

UN 38.3 TEST REPORT

Test Report No. WT-230714-240

Date of issue 2023-08-11

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TEST OBJECT IDENTIFICATION:

Type:	Lithium-Ion battery pack
Manufacturer:	Wamtechnik
Model:	4INR19/66-2 / 1243.4A
Configuration:	4S2P
Cell type:	N18650CP by BAK
Nominal voltage:	14,40 V
Rated capacity:	6,70 Ah
Energy	96,48 Wh
Max charging voltage:	16,80 V
Max charging current:	5,0 A
Mass (approx.):	570 g
Dimensions (approx.):	51 × 80 × 170 mm
Appearance:	Irregular shape battery pack in grey plastic housing.

Test sample identification:

Sample identification No.	Sample No.	Received	Tests	Manufacturer, configuration, ratings
U240/28062023/01	1	2023-06-28	T.1-T.5,T.7	Wamtechnik
U240/28062023/02	2	2023-06-28	T.1-T.5,T.7	Model: 4INR19/66-2 / 1243.4A
U240/28062023/03	3	2023-06-28	T.1-T.5,T.7	14,40 V / 6,70 Ah / 96,48 Wh
U240/28062023/04	4	2023-06-28	T.1-T.5,T.7	after 25 cycles, fully charged state
U240/28062023/05	5	2023-06-28	T.1-T.5,T.7	Wamtechnik
U240/28062023/06	6	2023-06-28	T.1-T.5,T.7	Model: 4INR19/66-2 / 1243.4A
U240/28062023/07	7	2023-06-28	T.1-T.5,T.7	14,40 V / 6,70 Ah / 96,48 Wh
U240/28062023/08	8	2023-06-28	T.1-T.5,T.7	at 1st cycle, fully charged state

Samples were cycled by: Wamtechnik Sp. z o.o.

Samples were cycled 25 times under profile listed below:

Charge		Discharge	
Charging voltage:	16,8 V	End of discharge voltage:	11,0 V
Charge current:	3,3 A	Discharge current:	3,3 A
Charge termination criteria:	0,33A		

SUMMARY OF TESTING

All the tests are performed in accordance with ST/SG/AC.10/11/Rev.7/Amend.1
UN Manual of Tests and Criteria, Part III, sub-section 38.3 Lithium metal and lithium ion batteries.

Date of tests start: 14-07-2023

Date of tests end: 11-08-2023

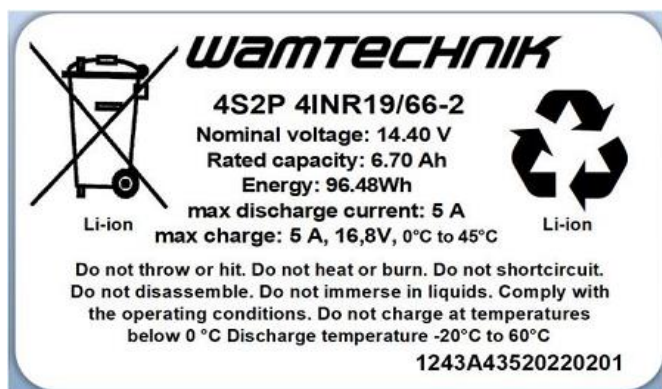
No.	Test performed	Test procedure acc. to	Requirements acc. to	Test result:	Report page
1	T.1: Altitude Simulation	Clause 38.3.4.1.2	Clause 38.3.4.1.3	Compliant	7
2	T.2: Thermal Test	Clause 38.3.4.2.2	Clause 38.3.4.2.3	Compliant	8
3	T.3: Vibration	Clause 38.3.4.3.2	Clause 38.3.4.3.3	Compliant	9
4	T.4: Shock	Clause 38.3.4.4.2	Clause 38.3.4.4.3	Compliant	10
5	T.5: External Short Circuit	Clause 38.3.4.5.2	Clause 38.3.4.5.3	Compliant	11
6	T.7: Overcharge	Clause 38.3.4.7.2	Clause 38.3.4.7.3	Compliant	12

The test results apply only to the samples actually tested by Wamtechnik Sp. z o.o.

