



JUNG Battery-powered Machine Skates
Powered by **non-flammable** Lithium-Ion Batteries



Will **NOT** burn or explode
due to

- ❖ External damage
- ❖ Internal damage
- ❖ Overcharging
- ❖ Dropping / shock
- ❖ Short circuit
- ❖ Heat/cold
- ❖ Vibration
- ❖ Transport

Engineered for Safety

Battery Technology
Made in Germany

1 Summary

Table 1-1: Summary of results

Test	Specification	Result
T.1 Altitude simulation	No leakage, no venting, no disassembly, no rupture, no fire and OCV after test \geq 90% OCV before test	passed
T.2 Thermal test	No leakage, no venting, no disassembly, no rupture, no fire and OCV after test \geq 90% OCV before test	passed
T.3 Vibration	No leakage, no venting, no disassembly, no rupture, no fire and OCV after test \geq 90% OCV before test	passed
T.4 Shock	No leakage, no venting, no disassembly, no rupture, no fire and OCV after test \geq 90% OCV before test	passed
T.5 External short circuit	No external temperature $>$ 170 °C, no disassembly, no rupture and no fire within 6 h after test	passed
T.7 Overcharge	There was no disassembly and no fire during test and within seven days after test.	passed

2 References

2.1 Specifications

- [1] United Nations ST/SG/AC.10/11/Rev.5 dated 2009, "Recommendation on the TRANSPORT OF DANGEROUS GOODS, Manual of Test and Criteria", fifth revised edition, section 38.3 "Lithium metal and lithium ion batteries"
- [2] United Nations ST/SG/AC.10/11/Rev.5/Amend.1 dated 2011, "Recommendation on the TRANSPORT OF DANGEROUS GOODS, Manual of Test and Criteria", fifth revised edition, amendment 1 and 2

2.2 Glossary of terms

BTH	Battery Test House
EUT	Equipment under Test
OCV	Open Circuit Voltage
SOC	State of Charge

2.3 Hazards according UN

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 loss of mass exceeds 0.1% of the mass of the cell or battery. (For cells or batteries with a mass less or equal 75 g a higher mass loss is tolerable.)
Venting	The release of excessive internal pressure from a cell or battery in a manner intended by design to preclude rupture or disassembly.
Fire	Flames are emitted from the test cell or battery.
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.
Disassembly	A vent or rupture where solid matter from any part of a cell or battery penetrates a wire mesh screen (annealed aluminium wire with a diameter of 0.25 mm and grid density of 6 to 7 wires per cm) placed 25 cm away from the cell or battery.

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3 General Information

3.1 Identification of client

Atec Batterien GmbH
Im Maurer 17
71144 Steinenbronn
Mr Bernd Knöpfle

3.2 Test laboratory

SGS Germany GmbH
Hofmannstraße 50
81379 München

3.3 Time schedule

Test period: May 07, 2015 – Feb 15, 2016

3.4 Participants

Table 3-1: List of participants

Name	Function	Phone	E-Mail
Michael Siessl	Testing	+49 89 787475-349	michael.siessl@sgs.com
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Andre Feldmann	Testing	+49 89 787475-340	andre.feldmann@sgs.com
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Manuela Zanzinger	Editor	+49 89 787475-348	manuela.zanzinger@sgs.com

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4 Equipment under Test

The tests were performed on four batteries (AL1520505-1, -2, -3, -4) manufactured by Atec Batterien GmbH. The nominal voltage of the battery is 48 V with a nominal capacity of 60 Ah. The following pictures show the labelling of the batteries:



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Figure 4-1: View of labelling

In terms of test specification the modules are large with a gross mass of more than 12 kg. Four rechargeable lithium ion batteries were tested. The charge and discharge cycles prior to the tests were performed by the customer.

Table 4-1: List of batteries

EUT No.	Charge Status	Test(s)
AL1520505-1, -2	1 cycle charged	T.1 to T.5 and T.7
AL1520505-3, -4	25 cycles charged	T.1 to T.5 and T.7

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5 Test Equipment

The tests were carried out at the Battery Test House of the SGS Germany GmbH.

