SAFETY AND ROBUSTNESS OF CELLS AND BATTERIES (UN38.3)

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Introduction

- Batteries – lots of energy inside a small volume
- Robustness and safety
- UN38.3

What threatens a battery?

- Robustness
  - Surrounding environment
  - Changes in pressure, vibrations, shocks, temperature variations.
- Safety
  - Thermal runway
  - Troublesome fire extinguishment
- Three types of stresses:
  1. Thermal
  2. Mechanical
  3. Electrical

Tesla reduced to ashes after catching fire on Pennsylvania highway

By Fox 13 News staff | Updated November 18, 2022 9:03am EST | Tesla | FOX 13 News |

(Courtesy: Morris Township Volunteer Fire Company #1)

MORRIS TOWNSHIP, Penn. - Firefighters are accustomed to responding to car fires, but electric vehicles have proven to be problematic for fire crews.

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https://www.fox13news.com/news/tesla-reduced-to-ashes-after-catching-fire-on-pennsylvania-highway

UN38.3 – the eight tests

- Global standard
- For Li-ion samt Na-ion batteries
- Transport simulation by flight, ship and truck
- In total 8 tests, depending on product type (cell/module/pack)
- Environmental tests (T1-T4)
- Electrical and mechanical abuse tests (T5-T8)

Table 38.3.3: Summary table of required tests for lithium rechargeable cells and batteries

Rechargeable cells and batteries										
		T.1	T.2	T.3	T.4	T.5	T.6	T.7[a]	T.8	Sum[d]
Cells not transported separately from a battery	first cycle, 50 % charged state						5			30
	25th cycle, 50 % charged state						5			
	first cycle, fully discharged state								10	
	25th cycle, fully discharged state								10	
Cells	first cycle, fully charged state	5								40
	25th cycle, fully charged state	5								
	first cycle, 50 % charged state						5			
	25th cycle, 50 % charged state						5			
	first cycle, fully discharged state								10	
	25th cycle, fully discharged state								10	
Single cell batteries[b]	first cycle, fully charged state	5						4		48
	25th cycle, fully charged state	5								
	first cycle, 50 % charged state						5			
	25th cycle, 50 % charged state						5			
	25th cycle, fully charged state							4		
	first cycle, fully discharged state								10	
	25th cycle, fully discharged state								10	
Small batteries	first cycle, fully charged state	4						4		16
	25th cycle, fully charged state	4						4		
Large batteries	first cycle, fully charged state	2						2		8
	25th cycle, fully charged state	2						2		
Batteries assembled with tested batteries ≤ 6 200 Wh or ≤500 g Li	fully charged state	1						1		2
Batteries assembled with tested batteries > 6 200 Wh or or >500 g Li[c]										0

[a] *Batteries or single cell batteries not equipped with battery overcharge protection that are designed for use only as a component in another battery or in equipment, which affords such protection, are not subject to the requirements of this test;*

[b] *Except for the T.7 Overcharge test, a single cell battery containing one tested cell does not require testing unless a change in cell design could result in the failure of any test;*

[c] *If the assembled battery is of a type that has been verified as preventing:*

(i) Overcharge;

(ii) Short circuits; and

(iii) Over discharge between the batteries.