List of Attachments:

No.	Name	Pages	Description
1	Appendix 1	1	Test Summary

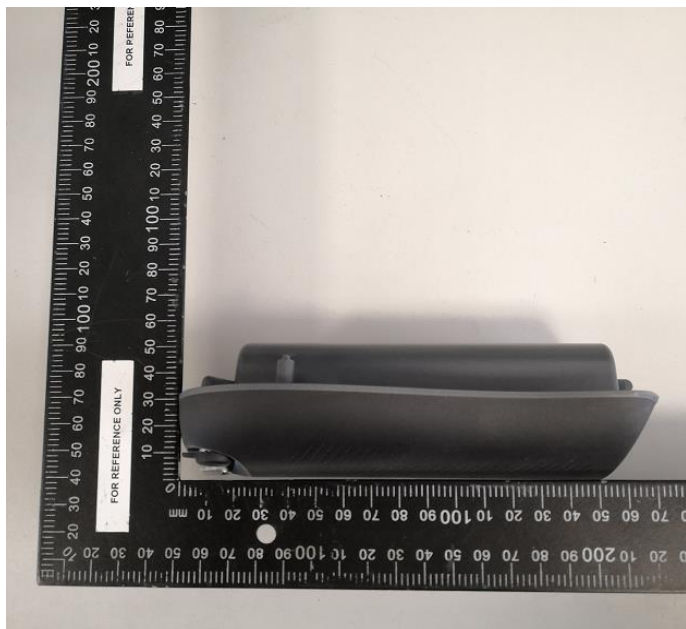
PHOTOGRAPHS OF SAMPLE



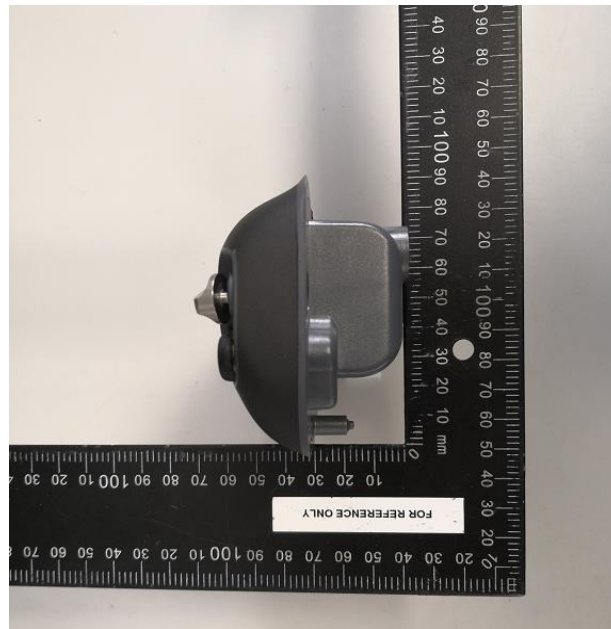
Picture 1: Label



Picture 2: X dimension



Picture 3: Y dimension



Picture 4: Z dimension

GENERAL

CELL SAFETY TESTING PRACTICES

Follow all battery Standard Operating Procedures when handling, testing, storing or disposing of battery samples. Follow appropriate procedures to prevent inadvertent shorting of battery and cell terminals during handling, storage and disposal of batteries. Follow Material Safety Data Sheets and battery Standard Operating Procedures when handling batteries where there is evidence of electrolyte leakage.

Some lithium batteries are capable of exploding when subjected to battery tests. It is important that personnel be protected from the flying fragments, explosive force, fire and sudden release of heat and noise that results from such explosions.

The test area is to be well ventilated to protect personnel from possible harmful fumes or gases that may be emitted during battery testing.

All personnel involved in the testing of lithium batteries are to be instructed never to approach a lithium battery while the surface temperature exceeds 90°C (194°F).

Definitions:

Battery - Two or more cells or batteries which are electrically connected together and fitted with devices necessary for use, for example, case, terminals, marking or protective devices. Units which have two or more cells that are commonly referred to as “battery packs”, “modules” or “battery assemblies” having the primary function of providing a source of power to another piece of equipment are treated as batteries.

Cell - A single encased electrochemical unit (one positive and one negative electrode) which exhibits a voltage differential across its two terminals, and may contain protective devices.

Component Cell - A cell contained in a battery. A component cell is not to be considered a single cell battery.

Cycle - One sequence of fully charging and fully discharging a rechargeable cell or battery.

Disassembly (Explosion) – A vent or rupture where solid matter from any part of a cell or a battery penetrates a wire mesh screen (annealed aluminum wire with a diameter of 0,25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cells or battery.

Fire - Flames are emitted from the test cell or battery.

First Cycle - The initial cycle following completion of all manufacturing processes.

Fully Charged – A rechargeable cell or battery, which has been electrically charged to its design rated capacity.

Fully Discharged - Either

- Primary cell or battery - Electrically discharged to remove 100% of its rated capacity
- Rechargeable cell or battery - Electrically discharged to its endpoint voltage as specified by the manufacturer

Large battery - A lithium metal battery or lithium ion battery with a gross mass of more than 12 kg.

Leakage – 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 mass loss exceeds the values in Table 1 below.

In order to quantify the mass loss the following procedure is provided:

$$\text{Mass Loss (\%)} = (M_1 - M_2) / M_1 \times 100$$

Where M_1 is the mass before the test and M_2 is the mass after the test. When mass loss does not exceed the values in the Table 1, it shall be considered as “no mass loss”.

