

TEST REPORT

AL/0021/(1 – 10)/2022/03

Test Object/Product: Lithium Battery (rechargeable)
3450mAh 3.6V 1S1P

Model: NCR18650GA-350PCM-T

	NAME / POSITION	SIGNATURE / STAMP
TEST RESULTS AUTHORIZED BY	Norbert Smoliński <i>Test Engineer</i>	Norbert Smoliński <i>Test Engineer</i>
TEST REPORT VALIDATED BY	Roman Gozdur <i>Laboratory Manager</i>	Roman Gozdur <i>Laboratory Manager</i>
Date of test report: 20/09/2022		Distribution list: 1 copy for Customer, 1 copy a/a



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6. Test summary (refers only to UN TESTS).

GENERAL INFORMATION	
Tests Requested by	Document
Name: BTO Sp. z o.o. Address: Fabryczna 25 Str. 90341PL Łódź, Poland, PL	Order No: 0021/2022 Date of order: 15.06.2022
Manufacturer	
Name: BTO Sp. z o.o. Address: Fabryczna 25 Str. 90341PL Łódź, Poland, PL	
TESTED OBJECT / PRODUCT	
Name:	Lithium Battery (rechargeable) 3450mAh 3.6V 1S1P NCR18650GA-350PCM-T
Description / state:	Rated capacity: 3450mAh (the initial full-charge state) Rated voltage: 3.6 V
Sampling / sample delivery method:	Samples delivered by Manufacturer
Sample size:	10 pieces
Sample collection date: 15.06.2022	Sample production date: 05.2022
Test initiation date: 20.07.2022	Test completion date: 06.09.2022
SCOPE AND METHODOLOGY	
Tests carried out according to: UN Recommendations on the Transport of Dangerous Goods. Test Manuals and Criteria: ST/SG/AC.10/11/Rev.7/Amend.1, Section 38.3, Lithium-Metal and Lithium-Ion batteries - (<i>hereinafter referred to as UN TEST</i>)	
SAMPLE IDENTIFICATION NUMBERS:	
Laboratory Identification Numbers (sample ID): AL / 0021 / (1 – 10/10)	
(after discharging carried out at BTO Lab.) AL/0021/(1–5/10)	(fully charged) AL/0021/(6–10/10)

Test Object



SCOPE OF TESTS

Item	Test Name	Test Procedure		Sample ID:	Page of report
1.	T1. Altitude simulation	A	UN TEST paragraph 38.3.4.1.2	AL/0021/(1-10/10)	4
2.	T2. Thermal test	A	UN TEST paragraph 38.3.4.2.2	AL/0021/(1-10/10)	5
3.	T3. Vibration	A	UN TEST paragraph 38.3.4.3.2	AL/0021/(1-10/10)	6
4.	T4. Shock	A	UN TEST paragraph 38.3.4.4.2	AL/0021/(1-10/10)	7
5.	T5. External short circuit	A	UN TEST paragraph 38.3.4.5.2	AL/0021/(1-10/10)	8
6	T7. Overcharge	A	UN TEST paragraph 38.3.4.7.2	AL/0021/(1-10/10)	9

* Battery packs assigned AL / 0021 / (1-10/10) were fully charged before the tests.

1. ALTITUDE SIMULATION

Test procedure (document): UN TEST paragraph 38.3.4.1.2 **Sample ID:** AL/0021/(1 - 10)

Test conditions: Pressure in the chamber: 11kPa; time: 6h; ambient temperature: 20±5°C

TEST RESULTS								
Sample ID	State	VOLTAGE [V]			MASS (g)			Sample observation
		Before testing	After testing	change OCV[%]	before testing	after testing	Change mass[%]	
AL/0021/(1/10)	after 25 cycles	4.154	4.153	0.04%	48.6	48.6	0.00%	○
AL/0021/(2/10)	after 25 cycles	4.152	4.151	0.03%	48.4	48.4	0.00%	○
AL/0021/(3/10)	after 25 cycles	4.153	4.152	0.03%	48.5	48.5	0.00%	○
AL/0021/(4/10)	after 25 cycles	4.154	4.153	0.03%	48.6	48.6	0.00%	○
AL/0021/(5/10)	after 25 cycles	4.154	4.153	0.04%	48.6	48.6	0.00%	○
AL/0021/(6/10)	after 1 full cycle	4.143	4.142	0.02%	48.5	48.5	0.00%	○
AL/0021/(7/10)	after 1 full cycle	4.143	4.142	0.02%	48.6	48.6	0.00%	○
AL/0021/(8/10)	after 1 full cycle	4.141	4.140	0.02%	48.7	48.7	0.00%	○
AL/0021/(9/10)	after 1 full cycle	4.143	4.142	0.02%	48.6	48.6	0.00%	○
AL/0021/(10/10)	after 1 full cycle	4.144	4.143	0.02%	48.6	48.6	0.00%	○
Measurement uncertainty:		± 0.002 V			± 0.2 g			
Result:		PASS						

