



Samsung Galaxy Note7 Case – Battery Safety Issues Impact on Business

January 2017

**Shmuel De-Leon
Shmuel De-Leon Energy, Ltd.
www.sdle.co.il
shmuel@sdle.co.il**

Samsung Galaxy Note7 Smartphone Recall



- Launch globally date: August 19, 2016
- Recall date: October 13, 2016
- Product name: Samsung Galaxy Note7 smartphones
- **Hazard:** The lithium-ion battery in the Galaxy Note7 smartphones can overheat and catch fire, posing serious fire and burn hazard to consumers.
- **Units: 1.9 Millions**

Samsung Note7 Incidents/Injuries

- 96 reports of batteries in Note7 phones overheating in the U.S.,
- Samsung has received 13 reports of burns and 47 reports of property damage associated with Note7 phones.



The Galaxy Note 7 implicated in dramatic Jeep and house fires, reports say



iPhone Mobile Phone Battery Explosion 2016



An Apple iPhone 6 exploded in cyclist's pocket

“I saw smoke coming out of my back pocket... I was completely bewildered about what it was. All of a sudden I felt a surging pain in my top right leg. I heard a kind of a snap and I could feel the thing melting through my shorts”.



Moli Energy – Lithium Metal Battery Explosion - 1989

- Moli Energy Canada was the first to mass produce lithium metal rechargeable 18650 cells on 1988
- Used in Cellular phones in Japan
- Explosion of a cellular phone battery in the face of a customer lead to a recall of 1.5M cells in 1989
- Shown to be safe in the lab
- Root Cause – Lithium metal plating during charge – Dendrites that led to a short circuit and thermal run away
- The recall and compensation to injures lead to bankruptcy of the company