Table 1:

Mass loss limit	
Mass M of cell or battery	Mass loss limit
$M < 1 \text{ g}$	0,5%
$1 \text{ g} \leq M \leq 75 \text{ g}$	0,2%
$M > 75 \text{ g}$	0,1%

Rupture – 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.

Single cell battery - A cell externally fitted with devices necessary for use in equipment or another battery which it is designed to power, for example protective devices.

Small Battery – A lithium metal battery or lithium ion battery with a gross mass of not more than 12 kg.

Small Cell – A cell with a gross mass of not more than 500 g.

Undischarged – A primary cell or battery that has not been wholly or partly discharged.

Venting – The release of excessive internal pressure from a cell or battery in a manner intended by design to preclude rupture or disassembly.

Condition legend :

- u** Undischarged state
- 1c** First cycle, fully charged state
- 1d** First cycle, fully discharged state
- 25c** 25 cycle, fully charged state
- 50c** 50 cycle, fully charged state

T.1 - ALTITUDE SIMULATION

Purpose: This test simulates air transport under low-pressure conditions.

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 ($20 \pm 5^{\circ}\text{C}$).

Sample No.	Conditions	Mass	Mass	Mass	Voltage	Voltage	Voltage	Results	
		before test	after test	loss	before test	after test	after test		
		[g]	[g]	[%]	[V]	[V]	[%]		
U240/28062023/01	25c	573,14	573,11	0,01	16,65	16,65	100,0	PASS	
U240/28062023/02	25c	569,70	569,67	0,01	16,65	16,64	99,9	PASS	
U240/28062023/03	25c	571,41	571,39	0,00	16,65	16,65	100,0	PASS	
U240/28062023/04	25c	569,68	569,67	0,00	16,67	16,67	100,0	PASS	
U240/28062023/05	1c	571,24	571,21	0,01	16,62	16,62	100,0	PASS	
U240/28062023/06	1c	570,15	570,14	0,00	16,63	16,62	99,9	PASS	
U240/28062023/07	1c	574,97	574,94	0,01	16,61	16,61	100,0	PASS	
U240/28062023/08	1c	568,85	568,77	0,01	16,61	16,61	100,0	PASS	

Tested by: Jarosław Kocon

Ambient temperature: 22,9°C

Results:

PASS: No leakage, no venting, no short-circuit (voltage not remain 90%), no rupture, no disassembly (explosion) and no fire.

FAIL: Other (please explain)

T.2 - THERMAL TEST

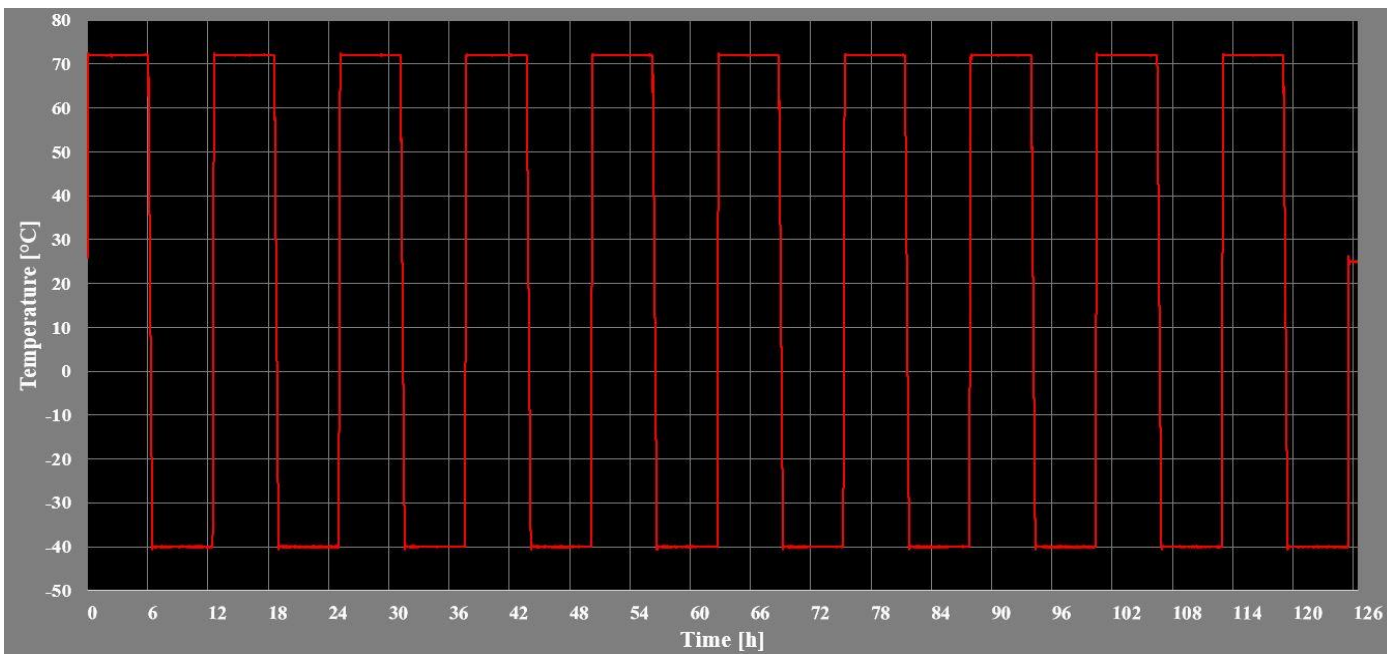
Purpose: This test assesses cell and battery seal integrity and internal electrical connections. The test is conducted using rapid and extreme temperature changes.