Table 5-1: List of test equipment used

ID No.	Measuring/Test Equipment	Test & Measured quantity	Status	Cal. valid until
B0141	Digital multimeter (TRMS)	T.1 + T.2 / Voltage	cal	Jan 31, 2016
B0283	Industrial Scale	T.1 to T.4 / Weight	cal	Dec 2016
B0247	Altitude Test Chamber	T.1	cal	May 31, 2017
B0254	Laptop BTH_21	T.1	cnn	
B0142	Digital multimeter (TRMS)	T.1 + T.2 + T.3 / Voltage	cal	Feb 29, 2016
B0143	Digital multimeter (TRMS)	T.1 + T.3 + T.4 / Voltage	cal	Feb 2016
B0108	Rapid temperature chamber (Messplatz 6)	T.2 / Temperature	ind	
B0140	Digital multimeter (TRMS)	T.2 + T.4 / Voltage	cal	Jan 31, 2016
B0115	Temperature chamber	T.2	ind	-
S0795	Frequency Counter	T.3	ind	-
S0854	Frequency Display	T.3	ind	-
S1419	80A Vibration Exciter VIB9000	T.3	cnn	-
S5452	Vib Control V2.12.25	T.3	cnn	-
S5560	Vibration Control and Analysis system (VIB9000)	T.3	cal	Feb 2016
S6267	Lenovo Think Centre Tower PC (VIB9000)	T.3	ind	-
S6188	Accelerometer	T.3 / Acceleration	cal	Feb 2017
B0086	Vibration Test System (Exciter 300 kN)	T.4	cnn	-
B0087	Vib Control V2.12.1.0	T.4	cnn	-
B0089	Control PC VIB 300KN	T.4	cnn	-
B0086	Vibration Test System (Exciter 300 kN)	T.4	cnn	-
B0024	Data logger	T.5 + T.7 / Temperature	cal	May 2016
B0050	Data Recorder, portable	T.5 + T.7 / Voltage and current	cal	May 2016
B0279	Heating/ Drying Cabinet	T.5 / Temperature	ind	-
B0121	Steel-grid fixed resistor	T.5	ind	-
B0260	Current Transducer System	T.5 / Current	cal	Nov 2016
B0349	High Voltage Conductors	T.5	ind	-
B0329	Power Supply (Laboratory)	T.5	ind	-

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ID No.	Measuring/Test Equipment	Test & Measured quantity	Status	Cal. valid until
B0028	Battery Test System	T.7 / Voltage and current	ind	-
B0004	Laptop BTH_01	T.7	cnn	-
O0717	Power Supply	T.7	ind	-

cal = Calibration, car = Calibration restricted use, chk = Check, chr = Check restricted use, cpu = Check prior to use, calchk = Calibration and check, ind = for indication only, cnn = Calibration not necessary

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6 Test Specifications and Results

The test results in the report refer exclusively to the test object described in section 4 and the test period in section 3.3.

6.1 Test T.1 Altitude simulation

Test specification

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).

Test setup

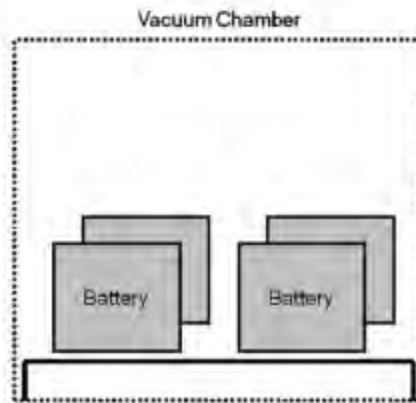


Figure 6-1: Schematic diagram of test setup

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Figure 6-2: Setup of test

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Result

There was no leakage¹, no venting, no disassembly, no rupture and no fire during the test. The OCV after test was greater than 90% of OCV before test. The test was passed.

The test was performed for 3 times on battery AL1520505-1 and AL1520505-3. Before third test of battery AL1520505-1 the circuit board was changed.

Table 6-1: Weight of batteries

EUT No.	Weight		
	before test (kg)	after test (kg)	loss (%)
AL1520505-1	68.210	68.198	0.018
AL1520505-2	68.060	68.056	0.006
AL1520505-3	68.112	68.110	0.003
AL1520505-4	68.116	68.104	0.018

¹ This requirement includes: no mass loss of more than 0.1 %.