Sony Laptop Battery recall 2006



P/N

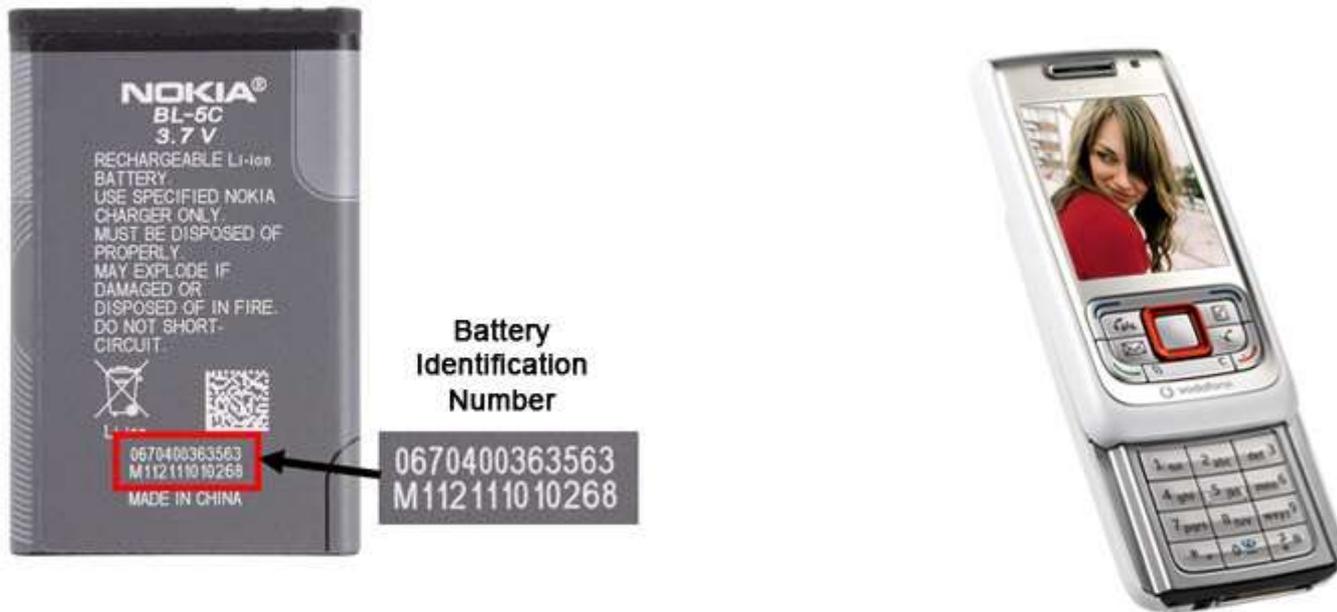
Lot Number

Cost for Sony: 1B\$ estimate

7 million 18650 cells affecting 6 PC makers

These lithium ion batteries can overheat, posing a fire hazard to consumers

Nokia Recall Cell-phone Batteries 2007



Cost for Nokia: 150M\$ estimate

**BL-5C Panasonic batteries to have internal short circuit
These lithium ion batteries can overheat, posing a fire
hazard to consumers**

Boeing Dreamliner Battery Fire 2013



Cost for Boeing: 600 M\$ estimate
Expected smoke event: 1 every 10 millions flights hours
Cause: Internal short circuit in one cell

Why that is happened?

External Short circuit
Internal Short circuit

- Particle
- Dendrites
- Separator failure
- Impact/puncture

Overcharge

Overdischarge

External Heating

Mechanical Damage

Elevated Temperatures
Generate Heat

Heat Dissipation <
Heat Generation

Thermal Run Away

Fuse or PTC

Shut Down Separator

CID – Charge Interrupt
Device

Vent, Flaming Vent

Rupture

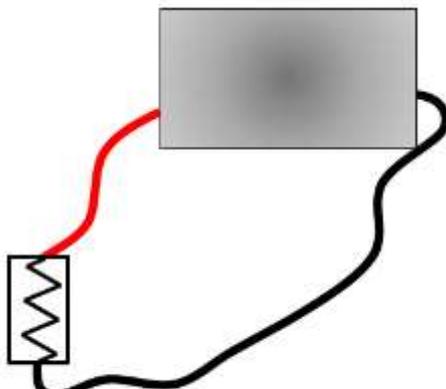
Fire

Explosion!!!

Heat Dissipation >
Heat Generation

Safe!!!