Procedure: Test cells and batteries are to be 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. 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 ($20 \pm 5^\circ\text{C}$). hours. For large cells and batteries the duration of exposure to the test temperature extremes should be at least 12 hours.

Sample No.	Conditions	Mass	Mass	Mass	Voltage	Voltage	Voltage	Results
		before test [g]	after test [g]	loss [%]	before test [V]	after test [V]	after test [%]	
U240/28062023/01	25c	573,11	573,12	0,00	16,65	16,51	99,1	PASS
U240/28062023/02	25c	569,67	569,79	-0,02	16,64	16,49	99,0	PASS
U240/28062023/03	25c	571,39	571,42	-0,01	16,65	16,51	99,1	PASS
U240/28062023/04	25c	569,67	569,74	-0,01	16,67	16,51	99,0	PASS
U240/28062023/05	1c	571,21	571,22	0,00	16,62	16,47	99,0	PASS
U240/28062023/06	1c	570,14	570,04	0,02	16,62	16,47	99,0	PASS
U240/28062023/07	1c	574,94	574,98	-0,01	16,61	16,47	99,1	PASS
U240/28062023/08	1c	568,77	568,88	-0,02	16,61	16,46	99,0	PASS

Tested by: Jarosław Kocon

Ambient temperature: 22,0°C



Picture 5: Thermal cycling plot

Results:

PASS: No leakage, no venting, no short-circuit (voltage not remain 90%), no rupture, no disassembly (explosion) and no fire.

FAIL: Other (please explain)

T.3 - VIBRATION

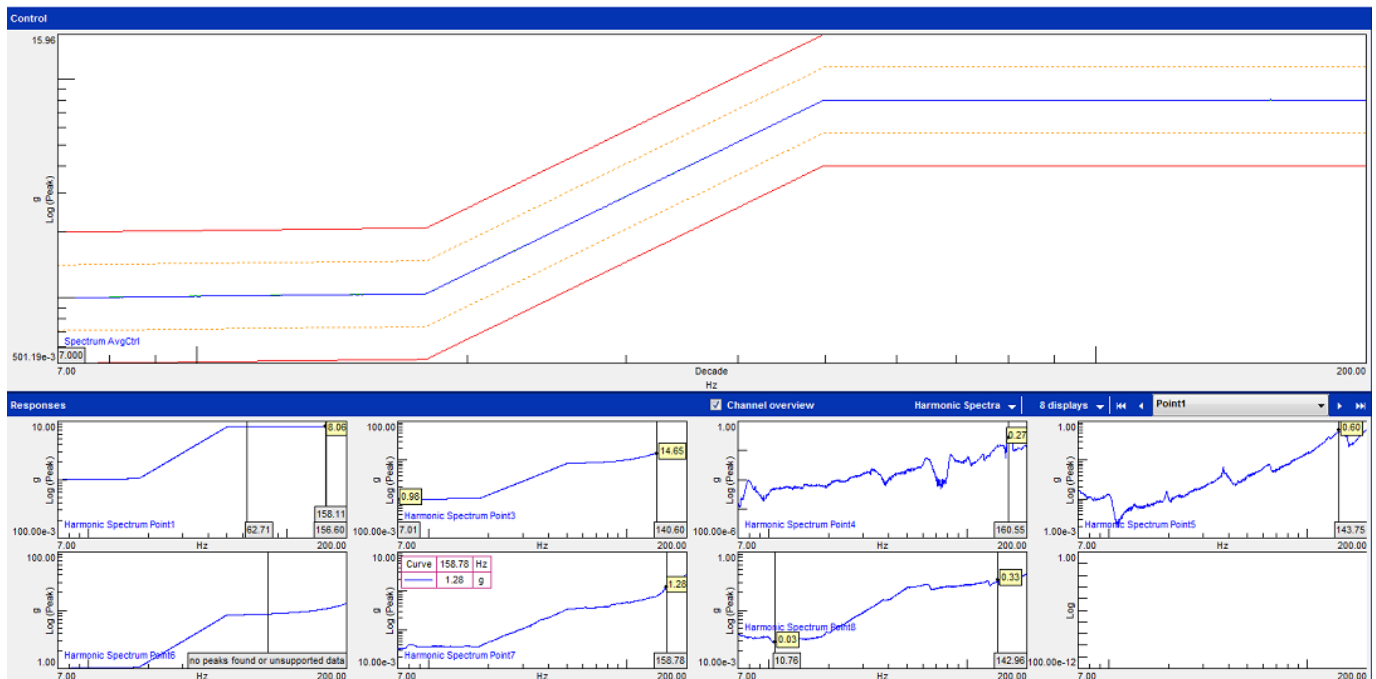
Purpose: This test simulates vibration during transport.

