Safety test

DUCATI

Skyrich
12V 4 Ah

Abstract

Li Polymer batteries design by Skyrich should be tested for safety relevant issues.

Dokument>	2014_Ducati_safetytest_4Ah_documentation (Version 1.7).docx				
Version:	1.7				
	Datum	Name	Abteilung	Telefon	Unterschrift
Erstellt:		Michael Clauß	VT-S11	-34516	
Bearbeitet:	22.07.2014	Andreas Kekedi	SLG	03722-7323824	
Überprüft:					
Freigegeben:					
Status:	Finish				

Document Information

History

version	data	autor	changes
1.0	24.03.2014	Michael Clauß	Draft
1.1	16.04.2014	Ronny Schubert	Addition of the test results for - Overcharge test - Short circuit test - Heating test
1.2	16.05.2014	Ronny Schubert	Addition of the test results for - Deep-discharge cycles test - Drop test - Penetration test - Crush test
1.3	20.05.2014	Andreas Kékedi	Review
1.4	26.05.2014	Andreas Kékedi	Addition of the test results for - Short circuit test with 70mOhm
1.5	02.06.2014	Andreas Kékedi	Remark for figure 2 Remark for figure 12 Remark for crush test at page 28
1.6	17.06.2014	Andreas Kékedi	Further explanation for remark for figure 12
1.7	22.07.2014	Andreas Kékedi	New test results for - Deep-discharge cycles retests - Heating retest at 105℃

Content

1 TEST SPECIFICATION 4
2 DOCUMENTATION 8
2.1 DEEP-DISCHARGE CYCLES TEST 11
2.2 OVERCHARGE TEST 13
2.3 SHORT CIRCUIT TEST 16
2.3.1 Short circuit test with 5 mOhm 16
2.3.2 Short circuit test with 70 mOhm 18
2.4 DROP TEST 20
2.5 HEATING TEST 22
2.6 PENETRATION TEST 27
2.7 CRUSH TEST 29

1 Test specification

Test

Data record:

Value	Sampling
Temperature	2 sensors (one at minus terminal and one at the surface of battery), sample rate >/=1sample/s
Current	Battery current sample rate depends on the test. In ohmic resistant relevant test we need sample- rates up to 100 ms (Hinweis SLG).
Voltage	Battery voltage sample rate depends on the test. In ohmic resistant relevant test we need sample- rates up to 100 ms (Hinweis SLG).
Time	Time in [s] e.g.: 1.05 s
Video	For the whole time of observation

The data record should be at least 2h after test. In case of changing values at the end of this time slot, time can increase after talking with the customer.

Analysis:

- Document of test results (graphs, values),
- Video-clips ,
- Classification of the tests related to the hazard levels
- CD with data,

Time schedule:

Test start: 17.03.2014

End: 30.04.2014 (suggestion SLG)

	Hazard Level		Classification Criteria, Effect
accept	0	No effect	No effect, no loss of functionality
	1	Passive Protection activated	No defect, no leakage, no venting, no fire or flame, no rupture, no explosion, no exothermic reaction or thermal runaway, cell reversibly damaged, repair of protection device needed
	2	Defect Damage	No leakage, no venting, no fire or flame, no rupture, no explosion, no exothermic reaction or thermal runaway, cell irreversibly damaged, repair needed
	3	Leakage > 50%	No venting, no fire or flame, no rupture, no explosion, weight loss ≤ 50 % of the electrolyte weight electrolyte = solvent + salt
	4	Venting > 50%	No fire or flame, no rupture, no explosion, weight loss ≥ 50 % of the electrolyte weight
reject	5	Fire or Flame	No rupture, no explosion, i.e. no flying parts
	6	Rupture	No explosion, but flying parts, ejection of parts of the active mass
	7	Explosion	Explosion, i.e. disintegration of the cell

Abbildung 1: classification of the test results

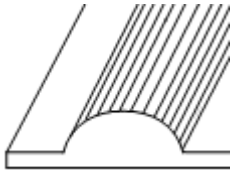

Abbildung 2: Waved surface of one of the crush plates.

Test sequence:

No.	Test Items	Standard and Requirement	Sample No.
1	Deep-discharge cycles test	Discharge the battery with a 0.5A up to 0V, after change to constant voltage step at 0V for 0.5 h. Relaxation time of 2h, then charge according to the manufacturer's specification. This is defined as 1 cycle. Repeat the cycle for 10 times (10 cycles). One battery at 0℃ and one battery at 40 ℃.	1,2
2	Overcharge test	Charging battery at 25 ℃ with power supply limited in voltage to 100V, current limited at 30A. Keep charging for 30 minutes. Relaxation time for 2h at Umax.	3
3	Short circuit test	Charge battery at 40 ℃ to 100 % SOC. Connecting positive and negative terminals of the battery with a wire as short circuit (wire resistance < 20 mΩ(→ 600 A short cut current).	4
4	Drop test	Drop from a height of 1,5m onto a steel cylinder with 150 mm radius based on SANDIA-drop test. Battery has to be charged completely at 25 ℃, one axis per time.	5
5	Heating test	Sample 6: keep the battery at 14,9V, current limited at 10A for charging. Keep the battery at 105℃ temperature for 2 hours then cool down to RT and wait for 2 hours. Sample 7: keep the battery at 14,9V (CCCV, I<C/20), current limited at 10A for charging. Keep the battery at 140℃ temperature for 2 hours then cool down to RT and wait for 2 hours. The heating rate should be 10K/h in both directions. (please note: housing of the battery can melt in case of temperatures higher than 80℃)	6,7
6	Penetration test	Execute the penetration test according to the existing normative. The points and directions of penetration are depends on the position of the cells in the battery (details later). Use a pin (30 °) with 10 mm in diameter. First put in the pin to 50 % of the thickness of the battery with a speed of 10mm/s then wait for 1min. After pierce through the battery with a speed of 80 mm/s.	8
7	Crush test	Test based on Sandia crush-test. Put the battery between a flat und a "waved" plate. Increase the force up to a displacement of 15 % in width of the battery. After wait for 5min, then increase the force again (max. 17 kN) up to a displacement of 50 % in width of the battery and wait 5min again. Direction depends on the position of the cells (details later).	9

Test sequence from highest priority(1) to lowest (7):