Term abbreviations: **D** - disassembly; **F** - fire; **L** - leakage; **R** - rupture; **V** - venting; **SN** - open circuit voltage after testing is not less than 90% of its voltage immediately prior the test

Acceptance criteria: **O** - none of the above phenomena were observed

Test equipment:	Attitude Simulation Test Chamber Model: BE-8104
	Voltmeter FLUKE 8845A
	Electronic balance RADWAG PS 200/2000.X2
NOTE: -	

2. THERMAL TEST

Test procedure (document): UN TEST paragraph 38.3.4.2.2

Sample ID: AL/0021/(1-10)

Test conditions: Storage at test temp. 72±2°C for 6h
Storage at test temp. - 40±2°C for 6h X 10 cycles

TEST RESULTS								
Sample ID	State	VOLTAGE [V]			MASS (g)			Sample observation
		Before testing	After testing	change OCV[%]	before testing	after testing	Change mass[%]	
AL/0021/ (1/10)	after 25 cycles	4.153	4.109	1.04%	48.6	48.6	0.00%	○
AL/0021/ (2/10)	after 25 cycles	4.151	4.108	1.03%	48.4	48.4	0.00%	○
AL/0021/ (3/10)	after 25 cycles	4.152	4.109	1.02%	48.5	48.5	0.00%	○
AL/0021/ (4/10)	after 25 cycles	4.153	4.110	1.03%	48.6	48.6	0.00%	○
AL/0021/ (5/10)	after 25 cycles	4.153	4.110	1.04%	48.6	48.6	0.00%	○
AL/0021/ (6/10)	after 1 full cycle	4.142	4.107	0.86%	48.5	48.5	0.00%	○
AL/0021/ (7/10)	after 1 full cycle	4.142	4.108	0.82%	48.6	48.6	0.00%	○
AL/0021/ (8/10)	after 1 full cycle	4.140	4.106	0.84%	48.7	48.7	0.00%	○
AL/0021/ (9/10)	after 1 full cycle	4.142	4.107	0.84%	48.6	48.6	0.00%	○
AL/0021/ (10/10)	after 1 full cycle	4.143	4.107	0.87%	48.6	48.6	0.00%	○
Measurement uncertainty:		± 0.002 V				± 0.2 g		
Result:	PASS							

Term abbreviations: **D** - disassembly; **F** - fire; **L** - leakage; **R** - rupture; **V** - venting; **SN** - open circuit voltage after testing is less than 90% of its voltage immediately prior the the test

Acceptance criteria: **O** - none of the above phenomena were observed

Test equipment:	Dynamic climate chamber DGBell BTT – 150D
	Thermometer Keithley DAQ6510+7708 TC K-type
	Voltmeter FLUKE 8845A
	Electronic balance RADWAG PS 200/2000.X2
NOTE: (*) –	

3. VIBRATIONS

Test procedure (document): UN TEST paragraph 38.3.4.3.2 **Sample ID:** AL/0021/(1 - 10)

Test conditions: Frequency: 7Hz↔ 200Hz / cycle time: 15 minutes / number of cycles: 12 cycles for each axis

TEST RESULTS								
Sample ID	State	VOLTAGE [V]			MASS (g)			Sample observation
		Before testing	After testing	change OCV[%]	before testing	after testing	Change mass[%]	
AL/0021/ (1/10)	after 25 cycles	4.109	4.108	0.03%	48.6	48.6	0.00%	○
AL/0021/ (2/10)	after 25 cycles	4.108	4.107	0.03%	48.4	48.4	0.00%	○
AL/0021/ (3/10)	after 25 cycles	4.109	4.108	0.03%	48.5	48.5	0.00%	○
AL/0021/ (4/10)	after 25 cycles	4.110	4.109	0.03%	48.6	48.6	0.00%	○
AL/0021/ (5/10)	after 25 cycles	4.110	4.108	0.03%	48.6	48.6	0.00%	○
AL/0021/ (6/10)	after 1 full cycle	4.107	4.106	0.03%	48.5	48.5	0.00%	○
AL/0021/ (7/10)	after 1 full cycle	4.108	4.106	0.03%	48.6	48.6	0.00%	○
AL/0021/ (8/10)	after 1 full cycle	4.106	4.104	0.03%	48.7	48.7	0.00%	○
AL/0021/ (9/10)	after 1 full cycle	4.107	4.106	0.03%	48.6	48.6	0.00%	○
AL/0021/ (10/10)	after 1 full cycle	4.107	4.105	0.03%	48.6	48.6	0.00%	○
Measurement uncertainty:		± 0.002 V				± 0.2 g		
Result:	PASS							

