



Test Protocol

UN Transportation Test

UN Manual of Tests and Criteria, PART III, Sub-Section 38.3, Rev. 6 A1

Protocol

Protocol No..... : 1129-17-MM-18-PP004

Tested by (+ signature)..... : Harmel

F. Harmel

Approved by (+ signature)..... : Stein

M. Stein

Date of issue..... : 15.10.2018

Contents..... : 11 pages

Testing laboratory

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Address..... : Burgstädter Straße 20, 09232 Hartmannsdorf, Germany

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Phone..... : +49 (0)3722 7323-0

Testing location..... : as above

Applicant

Name..... : Akku Power GmbH

Address..... : Paul-Strähle-Straße 26

..... : 73614 Schorndorf, Deutschland

Test specification

Standard..... : UN Manual of Tests and Criteria
PART III, Sub-Section 38.3, Rev. 6 A1

Test procedure..... : Test of battery pack, see above

Protocol update..... : 2018-01

Test item

Description..... : Akku

Brand / Type..... : 104300 APAL 25,2V / 5,0Ah / 7S2P

Manufacturer..... : Akku Power GmbH

Paul-Strähle-Straße 26

73614 Schorndorf, Deutschland

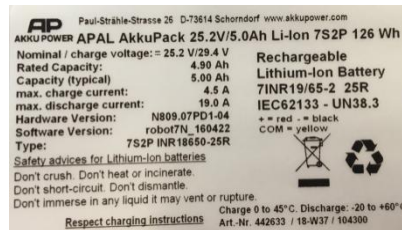
Testing

Date of receipt of test item..... : 2018-08-24

Date(s) of performance of test..... : Aug-2018...Oct-2018

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Copy of marking plate



Possible test case verdicts

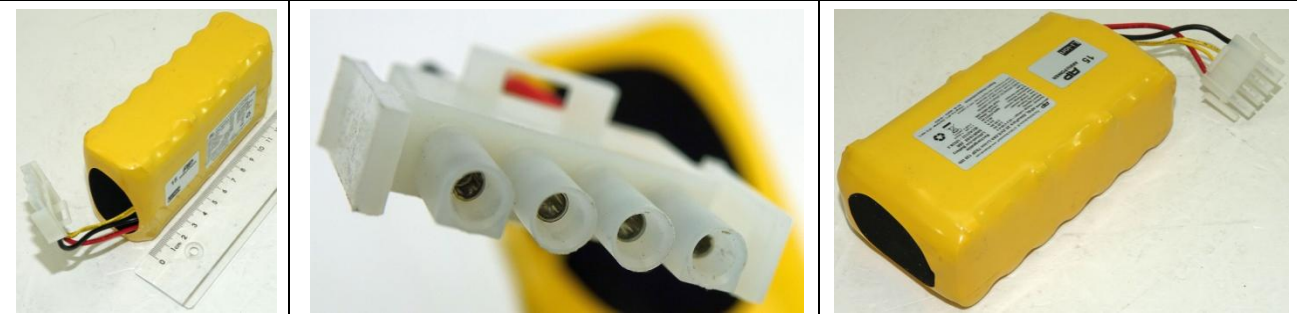
test case does not apply to the test object : N/A
 test object does meet the requirement..... : P(Pass)
 test object does not meet the requirement..... : F(Fail)

General remarks

The test results presented in this report relate only to the object tested.
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 Throughout this report a point is used as the decimal separator.