1. Heating
2. Overcharge
3. Deep discharge / charge cycles
4. Short circuit test
5. Penetration test
6. Crush test
7. Drop test

2 Documentation

Test Protocol

Safety Test

Test Specification DUCATI 12V 4Ah Battery

Protocol

Protocol No.....: 1145-13-MM-14-PP001

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

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

Date of issue.....: 2014-07-21

Contents .....: 30 pages

Testing laboratory

Name.....: SLG Prüf- und Zertifizierungs GmbH

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

Testing location .....: as above

Sub-Client

Name.....: IAV GmbH

Address .....: Kauffahrtei 25

.....: 09120 Chemnitz, Deutschland

Test specification

Standard.....: Test Specification DUCATI 12V 4Ah Battery

Test procedure .....: Safety Test

Protocol update .....: 2014-03

Test item

Description.....: Battery

Brand / Type .....: Skyrich 12V 4Ah (2p4s)

Manufacturer .....: Not stated

Testing

Date of receipt of test item..... : 2014-03-18 / 2014-06-11 / 2014-06-13

Date(s) of performance of test: March - July 2014

Copy of marking plate

Possible test case verdicts

Classification based on EUCAR

General remarks

The test results presented in this report relate only to the object tested.

General product information

Battery Name.....: Skyrich 12V 4Ah

SLG Reference Number.: 1145-13-MM

Summary of test results

Test number	Test description	EUCAR-level
1.1	Deep-discharge cycles test with battery 710009 and 710003	2 (at 0°C) 2 (at 40°C)
1.2	Deep-discharge cycles test with battery 870351 and 870182	2 (at 0°C) 2 (at 40°C)
2	Overcharge test	4
3.1	Short circuit test with 5 mOhm	2
3.2	Short circuit test with 70 mOhm	2
4	Drop test	0
5.1	Heating test	2 (at 105°C) 4 (at 140°C)
5.2	Heating test at 105°C with battery 870180	2
6	Penetration test	4
7	Crush test	0

TEST DESCRIPTION		
TABLE 1: Battery Data before start of test		
Battery	Voltage [V]	Weight [g]
1 (710003)	13.4	878
2 (710009)	13.6	876
3 (710001)	14.5	883
4 (710004)	13.5	882
5 (710006)	13.8	879
6 (710002)	14.5	895
7 (710008)	14.5	878
8 (710010)	13.7	876
9 (710007)	13.5	880
10 (710005)	14.2	880
11 (870351)	13.4	890
12 (870182)	13.7	885
13 (870180)	13.7	895
14 (870181) – not used for tests	13.2	884

2.1 Deep-discharge cycles test

TEST : Deep-discharge cycles test

Battery –ID: 710009 and 710003

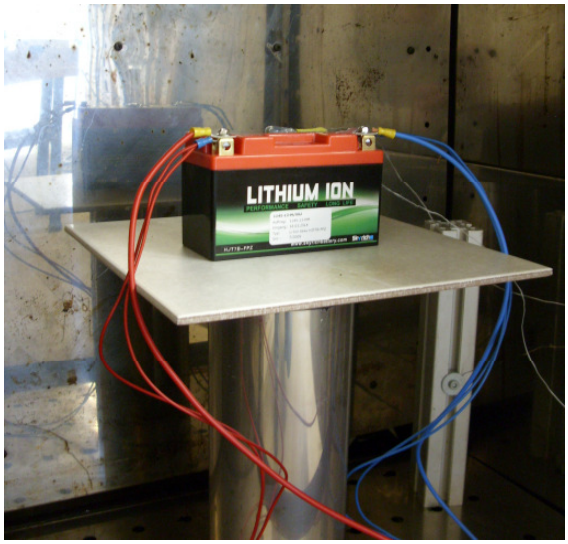

Figure 1: Deep-discharge cycle test in climate cabinet with the batteries 710003 (test at 0°C) and 710009 (test at 40°C)

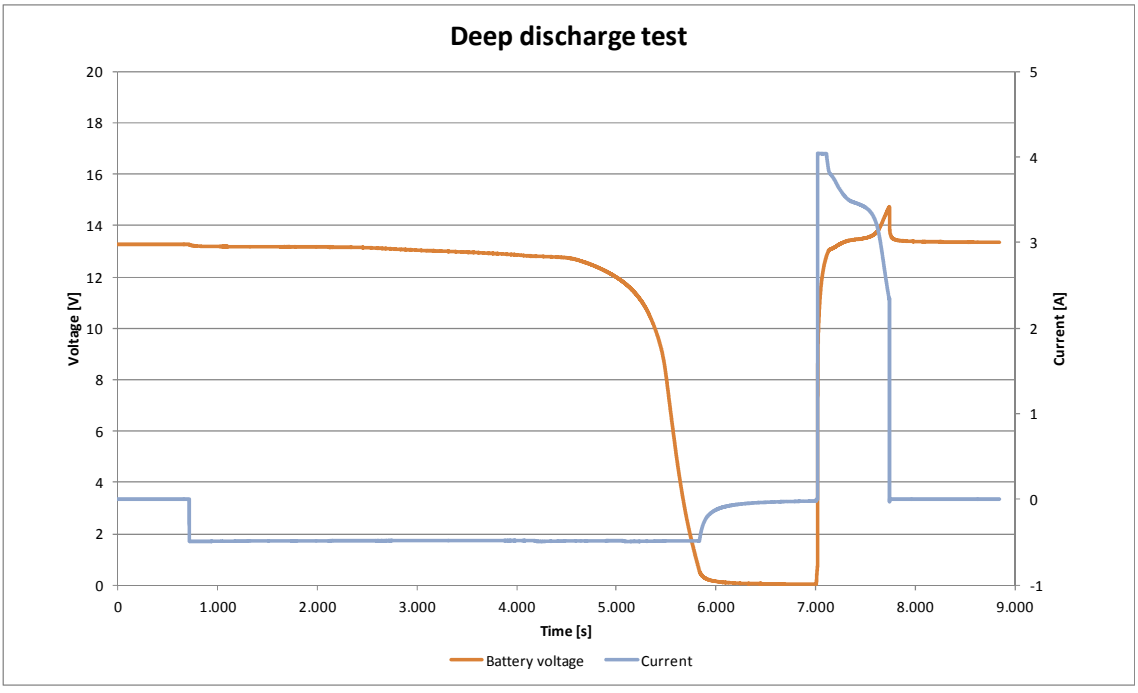

Figure 2a: One cycle (cycle no. 4) of the deep discharge test as example at 40°C with the battery 710009