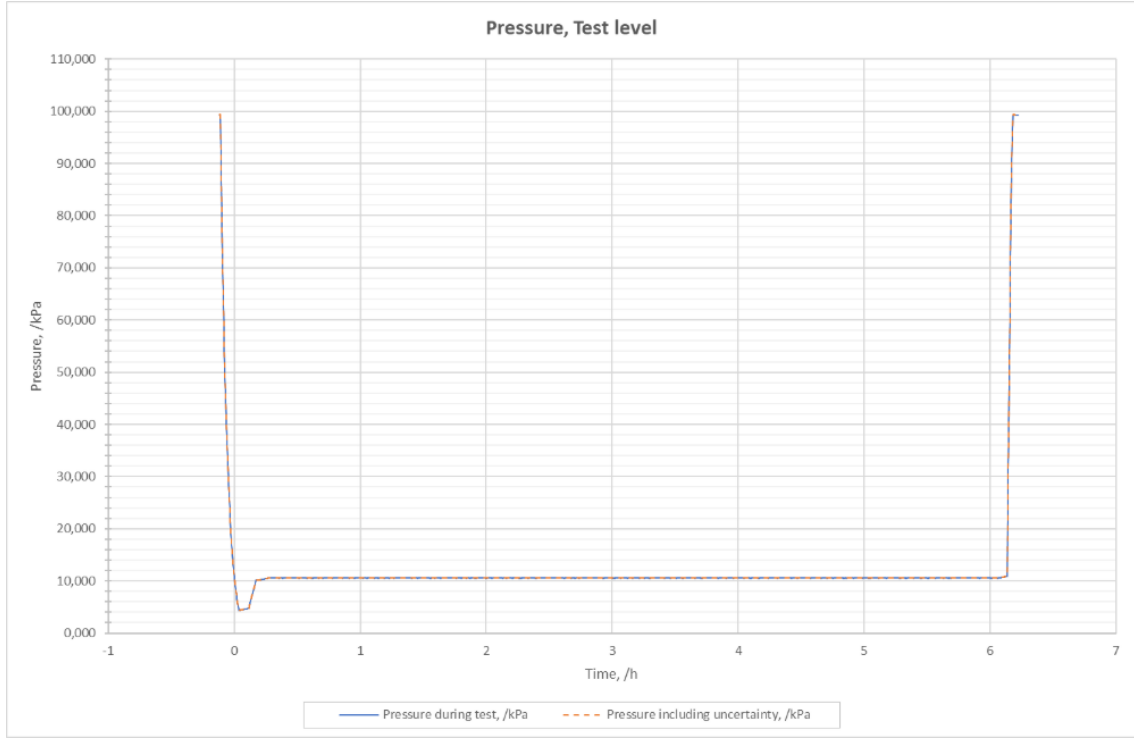
[d] *The sum represents the number of tests required, not the number of cells or batteries tested.*