Procedure: 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 is sinusoidal waveform with a logarithmic sweep between 7 Hz and 200 Hz and back to 7 Hz traversed in 15 minutes. This cycle is repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the cell.

Sample No.	Conditions	Mass	Mass	Mass	Voltage	Voltage	Voltage	Results
		before test [g]	after test [g]	loss [%]	before test [V]	after test [V]	after test [%]	
U240/28062023/01	25c	573,12	573,25	-0,02	16,51	16,51	100,0	PASS
U240/28062023/02	25c	569,79	569,84	-0,01	16,49	16,49	100,0	PASS
U240/28062023/03	25c	571,42	571,49	-0,01	16,51	16,51	100,0	PASS
U240/28062023/04	25c	569,74	569,89	-0,03	16,51	16,51	100,0	PASS
U240/28062023/05	1c	571,22	571,33	-0,02	16,47	16,47	100,0	PASS
U240/28062023/06	1c	570,04	570,34	-0,05	16,47	16,46	99,9	PASS
U240/28062023/07	1c	574,98	575,04	-0,01	16,47	16,47	100,0	PASS
U240/28062023/08	1c	568,88	568,91	-0,01	16,46	16,46	100,0	PASS

Tested by: Jarosław Kocon

Ambient temperature: 22,1°C



Picture 6: Vibration plot

Results:

PASS: No leakage, no venting, no short-circuit (voltage not remain 90%), no rupture, no disassembly (explosion) and no fire.

FAIL: Other (please explain)

T.4 - SHOCK

Purpose: This test assesses the robustness of cells and batteries against cumulative shocks.

Procedure: Batteries are firmly secured to the platform of the shock machine. Each battery is subjected to a half sine shock of a peak acceleration depending on the mass of the batteries and pulse duration is 6 ms, three shock in the positive direction and to three shock in the negative direction in each of three mutually perpendicular mounting position of the battery for a total of 18 shocks.

The formulas below are provided to calculate the appropriate minimum peak accelerations.

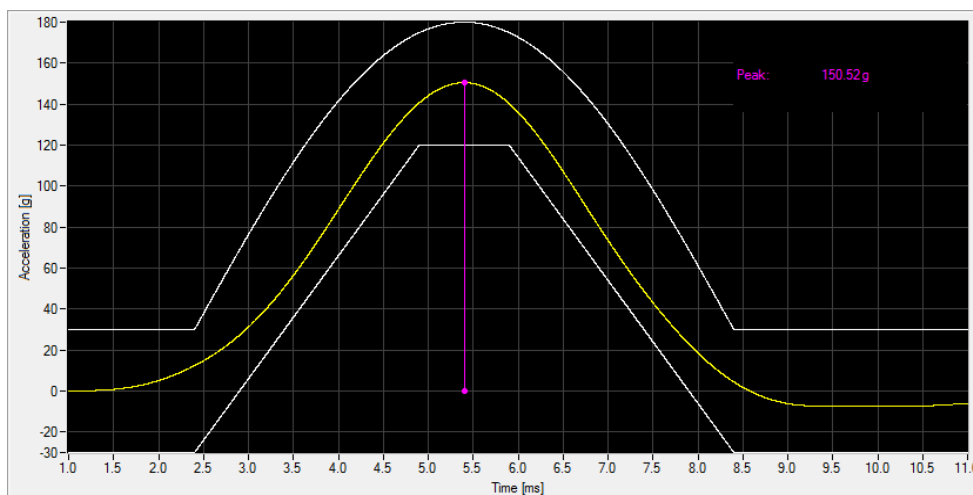
Minimum peak acceleration: 150 g or result of $g = \sqrt{\frac{100850}{mass}} = 420 \text{ g}$