During the whole test the temperature at the battery as well as the ambient temperature in the test champer was 40°C ± 2K

Deep-discharge cycles test with battery 870351 at 0℃ and 870182 at 40℃

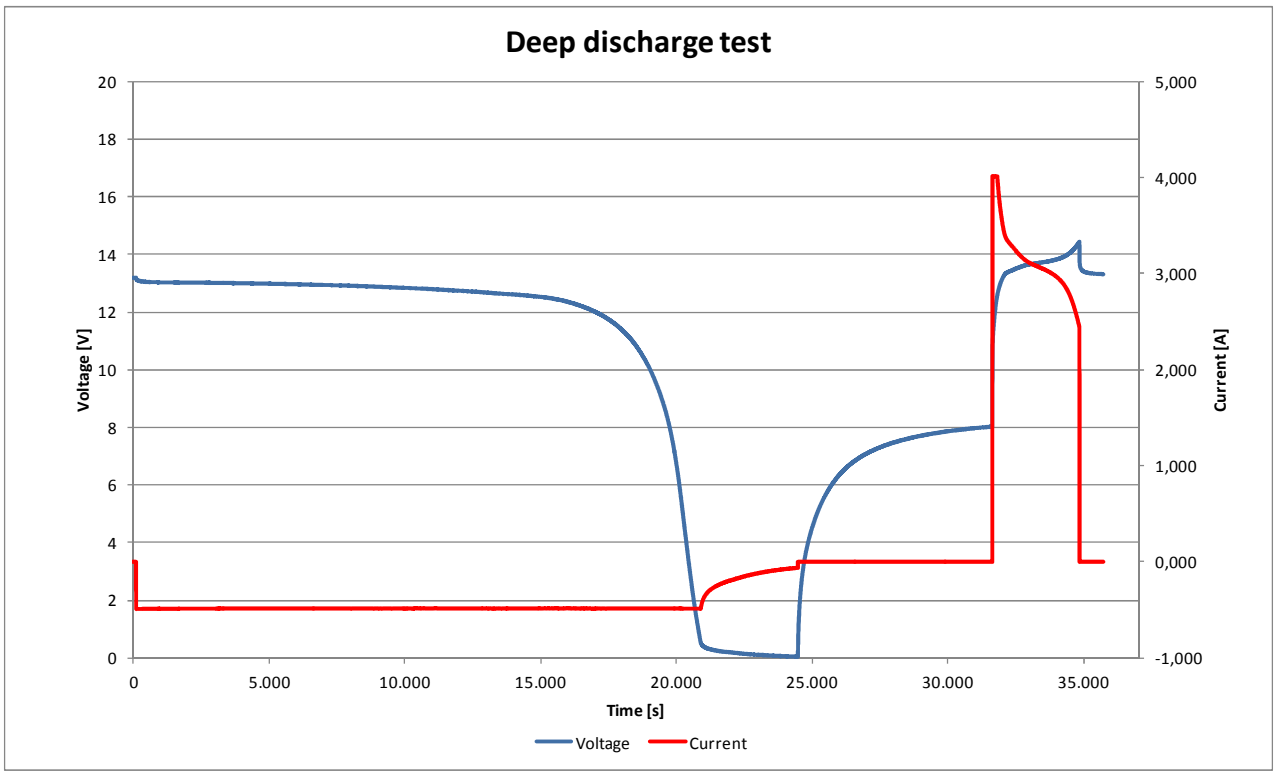

Figure 2b: One cycle (cycle no. 2) of the deep discharge test as example at 0℃ with the battery 870351

During the whole test the temperature at the battery as well as the ambient temperature in the test champer was 0℃ ± 2K

TABLE	Test results deep-discharge cycles test			
Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710003	13,4	878	13,3	878
710009	13,6	876	13,4	876
870351	13,4	890	13,2	890
870182	13,7	885	13,2	884

Name video: 1 Deep-discharge cycles test.m2v

Classification of the test based on EUCAR (Abb. 1): 2 (at 0℃)
2 (at 40℃)

Remark: Both batteries showing after ten cycles a shorter charging and discharging time, compared to the first cycles. Therefore it seems that the battery capacity is reduced.