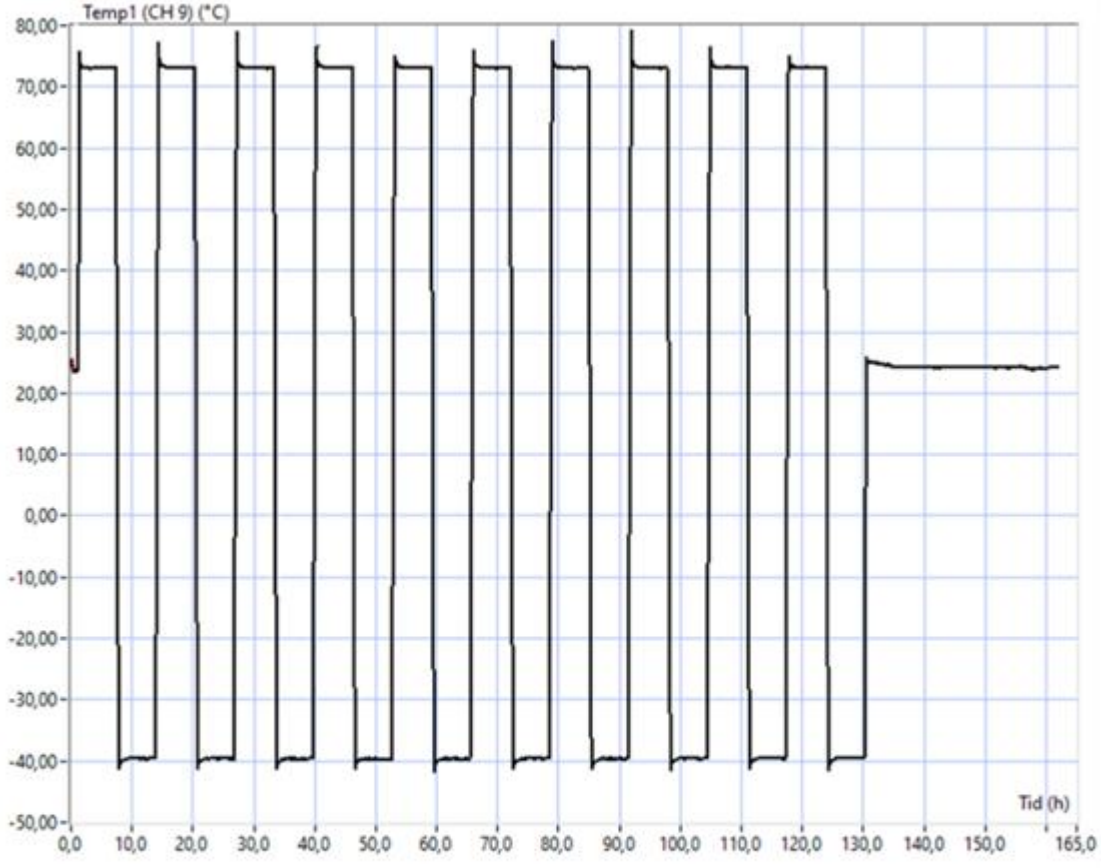
UN38.3 - definitions

- Primary or secondary?
- Small or large cells, small or large batteries?
- Number to be tested depends on the category
- Testing at 100% charge (100% SOC)
- Cycling – first cycle and 25th cycle
- Tests must be performed in sequence T1-T5. T6, T7 & T8 are tested on seperate DUTs.
- Voltage measurement and weighing in between tests

UN38.3 T1: Altitude simulation

- Simulates air transport
- 11.6 kPa for a minimum of 6h
- Pass criteria:
  - No leakage
  - No venting
  - No disassembly
  - No rupture
  - No fire
  - Allowed voltage drop: 10%





UN38.3 T2: Thermal test

- -40°C to +72°C in 30 min, 10 cycles
- Small cells and batteries: 6h dwell
- Large cells and batteries: 12h dwell
- Pass criteria:
  - No leakage
  - No venting
  - No disassembly
  - No rupture
  - No fire
  - Allowed voltage drop: 10%

UN38.3 T3: Vibration

- Simulates road transport
- 3 axes á 3h/axis (X, Y, Z).
- Pass criteria:
  - No leakage
  - No venting
  - No disassembly
  - No rupture
  - No fire
  - Allowed voltage drop: 10%

Vibration levels for small batteries and cells

Frequency [Hz]	Acceleration [g]	Displacement [mm]
7 – 18	1.0	-
18 – 50	-	0.8
50 – 200	8.0	

Vibration levels for large batteries

Frequency [Hz]	Acceleration [g]	Displacement [mm]
7 – 18	1.0	-
18 – 25	-	0.8
25 – 200	2.0	

UN38.3 T4: Shock

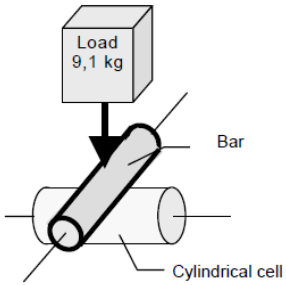
Battery	Minimum peak acceleration	Pulse duration
Small batteries	150 g_n or result of formula $\text{Acceleration}(g_n) = \sqrt{\left(\frac{100850}{\text{mass}^{a}}\right)}$ whichever is smaller	6 ms
Large batteries	50 g_n or result of formula $\text{Acceleration}(g_n) = \sqrt{\left(\frac{30000}{\text{mass}^{a}}\right)}$ whichever is smaller	11 ms