Term abbreviations: **D** - disassembly; **F** - fire; **L** - leakage; **R** - rupture; **V** - venting; **SN** - the open circuit voltage after testing is less than 90% of its voltage immediately prior the test

Acceptance criteria: **O** - none of the above phenomena were observed

Test equipment:	Vibration tester DGBell EV210VT650
	Voltmeter FLUKE 8845A
	Electronic balance RADWAG PS 200/2000.X2
NOTE: -	

4. SHOCK

Test procedure (document): UN TEST paragraph 38.3.4.4.2 **Sample ID:** AL/0021/(1-10)

Test conditions: Peak acceleration: 150G; pulse duration: 6 ms; 3 shocks for each axis and each direction; total: 18 shocks

TEST RESULTS								
Sample ID	State	VOLTAGE [V]			MASS (g)			Sample observation
		Before testing	After testing	change OCV[%]	before testing	after testing	Change mass[%]	
AL/0021/(1/10)	after 25 cycles	4.108	4.108	0.01%	48.6	48.6	0.00%	○
AL/0021/(2/10)	after 25 cycles	4.107	4.107	0.01%	48.4	48.4	0.00%	○
AL/0021/(3/10)	after 25 cycles	4.108	4.108	0.01%	48.5	48.5	0.00%	○
AL/0021/(4/10)	after 25 cycles	4.109	4.108	0.01%	48.6	48.6	0.00%	○
AL/0021/(5/10)	after 25 cycles	4.108	4.108	0.01%	48.6	48.6	0.00%	○
AL/0021/(6/10)	after 1 full cycle	4.106	4.105	0.01%	48.5	48.5	0.00%	○
AL/0021/(7/10)	after 1 full cycle	4.106	4.106	0.01%	48.6	48.6	0.00%	○
AL/0021/(8/10)	after 1 full cycle	4.104	4.104	0.01%	48.7	48.7	0.00%	○
AL/0021/(9/10)	after 1 full cycle	4.106	4.105	0.01%	48.6	48.6	0.00%	○
AL/0021/(10/10)	after 1 full cycle	4.105	4.105	0.01%	48.6	48.6	0.00%	○
Measurement uncertainty:	± 0.002 V			± 0.2 g				
Result:	PASS							

Term abbreviations: **D** - disassembly; **F** - fire; **L** - leakage; **R** - rupture; **V** - venting; **SN** - open circuit voltage after testing is less than 90% of voltage immediately prior the test

Acceptance criteria: **O** - None of the above phenomena were observed

Test equipment:	Shock Tester DGBell SKT50
	Voltmeter FLUKE 8845A
	Electronic balance RADWAG PS 200/2000.X2
NOTE: -	

5. EXTERNAL SHORT CIRCUIT

Test procedure (document): UN TEST paragraph 38.3.4.5.2

Sample ID: AL/0021/(1-10)

Test conditions: Heating time t = 6h; temperature: 57±4°C

External resistance < 0.1Ohm; short circuit duration t_{sc} = 1h

TEST RESULTS				
Sample ID	State	Temp. of external case after heating [°C]	Max. temp. of external case during test [°C]	Observation of the sample within 6h
AL/0021/ (1/10)	after 25 cycles	58.3	58.6	O
AL/0021/ (2/10)	after 25 cycles	58.5	58.8	O
AL/0021/ (3/10)	after 25 cycles	58.5	58.8	O
AL/0021/ (4/10)	after 25 cycles	58.6	58.9	O
AL/0021/ (5/10)	after 25 cycles	58.3	59.4	O
AL/0021/ (6/10)	after 1 full cycle	58.3	58.6	O
AL/0021/ (7/10)	after 1 full cycle	58.5	58.8	O
AL/0021/ (8/10)	after 1 full cycle	58.5	58.7	O
AL/0021/ (9/10)	after 1 full cycle	58.6	58.9	O
AL/0021/ (10/10)	after 1 full cycle	58.4	58.9	O
Measurement uncertainty:		± 1.5°C		
Result:		PASS		

Term abbreviations: D - disassembly; R - rupture; F - fire; T - temperature >170°C

Acceptance criteria: O - None of the above phenomena were observed during the test and within 6 h after the test.