Table 6-2: OCV of batteries

EUT No.	Open circuit voltage		
	before test (V)	after test (V)	ratio (%)
AL1520505-1	53.346	53.349	100.006
AL1520505-2	54.301	54.288	99.976
AL1520505-3	55.541	55.443	99.824
AL1520505-4	53.521	53.523	100.004

6.2 Test T.2 Thermal test

Test specification

Test cells and batteries are to be stored for at least 12 hours at a test temperature equal to $+72 \pm 2$ °C, followed by storage for at least 12 hours at a test temperature equal to -40 ± 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 cells and batteries are to be stored for 24 hours at ambient temperature ($+20 \pm 5$ °C).

Test setup

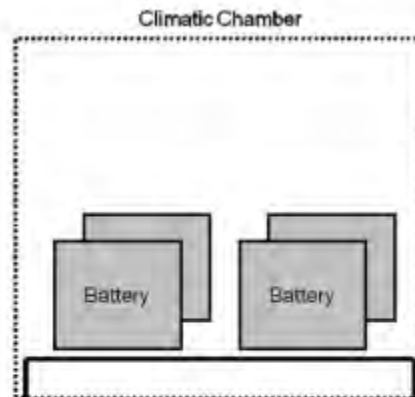


Figure 6-3: Schematic diagram of test setup

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Figure 6-4: Setup of test

Result

There was no leakage², no venting, no disassembly, no rupture and no fire during the test. The OCV after test was greater than 90% of OCV before test. The test was passed.

The test was performed for 3 times on battery AL1520505-1 and AL1520505-3. Before third test of battery AL1520505-1 the circuit board was changed. The third test of battery AL1520505-3 was interrupted after 1 cycle due to an outage of the temperature chamber. The last 9 cycles were restarted.

² This requirement includes: no mass loss of more than 0.1 %.

Table 6-3: Weight of batteries

EUT No.	Weight		
	before test (kg)	after test (kg)	loss (%)
AL1520505-1	68.208	68.148	0.088
AL1520505-2	68.056	68.012	0.065
AL1520505-3	68.114	68.060	0.079
AL1520505-4	68.104	68.060	0.065

Table 6-4: OCV of batteries

EUT No.	Open circuit voltage		
	before test (V)	after test (V)	ratio (%)
AL1520505-1	53.348	53.339	99.983
AL1520505-2	54.288	53.624	98.777
AL1520505-3	55.244	52.756	95.496
AL1520505-4	53.523	53.485	99.929

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Figure 6-5: Diagram of temperature profile

Test T.3 Vibration

Test specification

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.

The logarithmic frequency sweep is as follows: from 7 Hz 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 setup

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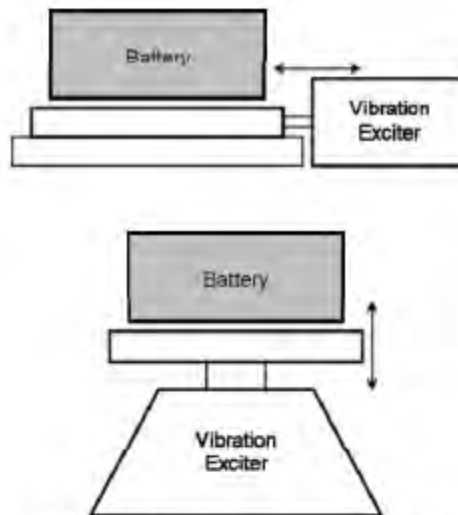


Figure 6-6: Schematic diagram of test setup



Figure 6-7: Setup of test, direction x



Figure 6-8: Setup of test, direction y

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Figure 6-9: Setup of test, direction z

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Result

There was no leakage³, no venting, no disassembly, no rupture and no fire during the test. The OCV after test was greater than 90% of OCV before test. The test was passed.

The vibration in z-axis was repeated at all batteries because the screwings of the top cover were loose.

After repetition no voltage was measured at battery AL1520505-1. The cell binders were strengthened and the test was repeated for x-, y- and z-axis.

Table 6-5: Weight of batteries

EUT No.	Weight		
	before test (kg)	after test (kg)	loss (%)
AL1520505-1	68.148	68.170	-0.032
AL1520505-2	67.978	67.984	-0.009
AL1520505-3	68.050	68.034	0.024
AL1520505-4	68.018	68.010	0.012

³ This requirement includes: no mass loss of more than 0.1 %.