[a] Mass is expressed in kilograms

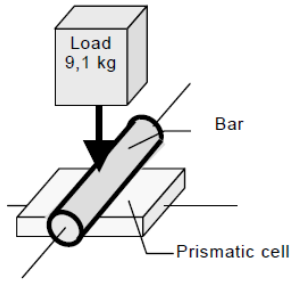
- Simulates retardation forces
- 6 axes á 3 shocks/axis (±X, ±Y, ±Z)
- Half-sine pulse
- Pass criteria:
  - No leakage
  - No venting
  - No disassembly
  - No rupture
  - No fire
  - Allowed voltage drop: 10%

UN38.3 T5: External short circuit

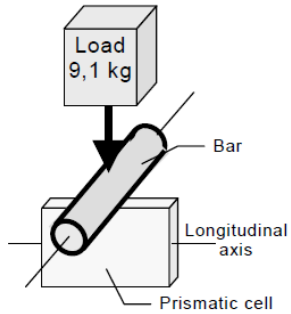
- Simulates short circuit of terminals
- 57 ± 4 °C
- Max 0.1 Ohm
- Pass criteria:
  - Max 170°C
  - No disassembly
  - No rupture
  - No fire



1a) Cylindrical cell



1b) Direction 1 of prismatic cell



1c) Direction 2 of prismatic cell

UN38.3 T6: Impact/Crush

- Simulates internal short circuit
- For cells only
- Impact – cylindrical with a diameter >18mm.
- Crush – all other types
- Pass criteria within 6h after test:
  - Max 170°C
  - No disassembly
  - No fire

UN38.3 T7: Overcharge

- Test for protective circuits
- Charge current is 2x recommended
- 24h
- Pass criteria within 7 days after test:
  - No disassembly
  - No fire

UN38.3 T8: Forced discharge

- Simulates forced discharge
- For cells only
- Serial connection with 12V DC supply
- Max discharge current according to specification
- Test duration according to specification; $(\frac{Capacity_r}{A})h$
- Pass criteria within 7 days after test:
  - No disassembly
  - No fire

From test to reality

- Minimum requirement
- Transport – ok
- In use – not ok

Samsung permanently stops Galaxy Note 7 production

11 October 2016

A Samsung Note 7 handset caught fire during a lab test in Singapore

South Korean tech giant Samsung has permanently ceased production of its high-end Galaxy Note 7 smartphones after reports of devices it had deemed safe catching fire.

From test to reality

- Samsung Note 7
- Design problem
- Other standards, such as IEC, in addition to UN38.3

Source: https://www.bbc.com/news/business-37618618

From test to reality

- Test summary
- Requirement since 2020

38.3.5 ***Cell and battery test summary***

The following test summary shall be made available:

Cell or battery test summary in accordance with subsection 38.3 of the *Manual of Tests and Criteria*
The following information shall be provided in this test summary:
(a) Name of cell, battery, or product manufacturer, as applicable;
(b) Cell, battery, or product manufacturer's contact information to include address, phone number, email address and website for more information;
(c) Name of the test laboratory to include address, phone number, email address and website for more information;
(d) A unique test report identification number;
(e) Date of test report;
(f) Description of cell or battery to include at a minimum:
(i) Lithium ion, lithium metal or sodium ion cell or battery;
(ii) Mass of cell or battery;
(iii) Watt-hour rating, or lithium content;
(iv) Physical description of the cell/battery; and
(v) Cell or battery model number or, alternatively, if the test summary is established for a product containing a cell or battery, the product model number.
(g) List of tests conducted and results (i.e., pass/fail);
(h) Reference to assembled battery testing requirements, if applicable (i.e. 38.3.3 (f) and 38.3.3 (g));
(i) Reference to the revised edition of the *Manual of Tests and Criteria* used and to amendments thereto, if any; and
(j) Name and title of responsible person as an indication of the validity of information provided.

SUMMARY AND CONCLUSION

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