximum discharge current	90A
1.9	Manufacturer recommended continuous discharge current	60A
1.10	Cell manufacturer	LG Chem, Ltd.
1.11	Cell Type	M50LT
1.12	Cell wiring scheme	S14 P8



**Battery images**  
**Baterijos nuotraukos**



<b>2. Test equipment and conditions / Bandymų įranga ir sąlygos</b>		
2.1.	Place / <i>Vieta</i>	Graičiūno g. 32, Vilnius, Lithuania
2.2.	Tested object ID / <i>Bandinio ID</i> Battery pack / <i>Baterija</i>	HRB2 #1 – #16
2.3.	Tests performed / <i>Bandymo data</i>	2023-10-09 – 2023 -11-09
2.4.	Environmental conditions / <i>Aplinkos sąlygos</i>	20 – 25 °C
2.5.	Testing conditions / <i>Bandymo sąlygos</i>	20 – 25 °C

<b>3. Measuring dimensions, instruments, range &amp; uncertainty Bandymų parametrai, priemonės, ribos ir neapibrėžtis</b>			
	<b>Measuring dimension / Matavimo parametras</b>	<b>Measuring instrument / Matavimo priemonės</b>	<b>Measurement range and uncertainty / Matavimo ribos ir neapibrėžtis</b>
3.1.	Voltage / <i>Įtampa</i>	Voltmeter / <i>Voltmetras</i>	0 – 600 V ± 0.061 V
3.2.	Current / <i>Srovė</i>	Current clamp meter / <i>Srovės replės</i>	0 – 200A ± 0.079 A
3.3.	Temperature / <i>Temperatūra</i>	Data logger + thermocouple / <i>Duomenų kaupiklis + termopora</i>	-50 ÷ +200°C ± 0.858 °C
3.4.	Acceleration / <i>Pagreitis</i>	Data logger + accelerometer / <i>Duomenų kaupiklis + akselerometras</i>	0 ÷ 200 g ± 1.53 g
3.5.	Frequency, acceleration / <i>Dažnis, pagreitis</i>	Vibration system / <i>AVibro sistema</i>	0.8-40 m/s ± 2%
3.6.	Vacuum / <i>Vakuumas</i>	Vacuum camera and vacuumeter / <i>Vakuomo kamera ir vakuumetras</i>	85-1000 hPa ±15.672 hPa
3.7.	Weight / <i>svoris</i>	Scales / <i>svarstyklės</i>	0 ÷ 60 kg ± 9 g

The decision rule applies to quantitative measurements. The requirements of normative documents must be complied with a margin greater than the expanded measurement uncertainty. The expanded uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by coverage factor  $k=2$ , which for a normal distribution corresponds to a coverage probability of approximately 95%.

*Kiekybiniams matavimams taikoma sprendimo taisyklė. Normatyvo reikalavimas turi būti tenkinamas su atsarga didesne nei išplėstinė matavimo neapibrėžtis. Išplėstinė matavimo neapibrėžtis apskaičiuota standartinę matavimo neapibrėžtį padauginus iš aprėpties daugiklio  $k=2$ , kuris, esant normaliajam skirstiniui, atitinka apytikriai 95% pasikliautiną tikimybę*



<b>4. Tested Samples / Bandyti objektai</b>			
UN38.3 Tests	Battery ID	Charging status	Remarks
Π-T5	HRB2 #1 – #4	1 <sup>st</sup> cycle, fully charged state	-
	HRB2 #5 – #8	25 <sup>th</sup> cycle, fully charged state	-
T7	HRB2 #9 – #12	1 <sup>st</sup> cycle, fully charged state	-
	HRB2 #13 – #16	25 <sup>th</sup> cycle, fully charged state	-

<b>5. Test results / Bandytų rezultatai</b>		
Requirement No. <i>Reikalavimo Nr.</i>	Requirement <i>Reikalavimas.</i>	Result <i>Rezultatas</i>
<b>38.3.4.1</b>	<b>Test T.1: Altitude simulation</b>	
38.3.4.1.1	Purpose This test simulates air transport under low-pressure conditions.	PASS  HRB2 #1-#8  NO LEAKAGE NO VENTING NO DISASSEMBLY NO RUPTURE NO FIRE OCV ≥ 90%  See Table 1
38.3.4.1.2	Test procedure Test cells and batteries shall be stored at a pressure of 11.6 kPa or less for at least six hours at ambient temperature (20 ± 5 °C).	
38.3.4.1.3	Requirement Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.	
<b>38.3.4.2</b>	<b>Test T.2: Thermal test</b>	
38.3.4.2.1	Purpose This test assesses cell and battery seal integrity and internal electrical connections. The test is conducted using rapid and extreme temperature changes.	