2.2 Overcharge test

TEST : Overcharge test
Battery –ID: 710001

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

TEST : Overcharge test

Battery –ID: 710001

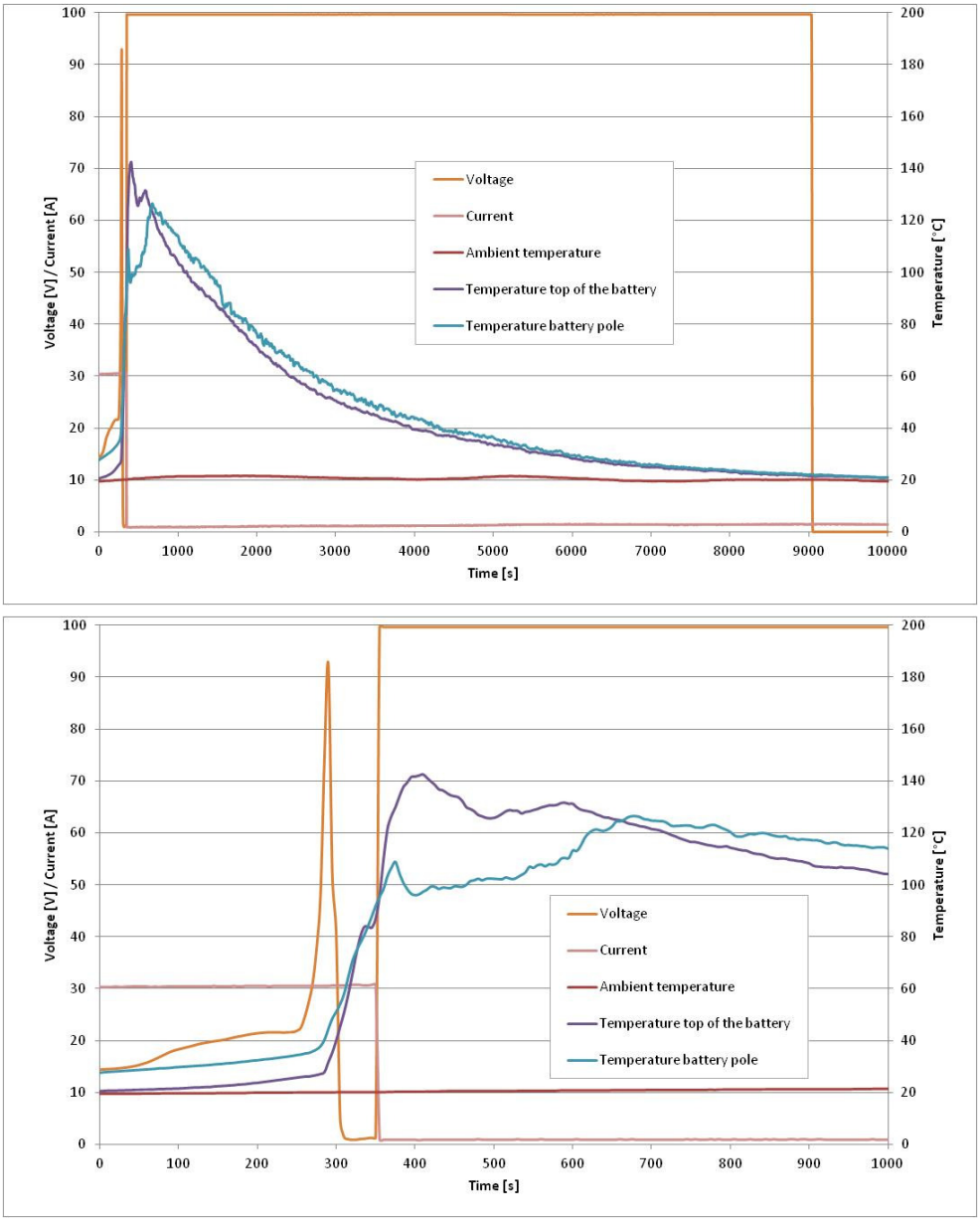

Figure 4: Temperature profile in climate cabinet with the battery 710001 inside with detail view (overcharge current 30 A, overcharge voltage 100 V)

Figure 5: Overcharge test in safety cabinet with battery 710001 (overcharge current 30 A, overcharge voltage 100 V)

TABLE	Test results overcharge test			
Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710001	14,5	883	0	761

Name video: 2 overcharge test.m2v

Classification of the test based on EUCAR (Abb. 1): 4

2.3 Short circuit test

2.3.1 Short circuit test with 5 mOhm

TEST : Short Circuit test with 5 mOhm
Battery –ID: 710004

Figure 6: Short circuit test in climate cabinet with the batteries inside

TEST : Short circuit test with 5 mOhm

Battery –ID: 710004

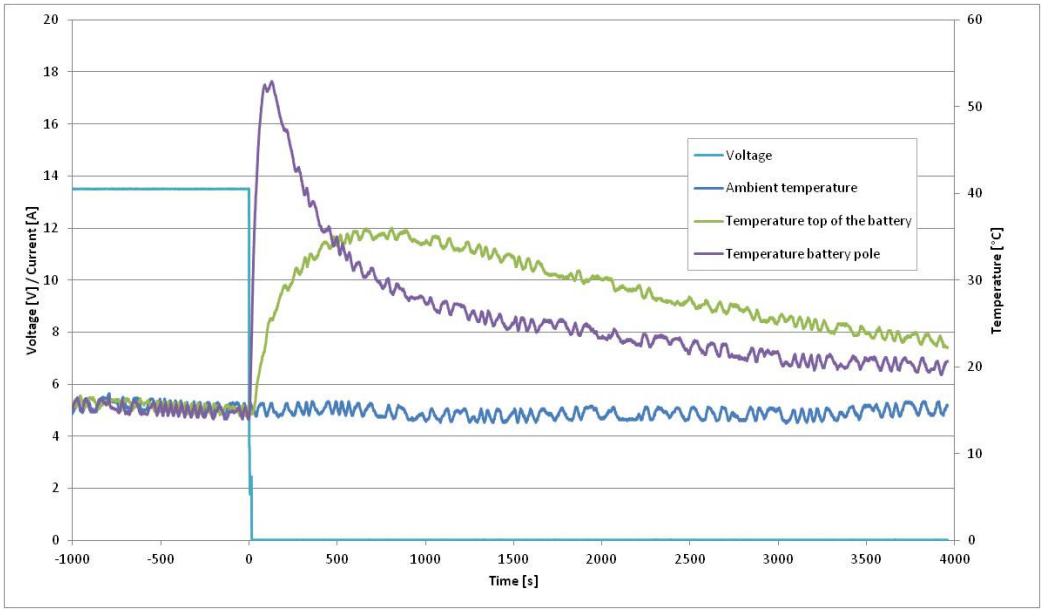

Figure 7: Diagramm with the measured values while short circuit test

TABLE	Test results short circuit test with 5 mOhm			
Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710004	13,5	882	0	879