Test equipment:	Temperature chamber and short-circuit tester BE-8102
	MicroOhm Meter Keithley 6220+2182A, Voltmeter FLUKE 8845A
	Electronic thermometer Keithley DAQ6510+7708 TC K-type
NOTE: -	

T.7 OVERCHARGE

Test procedure (document): UN TEST paragraph 38.3.4.7.2

Sample ID: AL/0021/(1-10)

Test conditions: Test duration: 24h; ambient temperature: 20±5°C; if max. charge voltage ≤ 18 V, then min. test voltage is 2 x max. charge voltage or 22 V; charge current = 2x max. charge current recommended by manufacturer.

TEST RESULTS		
Charge current I _{CH} : 3.3 A		Voltage U _{const} : 8.4V
Sample ID	State	Sample observation
AL/0021/ (1/10)	After 25 cycles	O
AL/0021/ (2/10)	After 25 cycles	O
AL/0021/ (3/10)	After 25 cycles	O
AL/0021/ (4/10)	After 25 cycles	O
AL/0021/ (5/10)	After 25 cycles	O
AL/0021/ (6/10)	After 1 full cycle	O
AL/0021/ (7/10)	After 1 full cycle	O
AL/0021/ (8/10)	After 1 full cycle	O
AL/0021/ (9/10)	After 1 full cycle	O
AL/0021/ (10/10)	After 1 full cycle	O
Result:		PASS

Term abbreviations: D - disassembly; F - fire

Acceptance criteria: O - None of the above phenomena were observed during the test and/or within 7 days after the test

Test equipment:	TTI power supply CPX200D, Temperature chamber and short-circuit tester DGBell BE-8102, Voltmeter FLUKE 8845A, Thermometer Keithley DAQ6510 TC type K,
NOTE: -	

- **END OF TEST REPORT** -



BTO Sp. z o.o.
 Fabryczna 25, 90-341 Łódź; Poland
 Phone: +48 42 672 42 02
 e-mail: office@bto.pl

TEST SUMMARY

Product name: **Lithium Battery (rechargeable)**
 Model/type/Configuration: **NCR18650GA-350PCM-T 1S1P**
 Rated parameters: **3.6 V; 3.450 Ah; 0.048 kg;**
 Tests Requested by: **BTO Sp. z o.o.; Fabryczna 25 Str.; 90-341 Łódź; Poland**
 Manufacturer: **BTO Sp. z o.o.; Fabryczna 25 Str.; 90-341 Łódź; Poland**

Based on the following test results:

UN TEST ID	TEST NAME	RESULT, CONFIRMATION OF CONFORMITY
38.3.4.1.2	T.1 Altitude simulation	Passed
38.3.4.2.2	T.2 Thermal test	Passed
38.3.4.3.2	T.3 Vibration	Passed
38.3.4.4.2	T.4 Shock	Passed
38.3.4.5.2	T.5 External short circuit	Passed
38.3.4.6.2	T.6a Impact	not applicable
38.3.4.6.3	T.6b Crush	not applicable
38.3.4.7.2	T.7 Overcharge	Passed
38.3.4.8.2	T.8 Forced discharge	not applicable

Test results terms: passed / failed / not applicable (not required or not included in the order)

It is hereby confirmed that the Test Object of this series of tests, mentioned in the title, meets the requirements of:

UN Recommendations on the Transport Of Dangerous Goods; Manual of Tests and Criteria ST/SG/AC.1 0/11/Rev.7/Amend.1, Lithium Metal and Lithium Ion batteries (Section 38.3) with the exception of paragraphs 38.3.4.6.2, 38.3.4.6.3, 38.3.4.8.2.

Norbert Smoliński

Test Engineer
 Test Engineer

Eng. Norbert Smoliński



Roman Gozdur
 Laboratory Manager

Laboratory Manager

PhD Eng. Roman Gozdur



Place and date of issue: Łódź, September, 20th, 2022