Pulse duration: 6 ms

Sample No.	Conditions	Mass	Mass	Mass	Voltage	Voltage	Voltage	Results
		before test [g]	after test [g]	loss [%]	before test [V]	after test [V]	after test [%]	
U240/28062023/01	25c	573,25	573,32	-0,01	16,51	16,50	99,9	PASS
U240/28062023/02	25c	569,84	569,91	-0,01	16,49	16,49	100,0	PASS
U240/28062023/03	25c	571,49	571,50	0,00	16,51	16,51	100,0	PASS
U240/28062023/04	25c	569,89	569,92	-0,01	16,51	16,51	100,0	PASS
U240/28062023/05	1c	571,33	571,35	0,00	16,47	16,47	100,0	PASS
U240/28062023/06	1c	570,34	570,49	-0,03	16,46	16,46	100,0	PASS
U240/28062023/07	1c	575,04	575,04	0,00	16,47	16,46	99,9	PASS
U240/28062023/08	1c	568,91	568,86	0,01	16,46	16,45	99,9	PASS

Tested by: Jarosław Kocon

Ambient temperature: 23,3°C



Picture 7: Shock plot

Results:

PASS: No leakage, no venting, no short-circuit (voltage not remain 90%), no rupture, no disassembly (explosion) and no fire.

FAIL: Other (please explain)

T.5 - EXTERNAL SHORT CIRCUIT

Purpose: This test simulates an external short circuit.

Procedure: The cell or battery is heated for a period of time necessary to reach homogeneous stabilized temperature of $57 \pm 4^\circ\text{C}$, measured on the external case. Then the cell or battery at $57 \pm 4^\circ\text{C}$ is subjected to one short circuit condition with a total external resistance of less than $0,1 \Omega$. This short circuit condition is continued for at least one hour after the cell or battery external case temperature has returned to $57 \pm 4^\circ\text{C}$.

Time to reach homogeneous stabilized temperature : 6 hours

Sample No.	Conditions	Voltage before test [V]	Max temperature [°C]	Results
U240/28062023/01	25c	16,50	57,0	PASS
U240/28062023/02	25c	16,49	57,0	PASS
U240/28062023/03	25c	16,51	57,0	PASS
U240/28062023/04	25c	16,51	57,0	PASS
U240/28062023/05	1c	16,47	57,0	PASS
U240/28062023/06	1c	16,46	57,0	PASS
U240/28062023/07	1c	16,46	57,0	PASS
U240/28062023/08	1c	16,45	57,0	PASS

Tested by: Jarosław Kocon

Ambient temperature: $21,9^\circ\text{C}$

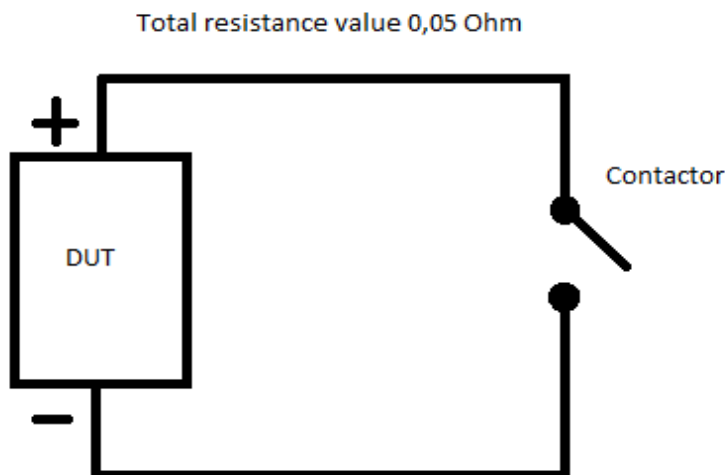


Diagram 1: Short circuit scheme

Results:

PASS: No excessive temperature rise (above 170°C), no rupture, no disassembly (explosion) and no fire.

FAIL: Other (please explain)

T.7 - OVERCHARGE

Purpose: This test evaluates the ability of a rechargeable battery or a single cell rechargeable battery to withstand an overcharge condition.

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 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.
- (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 conducted at ambient temperature. The duration of the test is 24 hours.

Sample No.	Conditions	Voltage before test [V]	Overcharge current [A]	Overcharge voltage [V]	Results
U240/28062023/01	25c	16,50	10,0	22,00	PASS
U240/28062023/02	25c	16,49	10,0	22,00	PASS
U240/28062023/03	25c	16,50	10,0	22,00	PASS
U240/28062023/04	25c	16,50	10,0	22,00	PASS
U240/28062023/05	1c	16,47	10,0	22,00	PASS
U240/28062023/06	1c	16,46	10,0	22,00	PASS
U240/28062023/07	1c	16,46	10,0	22,00	PASS
U240/28062023/08	1c	16,45	10,0	22,00	PASS