Name video: 3 short circuit test_5mOhm.m2v

Classification of the test based on EUCAR (Abb. 1): 2

2.3.2 Short circuit test with 70 mOhm

TEST : Short Circuit test with 70 mOhm
Battery –ID: 7100010

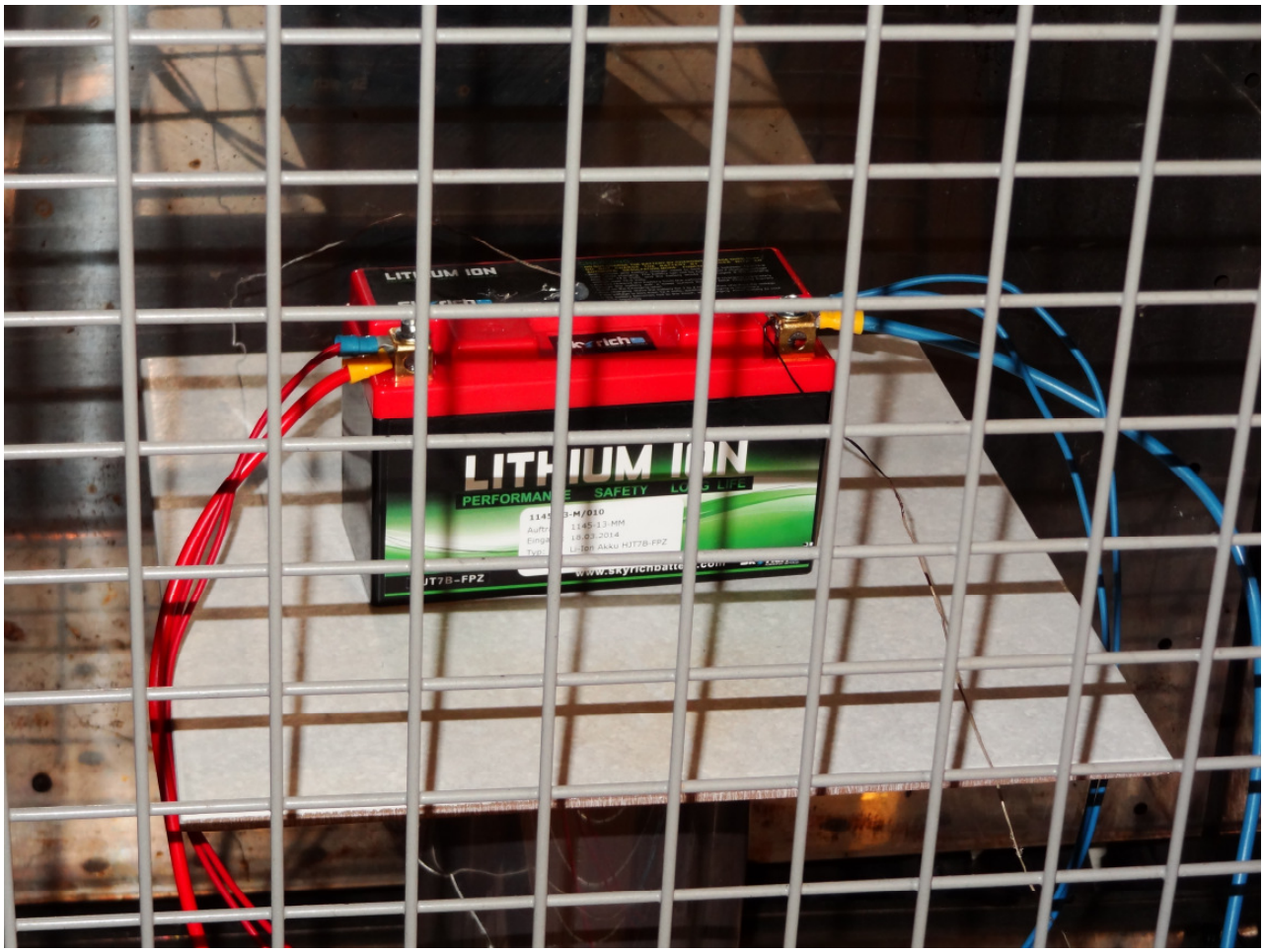

Figure 6: Short circuit test in climate cabinet with the batteries inside

TEST : Short circuit test with 70 mOhm

Battery –ID: 710010

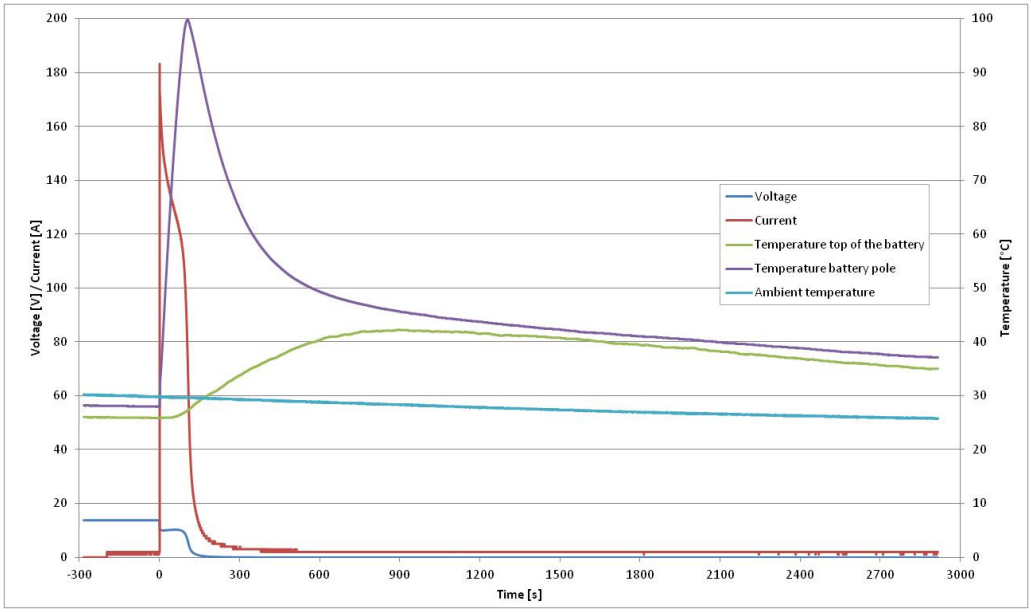

Figure 7: Diagramm with the measured values while short circuit test

TABLE Test results short circuit test with 5 mOhm

Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710010	13,7	888	0	884

Name video: 3 short circuit test_70mOhm.m2v

Classification of the test based on EUCAR (Abb. 1): 2

2.4 Drop test

TEST : Drop test

Battery –ID: 710006

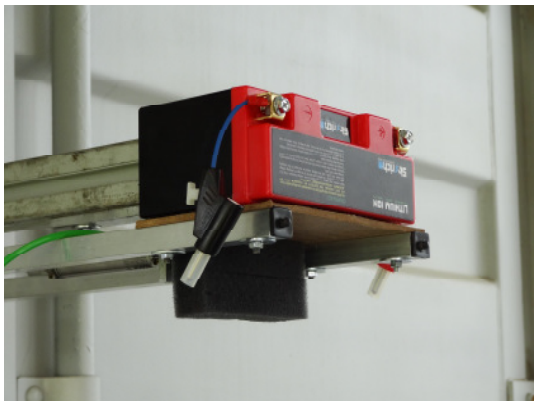

Figure 8: Pictures of the drop test

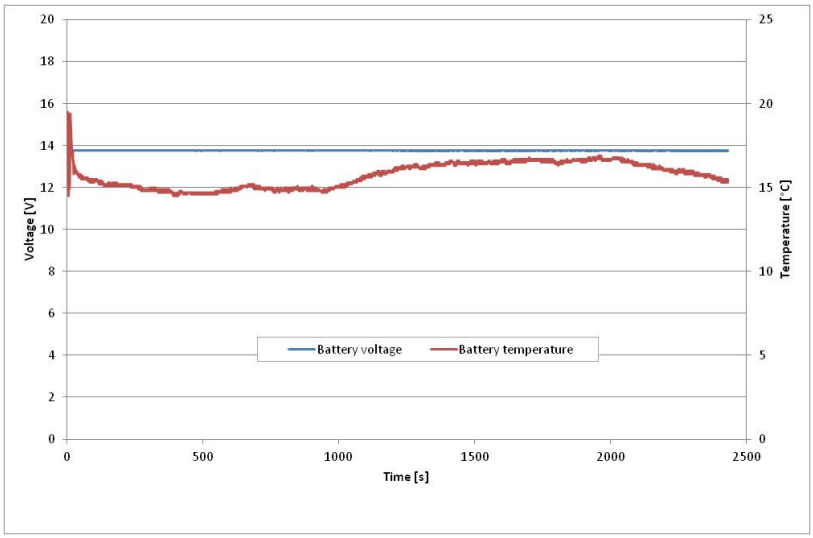

Figure 9: Diagramm with the measured values while the drop test