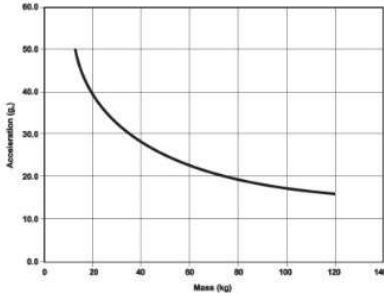
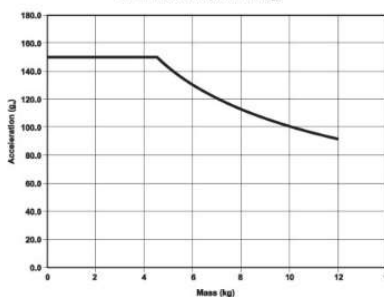


38.3.4.2.2	<p>Test procedure</p> <p>Test cells and batteries are to be stored for at least six hours at a test temperature equal to <math>72 \pm 2 \text{ }^\circ\text{C}</math>, followed by storage for at least six hours at a test temperature equal to <math>-40 \pm 2 \text{ }^\circ\text{C}</math>. The 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 cells and batteries are to be stored for 24 hours at ambient temperature (<math>20 \pm 5 \text{ }^\circ\text{C}</math>). <del>For large cells and batteries the duration of exposure to the test temperature extremes should be at least 12 hours.</del></p>	<p>PASS</p> <p>HRB2 #1-#8</p> <p>NO LEAKAGE NO VENTING NO DISASSEMBLY NO RUPTURE NO FIRE OCV <math>\geq 90\%</math></p>
38.3.4.2.3	<p>Requirement</p> <p>Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.</p>	
<p><b>38.3.4.3</b>      <b><u>Test T.3: Vibration</u></b></p>		<p>See Table 1</p>
38.3.4.3.1	<p>Purpose</p> <p>This test simulates vibration during transport.</p>	
38.3.4.3.2	<p>Test procedure</p> <p>Cells and batteries are firmly secured to the platform of the vibration machine without distorting the cells in such a manner as to faithfully transmit the vibration. The vibration shall be 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 three mutually perpendicular mounting positions of the cell. One of the directions of vibration must be perpendicular to the terminal face.</p> <p>The logarithmic frequency sweep shall differ for cells and batteries with a gross mass of not more than 12 kg (cells and small batteries), and for batteries with a gross mass of more than 12 kg (large batteries).</p> <p>For cells and small batteries: from 7 Hz a peak acceleration of 1 gn 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 gn occurs (approximately 50 Hz). A peak acceleration of 8 gn is then maintained until the frequency is increased to 200 Hz.</p>	



	<p>For large batteries: from 7 Hz to a peak acceleration of 1 gn 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 gn occurs (approximately 25 Hz). A peak acceleration of 2 gn is then maintained until the frequency is increased to 200 Hz.</p>	
<p>38.3.4.3.3</p>	<p>Requirement Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire during the test and after the test and if the open circuit voltage of each test cell or battery directly after testing in its third perpendicular mounting position is not less than 90 % of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.</p>	



<p><b>38.3.4.4</b></p>	<p><b>Test T.4: Shock</b></p>	
<p>38.3.4.4.1</p>	<p>Purpose This test assesses the robustness of cells and batteries against cumulative shocks.</p>	
<p>38.3.4.4.2</p>	<p>Test procedure Test cells and batteries shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery. <del>Each cell shall be subjected to a half sine shock of peak acceleration of 150 g<sub>n</sub> and pulse duration of 6 milliseconds.</del> <del>Alternatively, large cells may be subjected to a half sine shock of peak acceleration of 50 g<sub>n</sub> and pulse duration of 11 milliseconds.</del> 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.</p> <p>Figure 38.3.4.2: Relation between the peak acceleration and the mass for large batteries (equal or above 12.0 kg)</p>  <p>Figure 38.3.4.1: Relation between the peak acceleration and the mass for small batteries (below 12.0 kg)</p>  <p>Each cell or 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 cell or battery for a total of 18 shocks.</p>	<p>PASS</p> <p>HRB2 #1-#8</p> <p>ACCELERATION =</p> <p>103.58 g<sub>n</sub></p> <p>NO LEAKAGE NO VENTING NO DISASSEMBLY NO RUPTURE NO FIRE OCV ≥ 90%</p> <p>See Table 1</p>
<p>38.3.4.4.3</p>	<p>Requirement Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90 %</p>	