General product information

Battery Name..... : 104300 APAL 25,2V / 5,0Ah / 7S2P
 SLG Reference Number..... : 1129-17-M/32...39



Composition Description:

Battery assembled for use in mobile applications with a rated voltage of 25.2 V and a capacity of 5.0 Ah, with 14 single cells a 2.5 Ah, Samsung SDI INR18650-25R (successful UN-Test, Document No. MT0080405)

Summary of test results

| Test number | Test description | Result |
|-------------|---|--------|
| 38.3.4.1 | Altitude Simulation (Unterdrucktest) | P |
| 38.3.4.2 | Thermal Cycle Test (Thermischer Zyklentest) | P |
| 38.3.4.3 | Vibration (Vibrationstest) | P |
| 38.3.4.4 | Shock (Mechanischer Stoß) | P |
| 38.3.4.5 | External Short Circuit (Äußerer Kurzschlussstest) | P |
| 38.3.4.6 | Impact (Schlagprüfung) | N/A |
| 38.3.4.7 | Overcharge (Überlaststest) | P |
| 38.3.4.8 | Forced Discharge (Erzwungene Entladung) | N/A |



| |
|---------------------------|
| CYCLE CONDITIONING |
|---------------------------|

| |
|---|
| The preparation of the battery pack/single cells in accordance with the provisions in the UN Manual of Test and Criteria Part III, Sub-Section 38.3, Paragraph 38.3.3 was carried out by the contracting authority. |
|---|

| |
|-------------------------|
| TEST DESCRIPTION |
|-------------------------|

| |
|---|
| TABLE 1: Important Battery Data before start of test |
|---|

| Battery | Voltage [V] | Weight [g] |
|---------------|-------------|------------|
| 1129-17-M/032 | 28.9 | 701 |
| 1129-17-M/033 | 29.2 | 700 |
| 1129-17-M/034 | 29.3 | 704 |
| 1129-17-M/035 | 29.3 | 704 |
| 1129-17-M/036 | 29.3 | 702 |
| 1129-17-M/037 | 29.3 | 702 |
| 1129-17-M/038 | 29.4 | 704 |
| 1129-17-M/039 | 29.2 | 702 |

| |
|--|
| Samples 36 - 39 are in the first charging/discharging cycle. |
|--|

| |
|--|
| Samples 32 - 35 have completed 50 charging/discharging cycles. |
|--|

TEST 1: LOW PRESSURE TEST (38.3.4.1)



Figure 1: Pressure level in test chamber with the batteries inside

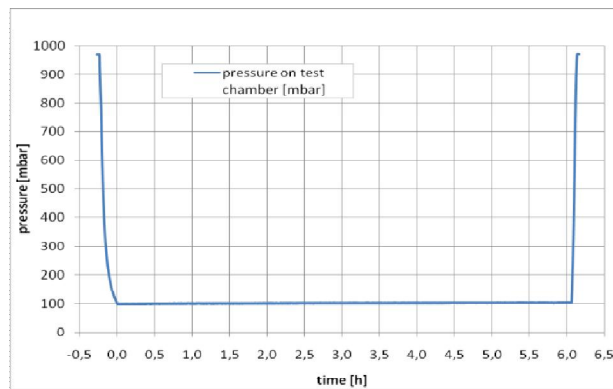


Figure 2: Diagram of pressure level in test chamber with the batteries inside

| TABLE 2 Test results low pressure test | | | | | |
|--|-------------------------|------------------------|------------------------|-----------------------|--------|
| Battery | Voltage [V] before test | Weight [g] before test | Voltage [V] after test | Weight [g] after test | Result |
| 1129-17-M/032 | 28.9 | 701 | 28.9 | 702 | P |
| 1129-17-M/033 | 29.2 | 700 | 29.1 | 700 | P |
| 1129-17-M/034 | 29.3 | 704 | 29.2 | 703 | P |
| 1129-17-M/035 | 29.3 | 704 | 29.1 | 704 | P |
| 1129-17-M/036 | 29.3 | 702 | 29.2 | 702 | P |
| 1129-17-M/037 | 29.3 | 702 | 29.2 | 701 | P |
| 1129-17-M/038 | 29.4 | 704 | 29.2 | 703 | P |
| 1129-17-M/039 | 29.2 | 702 | 29.1 | 701 | P |

TEST 2: THERMAL TEST (38.3.4.2)