Tested by: Jarosław Kocon

Ambient temperature: 22,3°C

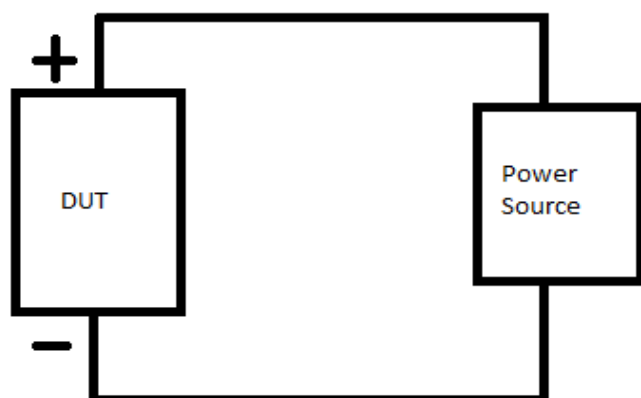


Diagram 2: Overcharge scheme

Results:

PASS: No disassembly (explosion) and no fire.

FAIL: Other (please explain)

TEST EQUIPMENT

No.	Equipment type	Manufacturer	Model	Serial No.
1	Balance	Radwag	PS 4500.R2	640524
2	Multimeter	Sanwa	PC 5000a	13055101070
3	Vaccum chamber	AA Portable Power Corp	BS-056	20161100448
4	Climatic chamber	Climats	Excal2 5424-HA	56766053180010
5	Vibrating system	Dongling Technologies	ES-20-320	D2101019
6	Vibration controller	Siemens	SCADAS SCM2E01V	21210609
7	Accelerometer	PCB Piezotronics	No.1 352C33	LW356603
8	Accelerometer	PCB Piezotronics	No.5 356A16	LW302639
9	Accelerometer	PCB Piezotronics	No.6 356A16	LW299552
10	Shock tester	ELSTAR	STM-50P	77-11706
11	Shock controller	ELSTAR	SCB02-24	360901
12	Accelerometer	DYTRAN	3200B6M	11796
13	Data logger	Graphtec	GL840-WV	C61121609
14	Short circuit	Wamtechnik	SCM BOX	1;2;3;4
15	Power Source	Aim-TTi	QPX 600 DP	507732 ; 508299