	of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.	
<b>38.3.4.5</b>	<b><u>Test T.5: External short circuit</u></b>	
38.3.4.5.1	Purpose This test simulates an external short circuit.	
38.3.4.5.2	Test procedure The cell or battery to be tested shall be heated for a period of time necessary to reach a homogeneous stabilized temperature of $57 \pm 4$ °C, measured on the external case. This period of time depends on the size and design of the cell or battery and should be assessed and documented. If this assessment is not feasible, the exposure time shall be at least 6 hours for small cells and small batteries, and 12 hours for large cells and large batteries. Then the cell or battery at $57 \pm 4$ °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 cell or battery external case temperature has returned to $57 \pm 4$ °C, <del>or in the case of the large batteries, has decreased by half of the maximum temperature increase observed during the test and remains below that value.</del> The short circuit and cooling down phases shall be conducted at least at ambient temperature.	PASS  HRB2 #1-#8  NO DISASSEMBLY NO RUPTURE NO FIRE  $T_{max}: 57^{\circ}C < 170^{\circ}C$  See Table 1
38.3.4.5.3	Requirement Cells and batteries meet this requirement if their external temperature does not exceed 170°C and there is no disassembly, no rupture and no fire during the test and within six hours after the test.	
<b>38.3.4.6</b>	<b><u>Test T.6: Impact/Crush</u></b>	
38.3.4.6.1	Purpose These tests simulate mechanical abuse from an impact or crush that may result in an internal short circuit.	
38.3.4.6.2	Test procedure – Impact (applicable to cylindrical cells not less than 18.0 mm in diameter) NOTE: Diameter here refers to the design parameter (for example the diameter of 18 650 cells is 18.0 mm).  The test sample cell or component cell is to be placed on a flat smooth surface. A 15.8 mm $\pm$ 0.1 mm diameter, at least 6 cm long, or the longest dimension of the cell, whichever is greater, Type 316 stainless steel bar is to be placed across the	N/A



	<p>centre of the sample. A 9.1 kg ± 0.1kg mass is to be dropped from a height of 61 ± 2.5 cm at the intersection of the bar and sample in a controlled manner using a near frictionless, vertical sliding track or channel with minimal drag on the falling mass. The vertical track or channel used to guide the falling mass shall be oriented 90 degrees from the horizontal supporting surface.</p> <p>The test sample is to be impacted with its longitudinal axis parallel to the flat surface and perpendicular to the longitudinal axis of the 15.8 mm ± 0.1 mm diameter curved surface lying across the centre of the test sample. Each sample is to be subjected to only a single impact.</p>	
<p>38.3.4.6.3</p>	<p>Test Procedure – Crush (applicable to prismatic, pouch, coin/button cells and cylindrical cells less than 18.0 mm in diameter)                  NOTE: Diameter here refers to the design parameter (for example the diameter of 18 650 cells is 18.0 mm).                  A cell or component cell is to be crushed between two flat surfaces. The crushing is to be gradual with a speed of approximately 1.5 cm/s at the first point of contact. The crushing is to be continued until the first of the three options below is reached.</p> <ul style="list-style-type: none"> <li>(a) The applied force reaches 13 kN ± 0.78 kN;                      Example: The force shall be applied by a hydraulic ram with a 32 mm diameter piston until a pressure of 17 MPa is reached on the hydraulic ram.</li> <li>(b) The voltage of the cell drops by at least 100 mV; or</li> <li>(c) The cell is deformed by 50 % or more of its original thickness.</li> </ul> <p>Once the maximum pressure has been obtained, the voltage drops by 100 mV or more, or the cell is deformed by at least 50 % of its original thickness, the pressure shall be released.</p> <p>A prismatic or pouch cell shall be crushed by applying the force to the widest side. A button/coin cell shall be crushed by applying the force on its flat surfaces. For cylindrical cells, the crush force shall be applied perpendicular to the longitudinal axis.</p> <p>Each test cell or component cell is to be subjected to one crush only. The test sample shall be observed for a further 6 h. The test shall be conducted using test cells or component cells that have not previously been subjected to other tests.</p>	<p>N/A</p>