Figure 3: Thermal test in climate cabinet with the batteries inside

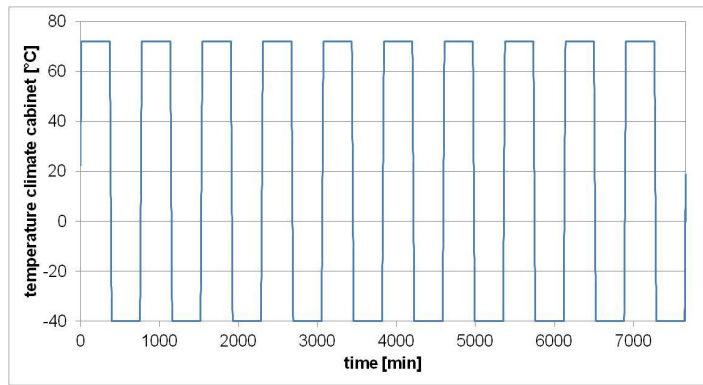


Figure 4: Temperature profile in climate cabinet with the batteries inside

| TABLE 3 Test results thermal test | | | | | |
|-----------------------------------|-------------------------|------------------------|------------------------|-----------------------|--------|
| Battery | Voltage [V] before test | Weight [g] before test | Voltage [V] after test | Weight [g] after test | Result |
| 1129-17-M/032 | 28.9 | 702 | 28.6 | 702 | P |
| 1129-17-M/033 | 29.1 | 700 | 28.5 | 700 | P |
| 1129-17-M/034 | 29.2 | 703 | 28.6 | 703 | P |
| 1129-17-M/035 | 29.1 | 704 | 28.6 | 704 | P |
| 1129-17-M/036 | 29.2 | 702 | 28.6 | 702 | P |
| 1129-17-M/037 | 29.2 | 701 | 28.5 | 701 | P |
| 1129-17-M/038 | 29.2 | 703 | 28.6 | 703 | P |
| 1129-17-M/039 | 29.1 | 701 | 28.6 | 701 | P |

TEST 3: VIBRATION TEST (38.3.4.3)