Figure 10: Pictures after the drop test

TABLE	Test results drop test			
Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710006	13,8	879	13,8	879

Name video: 4 drop test.m2v

Classification of the test based on EUCAR (Abb. 1): 0

2.5 Heating test

TEST : Heating test 105°C and 140°C

Battery –ID: 870180 and 710008

Figure 11: Heating test in climate cabinet with the batteries inside

TEST : Heating test at 105°C

Battery –ID: 710002

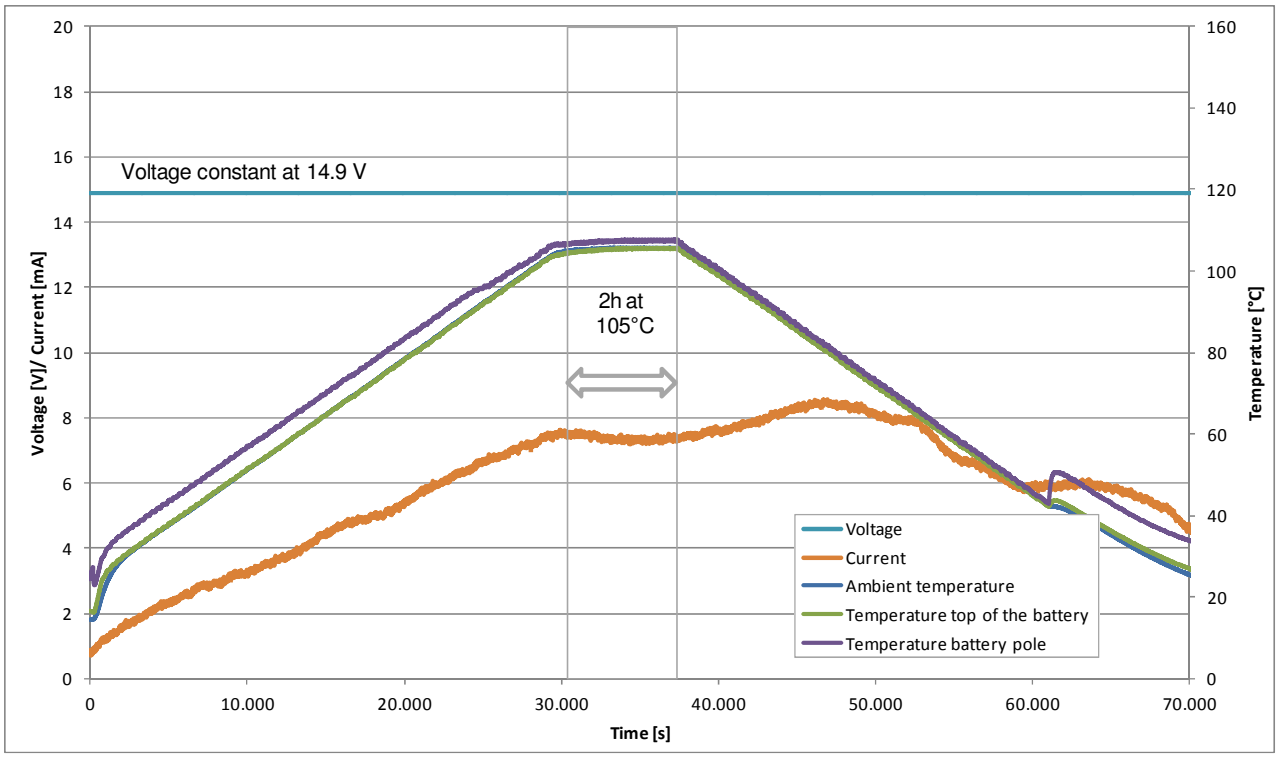

Figure 12: Temperature profile with 105°C in climate cabinet with the battery 710002 inside

Remark: The small peak around 40°C while cooling down results from the temperature control characteristic of the oven. The ambient temperature is nearly not influenced and still in the limit of the test specification of 10K/h. Because the fan of the oven switched off, the temperature of the battery terminal got higher and the cooling down rate went on a higher level. It was not influenced by the battery directly.