38.3.4.6.4	Requirement Cells and component cells meet this requirement if their external temperature does not exceed 170 °C and there is no disassembly and no fire during the test and within six hours after this test.	
<b>38.3.4.7</b>	<b>Test T.7: Overcharge</b>	
38.3.4.7.1	Purpose This test evaluates the ability of a rechargeable battery or a single cell rechargeable battery to withstand an overcharge condition.	
38.3.4.7.2	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) <del>when the manufacturer's recommended charge voltage is not more than 18 V, the minimum voltage of the test shall be the lesser of two times the maximum charge voltage of the battery or 22 V.</del> (b) when the manufacturer's recommended charge voltage is more than 18 V, the minimum voltage of the test shall be 1.2 times the maximum charge voltage. Tests are to be conducted at ambient temperature. The duration of the test shall be 24 hours.	PASS B#9-B#16  TEST CURRENT = 24A  TARGET MAX TEST VOLTAGE = 70.56V  BMS CUT-OFF VOLTAGE: 58.8V  NO DISASSEMBLY NO FIRE
38.3.4.7.3	Requirement Rechargeable batteries meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.	
<b>38.3.4.8</b>	<b>Test T.8: Forced discharge</b>	
38.3.4.8.1	Purpose This test evaluates the ability of a primary or a rechargeable cell to withstand a forced discharge condition.	
38.3.4.8.2	Test procedure Each cell shall be forced discharged at ambient temperature by connecting it in series with a 12V D.C. power supply at an initial current equal to the maximum discharge current specified by the manufacturer. The specified discharge current is to be obtained by connecting a resistive load of the appropriate size and rating in series with the test cell. Each cell shall be forced discharged for a time interval (in hours) equal to its rated capacity divided by the initial test current (in ampere).	N/A



38.3.4.8.3	Primary or rechargeable cells meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.	N/A
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TABLE 1: UN38.3 T1-T5 TESTS											
Object ID	Mass before test (kg)	Voltage before test (V)	T1: Altitude Simulation		T2: Thermal test		T3: Vibration		T4: Shock		T5: External Short Circuit
			% Mass loss	% V loss	% Mass loss	% V loss	% Mass loss	% V loss	% Mass loss	% V loss	Maximum Temperature (°C)
B#1	9.41	57.94	0.0	0.02	0.0	0.92	0.0	0.02	0.0	0.00	57.0
B#2	9.41	58.12	0.0	0.00	0.0	0.98	0.0	0.00	0.0	0.00	57.0
B#3	9.41	58.08	0.0	0.00	0.0	1.02	0.0	0.02	0.0	0.00	57.0
B#4	9.41	57.75	0.0	0.04	0.0	0.94	0.0	0.00	0.0	0.00	57.0
B#5	9.41	57.94	0.0	0.00	0.0	0.90	0.0	0.00	0.0	0.00	57.0
B#6	9.41	57.82	0.0	0.02	0.0	1.00	0.0	0.00	0.0	0.00	57.0
B#7	9.41	57.96	0.0	0.00	0.0	0.98	0.0	0.00	0.0	0.00	57.0
B#8	9.41	58.18	0.0	0.02	0.0	0.92	0.0	0.02	0.0	0.00	57.0

## 6. Compliance to requirements / *Atitikimas reikalavimams*

Test results of this test report for battery HRB2 comply with requirements of United Nations Manual for Tests and Criteria 7<sup>th</sup> edition. 38.3 Lithium metal and lithium-ion batteries. *Bandyimų protokole pateikti baterijos HRB2 bandymų rezultatai tenkina Jungtinių Tautų Vadovas Bandyamams 7-o leidimo Kriterijai. 38.3 Ličio metalų ir Ličio jonų baterijos.*

**2023-11-09**

Confirm / *Tvirtinu:*

Head of laboratory  
*Laboratorijos vadovas,* Domas Girtavičius

Tests performed / *Bandymus atliko:*

Technical manager  
*Technikos vadovas* Artūras Sabaliauskas



## IMPORTANT SVARBU

1. The test report is invalid without the seal of MB EWVTA
2. Nobody is allowed to photocopy or partly photocopy this test report without written permission of MB EWVTA.
3. The test report is invalid without the signatures of technical manager and head of laboratory
4. The test report is invalid if altered
5. Objections to the test report must be submitted to MB EWVTA within 15 days.
6. The test report is valid for the tested samples only.

## THE END OF TEST REPORT PROTOKOLO PABAIGA