Test setup

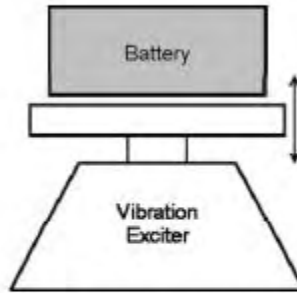


Figure 6-11: Schematic diagram of test setup



Figure 6-12: Setup of test, direction x

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Figure 6-13: Setup of test, direction y

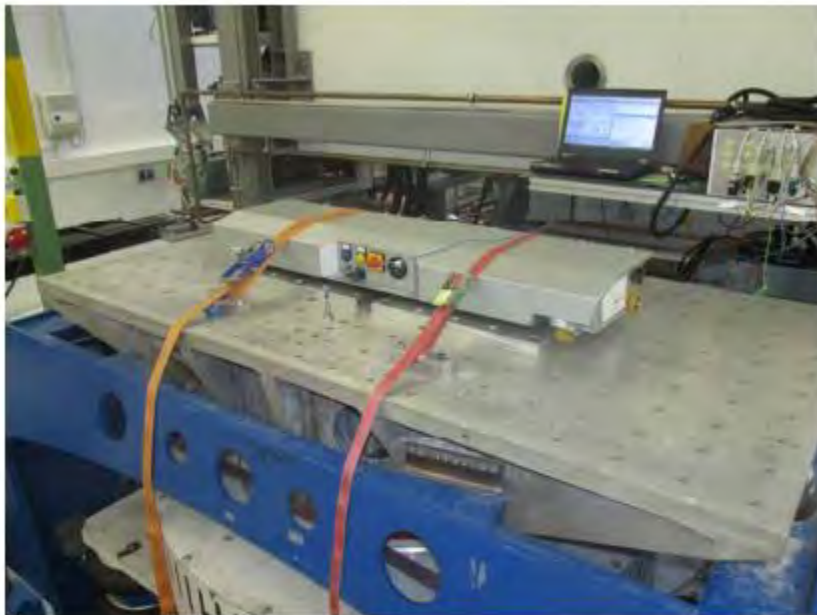


Figure 6-14: Setup of test, direction z

Result

There was no leakage⁴, no venting, no disassembly, no rupture and no fire during test. The OCV after test was greater than 90% of OCV before test. The test was passed.

After test no voltage was measured at battery AL1520505-1. The test was repeated.

Table 6-7: Weight of batteries

EUT No.	Weight		
	before test (kg)	after test (kg)	loss (%)
AL1520505-1	68.154	68.170	-0.023
AL1520505-2	67.986	67.954	0.047
AL1520505-3	68.038	68.024	0.021
AL1520505-4	68.000	68.014	-0.021

Table 6-8: OCV of batteries

EUT No.	Open circuit voltage		
	before test (V)	after test (V)	ratio (%)
AL1520505-1	53.351	53.343	99.985
AL1520505-2	53.515	53.496	99.964
AL1520505-3	52.841	52.838	99.994
AL1520505-4	53.395	53.392	99.994

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⁴ This requirement includes: no mass loss of more than 0.1 %.