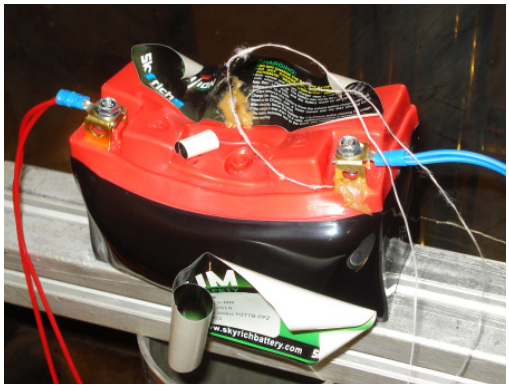

Figure 12a: Heating test in climate cabinet with the battery 710002 inside (after the test with 105°C)

TEST : Heating test at 105°C

Battery –ID: 870180

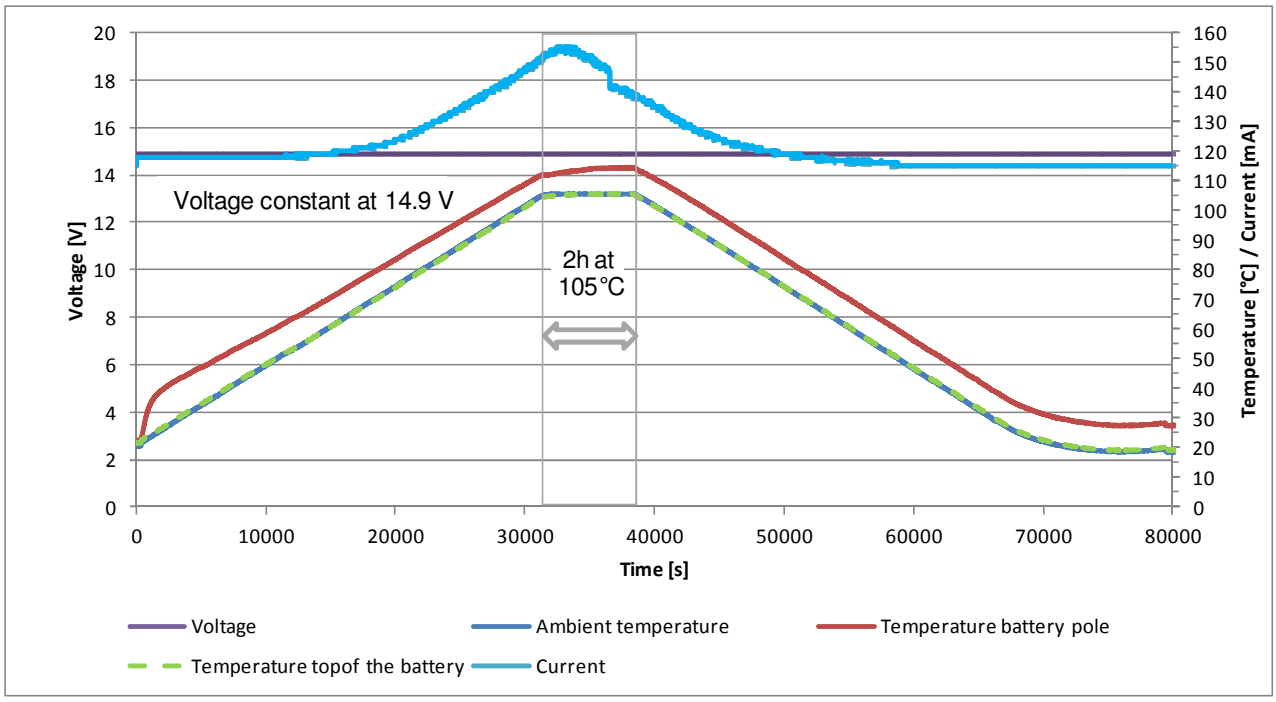

Figure 13: Temperature profile with 105°C in climate cabinet with the battery 870180 inside

Figure 13a: Heating test in climate cabinet with the battery 870180 inside (after the test with 105°C)

TEST : Heating test at 140°C

Battery –ID: 710008

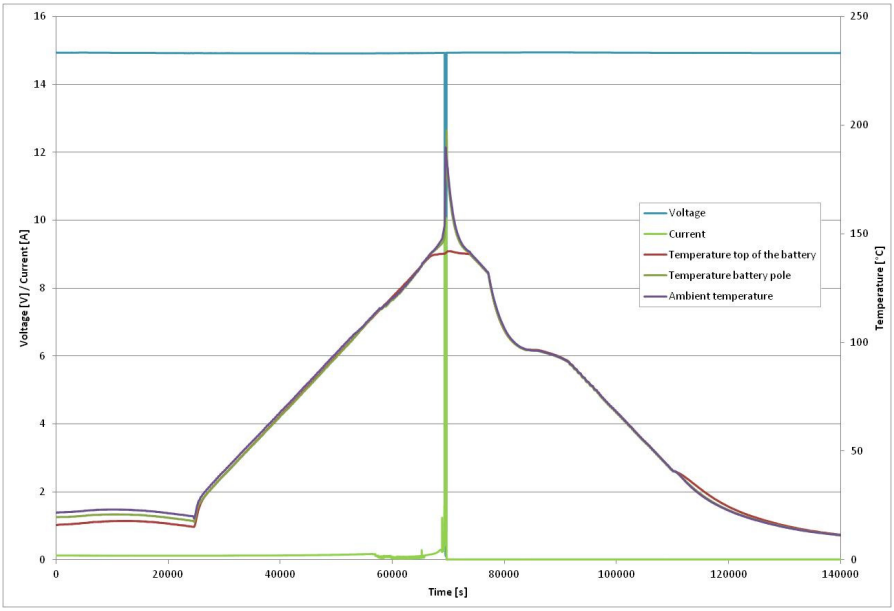

Diagram with the whole test (temperature, current, voltage) for details please see the two diagrams below