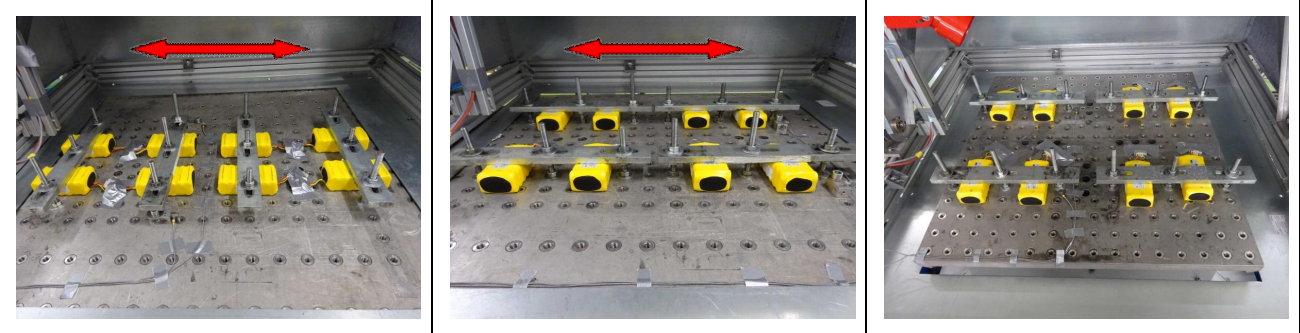


Figure 5: Vibration test on shaker table with the batteries

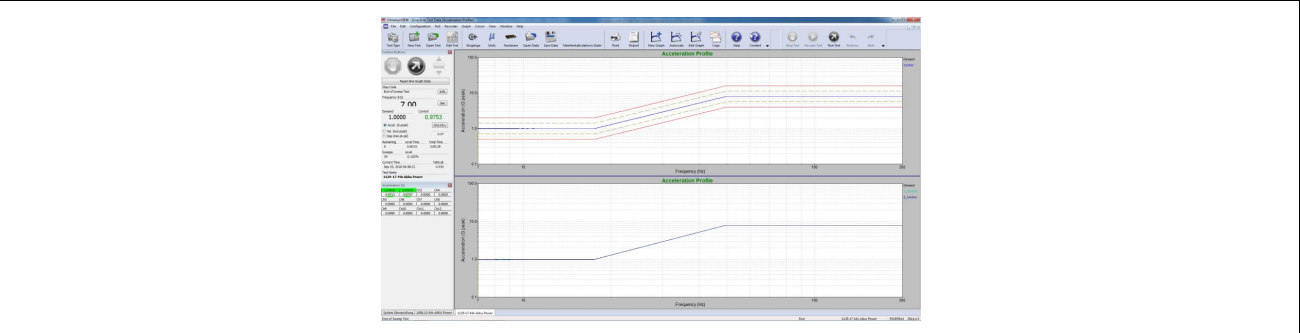


Figure 6: Vibration profile on shaker table with the batteries

| TABLE 4 | | Test results vibration test | | | |
|---------------|----------------------------|-----------------------------|---------------------------|--------------------------|--------|
| Battery | Voltage [V] before test | Weight [g] before test | Voltage [V] after test | Weight [g] after test | Result |
| 1129-17-M/032 | 28.6 | 702 | 28.5 | 702 | P |
| 1129-17-M/033 | 28.5 | 700 | 28.2 | 701 | P |
| 1129-17-M/034 | 28.6 | 703 | 28.6 | 704 | P |
| 1129-17-M/035 | 28.6 | 704 | 28.6 | 703 | P |
| 1129-17-M/036 | 28.6 | 702 | 28.5 | 702 | P |
| 1129-17-M/037 | 28.5 | 701 | 28.3 | 702 | P |
| 1129-17-M/038 | 28.6 | 703 | 28.5 | 702 | P |
| 1129-17-M/039 | 28.6 | 701 | 28.5 | 700 | P |

TEST 4: SHOCK TEST (38.3.4.4)



Figure 7: Shock test on shaker table with the batteries

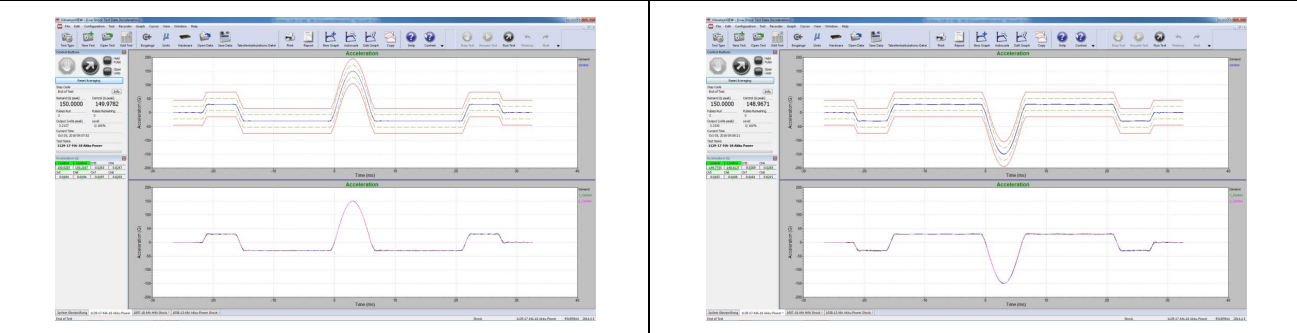


Figure 8: Vibration profile on shaker table with the batteries

| TABLE 5 Test results shock test | | | | | |
|-----------------------------------|-------------------------|------------------------|------------------------|-----------------------|--------|
| Battery | Voltage [V] before test | Weight [g] before test | Voltage [V] after test | Weight [g] after test | Result |
| 1129-17-M/032 | 28.5 | 702 | 28.5 | 701 | P |
| 1129-17-M/033 | 28.2 | 701 | 28.1 | 701 | P |
| 1129-17-M/034 | 28.6 | 704 | 28.6 | 704 | P |
| 1129-17-M/035 | 28.6 | 703 | 28.6 | 704 | P |
| 1129-17-M/036 | 28.5 | 702 | 28.5 | 702 | P |
| 1129-17-M/037 | 28.3 | 702 | 28.2 | 702 | P |
| 1129-17-M/038 | 28.5 | 702 | 28.5 | 702 | P |
| 1129-17-M/039 | 28.5 | 700 | 28.5 | 701 | P |