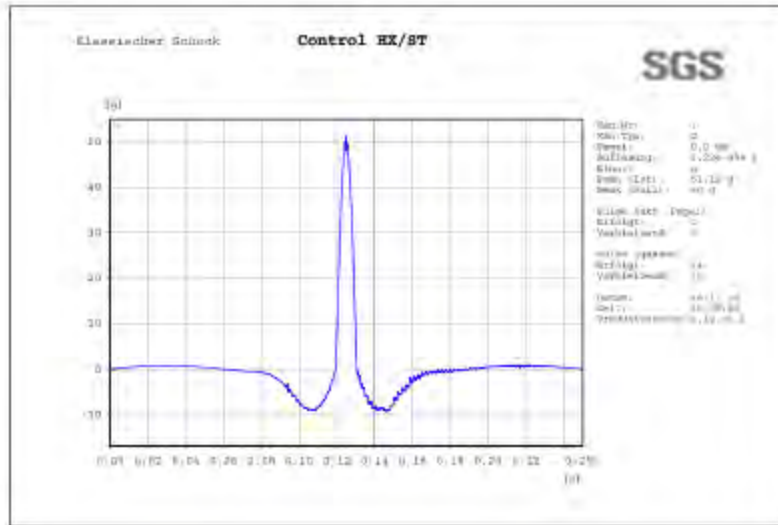


Figure 6-15: Diagram of positive shock profile

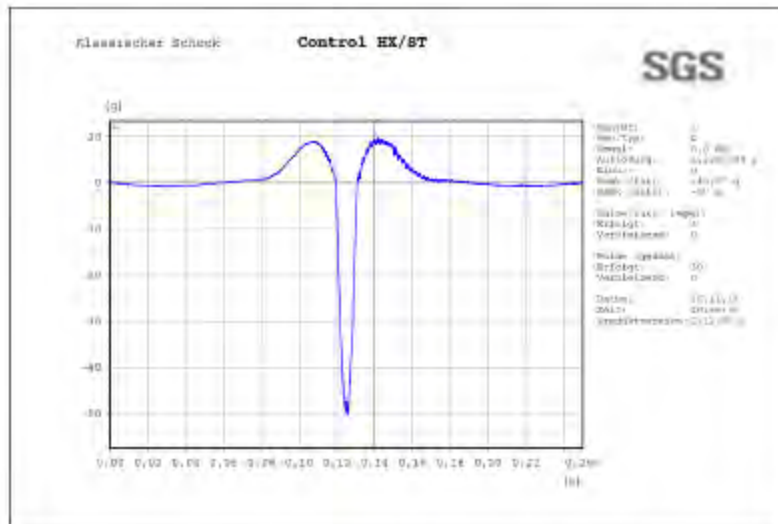


Figure 6-16: Diagram of negative shock profile

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6.5 Test T.5 External short circuit

Test specification

The cell or battery to be tested shall be temperature stabilized so that its external case temperature reaches $+55 \pm 2 \text{ }^\circ\text{C}$ and then the cell or battery shall be subjected to a short circuit condition with a total external resistance of less than 0.1 Ohm at $+55 \pm 2 \text{ }^\circ\text{C}$. This short circuit condition is continued for at least one hour after the cell or battery external case temperature has returned to $+55 \pm 2 \text{ }^\circ\text{C}$.

Test setup

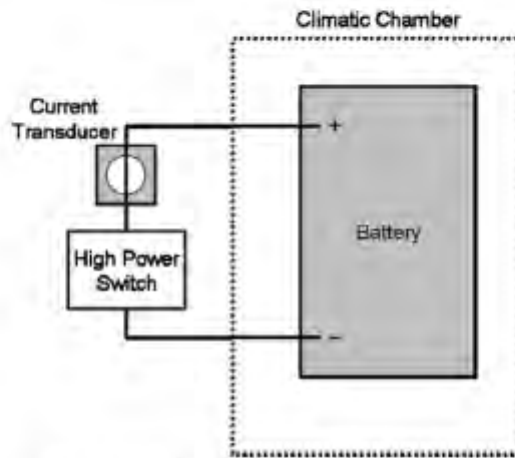


Figure 6-17: Schematic diagram of test setup

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Figure 6-18: Setup of test

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Result

There was no external temperature greater than 170 °C, no disassembly, no rupture and no fire during test and within 6 h after test. The test was passed.

Table 6-9: Maximum temperature (housing)

EUT No.	Maximum temperature (°C)
AL1520505-1	56.2
AL1520505-2	56.1
AL1520505-3	56.4
AL1520505-4	56.2

Battery AL1520505-4 was repaired by the customer after short circuit test.

Test T.7 Overcharging

Test specification

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

Test setup

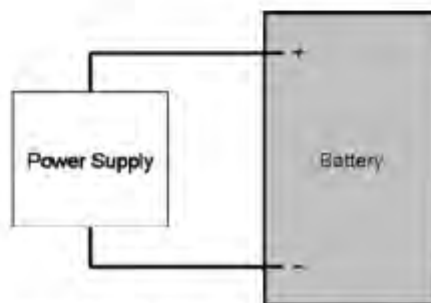


Figure 6-19: Schematic diagram of test setup



Figure 6-20: Setup of test

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Result

The overcharge voltage was 68.16 V and the overcharge current was 120 A. There was no disassembly and no fire during test and within seven days after test. The test was passed.

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