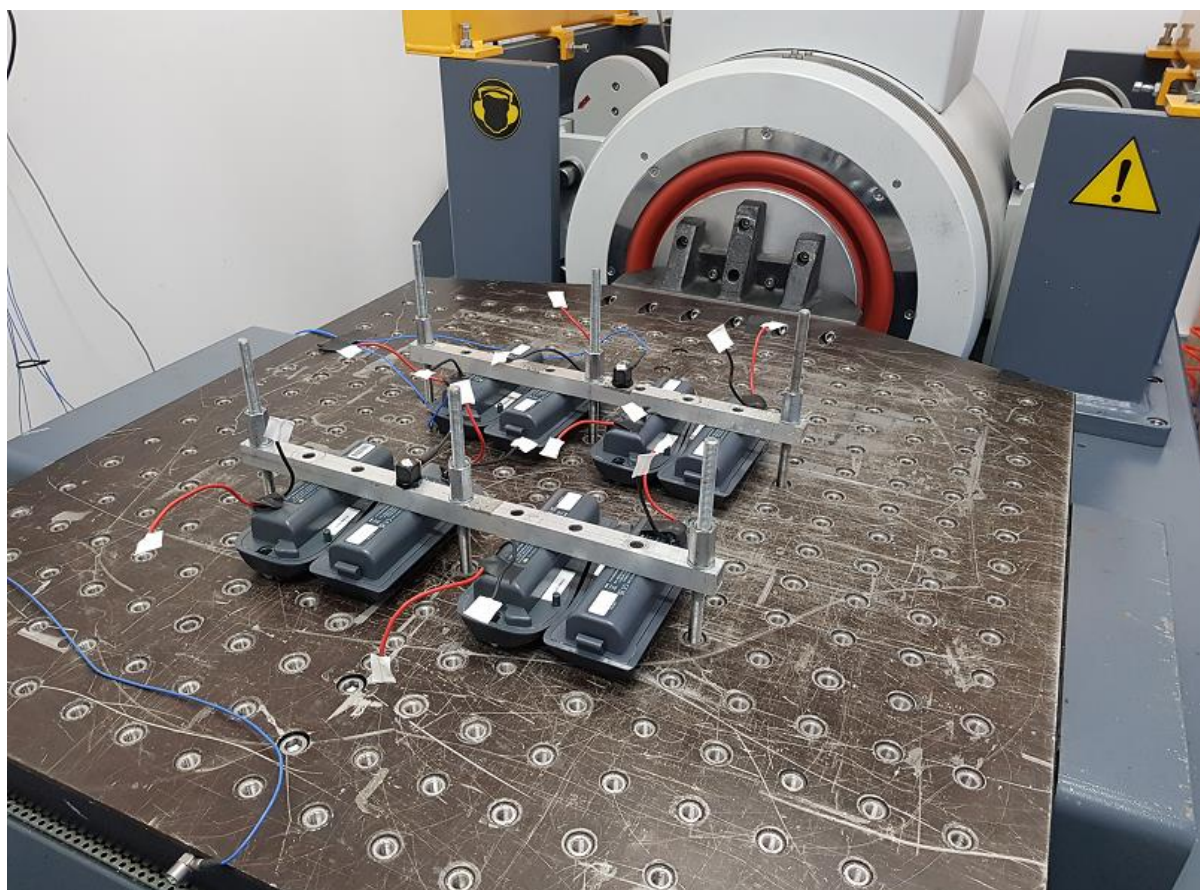
PHOTOGRAPHS OF SAMPLE ON TEST BENCH



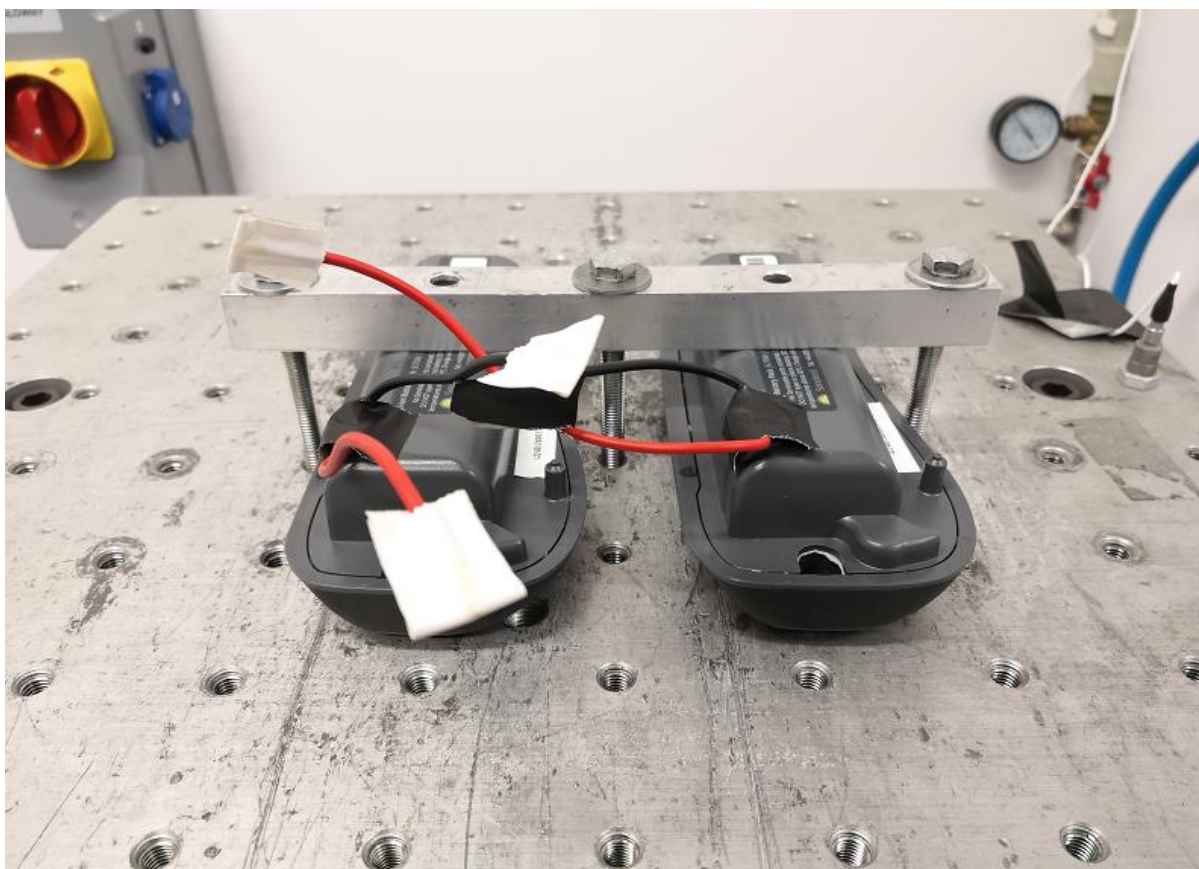
Picture 8: Samples in vacuum chamber



Picture 9: Samples in climatic chamber



Picture 10: Samples on vibration machine



Picture 11: Samples on shock tester



Picture 12: Sample connected to short circuit contactor



Picture 13: Sample connected to power source

END OF TEST REPORT