TEST 5: SHORT-CIRCUIT TEST (38.3.4.5)



Figure 9: Short-circuit test in heat cabinet at 55 °C with the batteries

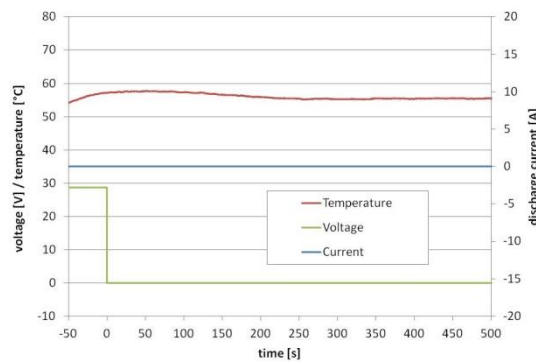


Figure 10: Short-circuit test diagram in heat cabinet at 55 °C with the batteries (at time 0 discharge current was switched on)

| TABLE 6 Test results short-circuit test | | | | | | |
|---|-------------------------|------------------------|--------------------------|------------------------|-----------------------|--------|
| Battery | Voltage [V] before test | Weight [g] before test | Maximum temperature [°C] | Voltage [V] after test | Weight [g] after test | Result |
| 1129-17-M/032 | 28.5 | 701 | < 60 | 0.0 | 701 | P |
| 1129-17-M/033 | 28.1 | 701 | < 60 | 0.0 | 701 | P |
| 1129-17-M/034 | 28.6 | 704 | < 60 | 0.0 | 703 | P |
| 1129-17-M/035 | 28.6 | 704 | < 60 | 0.0 | 703 | P |
| 1129-17-M/036 | 28.5 | 702 | < 60 | 0.0 | 702 | P |
| 1129-17-M/037 | 28.2 | 702 | < 60 | 0.0 | 702 | P |
| 1129-17-M/038 | 28.5 | 702 | < 60 | 0.0 | 702 | P |
| 1129-17-M/039 | 28.5 | 701 | < 60 | 0.0 | 701 | P |

TEST 7: OVERCHARGE TEST (38.3.4.7)



Figure 11: Overcharge test in safety cabinet with charge equipment (overcharge current 16 A, overcharge voltage 35.1 V)

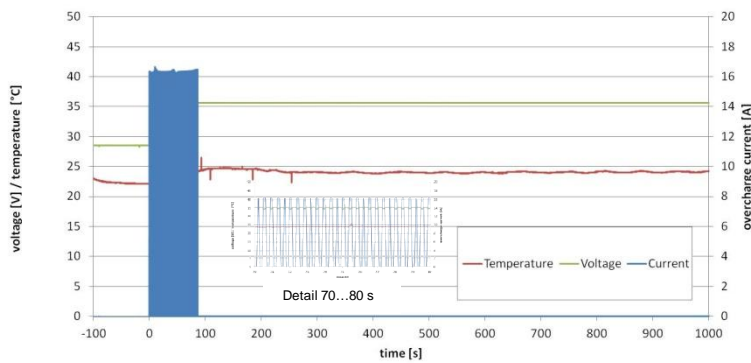


Figure 12: Overcharge test diagram (overcharge current 16 A, overcharge voltage 35.1 V, at time 0 overcharge current was switched on)