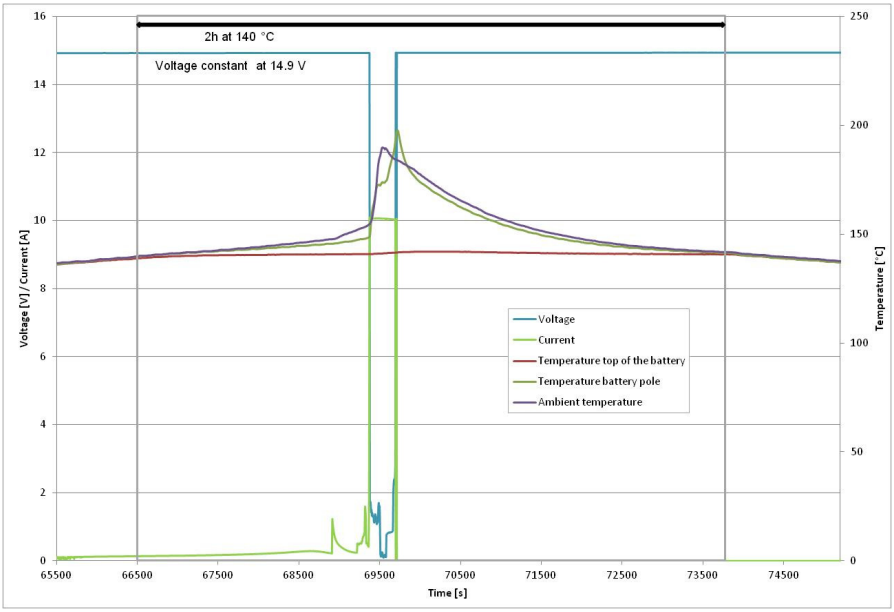

Figure 14: Temperature profile with 140°C in climate cabinet with the battery 710008 inside

Figure 15: Heating test in climate cabinet with the battery 710008 inside (after the test with 140°C)

TABLE Test results heating test

Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710002	14,5	875	13,6	873
870180	14,5	895	13,6	894
710008	14,5	878	0	834

Name video: 5 heating test.m2v

Classification of the test based on EUCAR (Abb. 1): 2 (at 105°C)
4 (at 140°C)

2.6 Penetration test

TEST : Penetration test
Battery –ID: 710010

Figure 16: Pictures of the penetration test apparatus

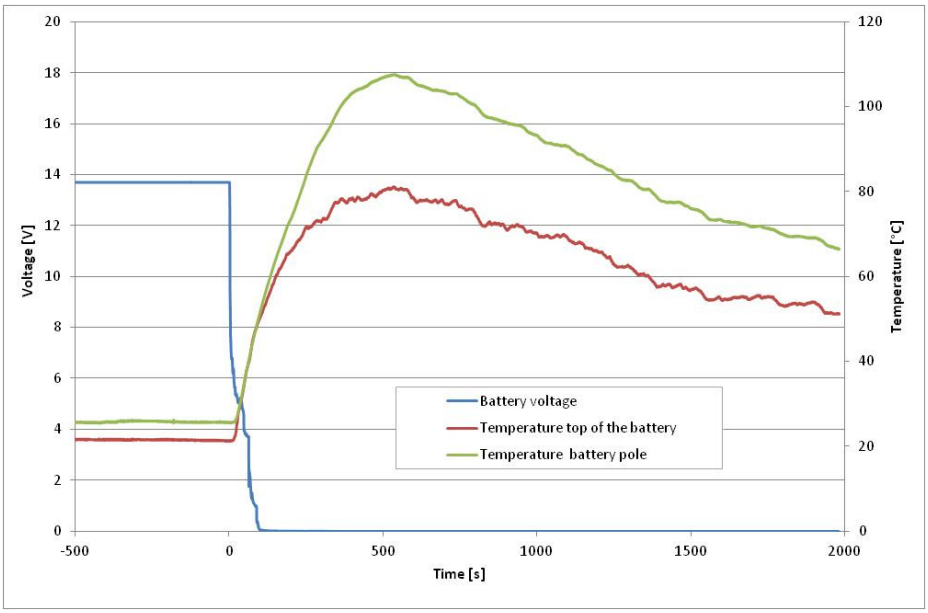

Figure 17: Diagramm with the measured values while the penetration test, penetration tests starts at 0 sec

TABLE	Test results penetration test			
Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710010	13,7	876	0,0	872

Name video: 6 penetration test.m2v

Classification of the test based on EUCAR (Abb. 1): 4

2.7 Crush test

TEST : Crush test

Battery –ID: 710007

Figure 18: Battery at crush test apparatus

Figure 19: Battery after crush test with deformation at housing

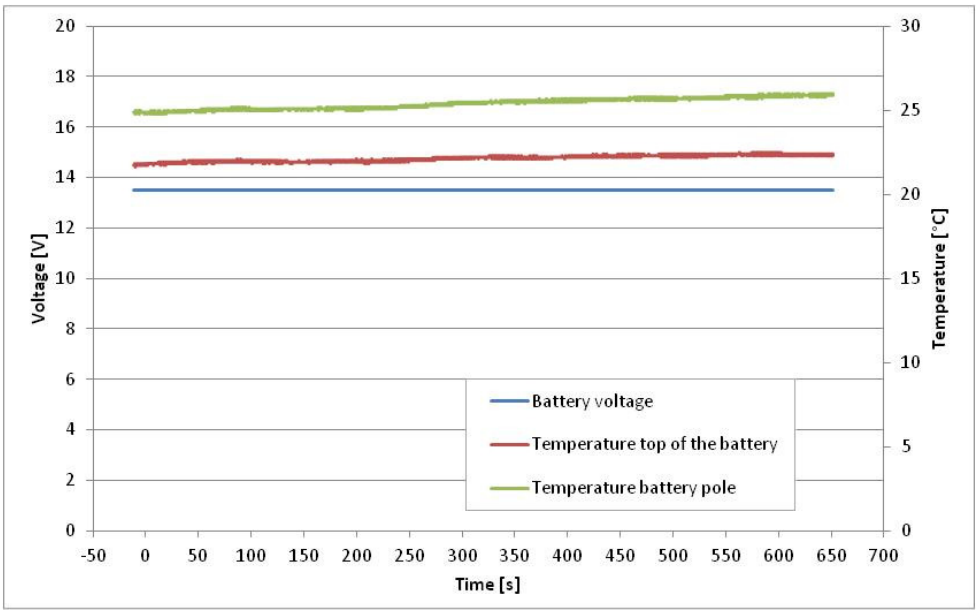

Figure 20: Diagramm with the measured values while the crushing test , crushing test starts at 0 sec

Remark: The crush force was limited to 17kN. With this force of 17kN there is no further deformation of the battery as shown in the picture.

TABLE	Test results crush test			
Battery	Voltage [V] before test	Weight [g] before test	Voltage [V] after test	Weight [g] after test
710007	13,5	880	13,5	879

Name video: 7 crush test.m2v

Classification of the test based on EUCAR (Abb. 1): 0