| TABLE 7 | | Test results overcharge test | | | | | |
|---------------|-------------------------|------------------------------|--------|------|------------------------|-----------------------|--------|
| Battery | Voltage [V] before test | Weight [g] before test | Damage | Fire | Voltage [V] after test | Weight [g] after test | Result |
| 1129-17-M/032 | 28.5 | 701 | No | No | 0.0 | 701 | P |
| 1129-17-M/033 | 28.1 | 701 | No | No | 0.0 | 701 | P |
| 1129-17-M/034 | 28.5 | 703 | No | No | 0.0 | 703 | P |
| 1129-17-M/035 | 28.6 | 703 | No | No | 0.0 | 703 | P |
| 1129-17-M/036 | 28.5 | 702 | No | No | 0.0 | 702 | P |
| 1129-17-M/037 | 28.1 | 702 | No | No | 0.0 | 702 | P |
| 1129-17-M/038 | 28.5 | 702 | No | No | 0.0 | 702 | P |
| 1129-17-M/039 | 28.5 | 701 | No | No | 0.0 | 701 | P |



| TABLE 8: List of Critical Components | | | | | |
|--------------------------------------|----------------------------|--------------|-------------------|----------|---|
| Object/Part No. | Manufacturer/ Trademark | Type/Model | Technical Data | Standard | Mark(s) of Conformity ¹⁾ |
| Battery Pack: | | | | | |
| Enclosure material (all models) | Not stated | Not stated | Not stated | - | - |
| Cell holder | Not stated | Not stated | Not stated | - | - |
| PCB material | Not stated | Not stated | Not stated | - | - |
| Single cell | Samsung | INR18650-25R | 3.6 V 2500 mAh | - | CB-Certificate IEC62133 DK-34607-UL |
| NTC | Not stated | Not stated | Not stated | - | - |
| Charger | | | | | |

End of test protocol



| ANNEX Test Equipment | | | | |
|---------------------------|---------------------------------|--|---|--|
| Clause | Test | Equipment | | Range used |
| 38.3.4.1 | Low pressure | Temperature controlled room (IEC17025) Low pressure chamber | 20°C ± 5 K Low pressure chamber Inv. no. 1499 | 20°C ± 5 K Low pressure ≤ 11.6 kPa |
| 38.3.4.2 | Cycling temperature change | Conditioning cabinet | Vötsch VC4034 Inv. no. 1400 | -20 °C ± 2 K...75 °C ± 2 K |
| 38.3.4.3 | Vibration | Vibration test system | Vibration test system TIRA TV 59335/AIT-440 with slip table. Inv. no. 1544 Rated peak force 35 kN Fluke 179 Inv. no. 5005 | Sinusoidal vibration test Frequency range: 10 Hz to 55 Hz; Displacement amplitude: 0.76 mm; Acceleration amplitude: 3 to 91 m/s ² |
| 38.3.4.4 | Mechanical shock (crash hazard) | Vibration test system | Vibration test system TIRA TV 59335/AIT-440 Inv. no. 1544 | 20 °C ± 5 K Shock test (halfsine) Max. shock amplitude from 125 g to 175 g (remark: test can only be realized for small test samples) |
| 38.3.4.5 | Outer short circuit | Conditioning cabinet contactor; test sample in steel box | Memmert ULE500 Inv. no. 0469 Contactor Steel box | -20°C ± 5 K...55°C ± 5 K ≤ 100 mΩ |
| 38.3.4.6 | Impact | Test equipment impact | | |
| 38.3.4.7 | Overcharge | Charging power station | Elektro-Automatik GmbH EA-532-100. Inv. no. 2731 Hioki LR8400-20 inv.no.: 2429 | $I_{\text{charge}} = 2 I_{\text{nominal}}$ Max. DC voltage 54 V, current 40 A Max. DC voltage 54 V, current 20 A |
| 38.3.4.8 | Forced discharge | Discharge power station | Höcherl&Hackerl ZS1406 | Max. DC voltage 60 V, current 150 A Max. DC voltage 44 V, current 40 A Max. DC voltage 44 V, current 20 A |
| 38.3.4.1 – 38.3.4.8 | All tests | Voltage measurement Current measurement | Data Logger Hioki LR8431-20 inv.no.: 2856, 2422, 2423 Current probe Z202A, inv.-no. 2425 | Max. DC voltage 60 V |