Leaking of
Noxious or acid
gasses, Strong
acids,
Flammable
gasses and
liquids

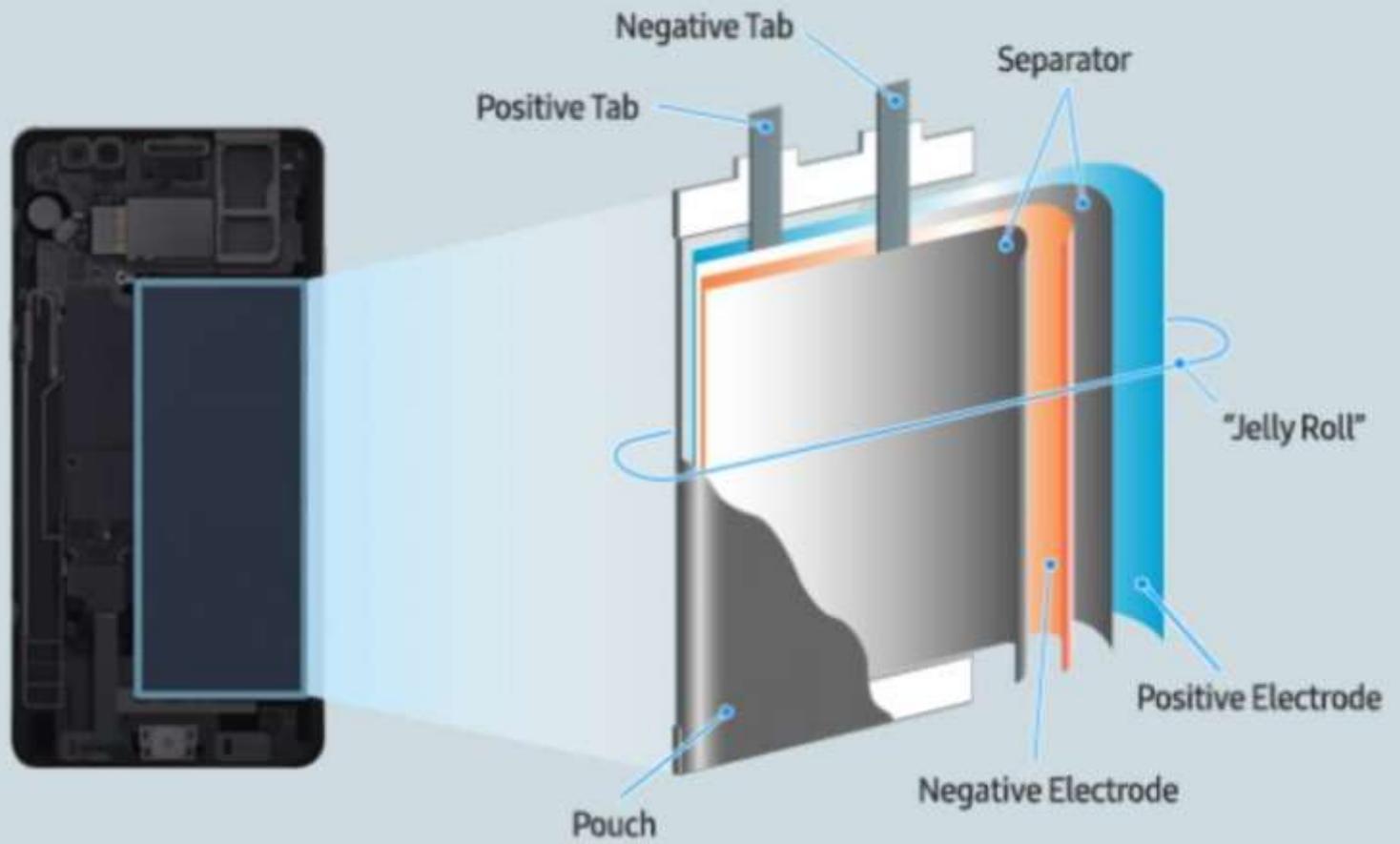


External Short Circuit Test

What Cause the Samsung Galaxy Note7 Safety Problems

- **Samsung didn't disclose officially the battery safety root cause – All what described here is my personal assumption**
- **Samsung used a high energy cathode for maximizing the battery energy density**
- **Thin separator was used for freeing volume for more active materials**
- **Charging the battery cause some sort of lithium metal plating as a dendrites**
- **On some cases lithium dendrites penetrate the thin separator and cause Internal short circuit, heat and safety event**

Lithium-Ion Battery Structure



Samsung Galaxy Note 7 Battery Hold an Impressive 3,500mAh Despite its Slim Profile



Samsung Reaction

- **2/9/2016** First recall of Galaxy Note7 used Samsung Korea made batteries and replaced it by Galaxy Note7 used ATL china made batteries (ATL was selected by Samsung as a battery sub-contracture producer)
- **15/9/2016** After reports of the same safety events with the Galaxy Note7 used ATL china made batteries Samsung halted that recall
- Then Samsung stop marketing the Note7 and to concentrate on full worldwide recall for not taking any extra risks for customers safety
- We should wait for Samsung final root cause after completing internal investigation

Samsung took the responsibility

Samsung Official Investigation Results 22/1/2017

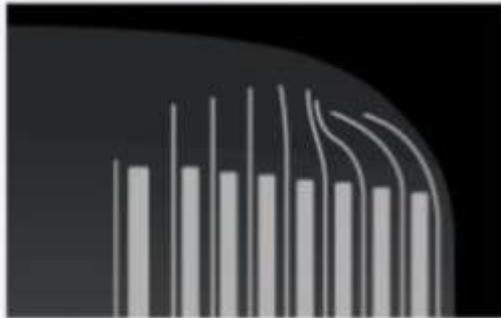
- **Samsung said over 700 researchers and engineers spent months analyzing 200,000 Note 7 devices and 30,000 Note 7 batteries**
- **Samsung conducted an internal review and sought independent reviews from UL, a safety science organization, Exponent, a US-based consulting and engineering firm and TuvRheinland, a German-based company**
- **Samsung Electronics has found internal short circuiting in Galaxy Note 7 batteries caused the phones to heat up and catch on fire**



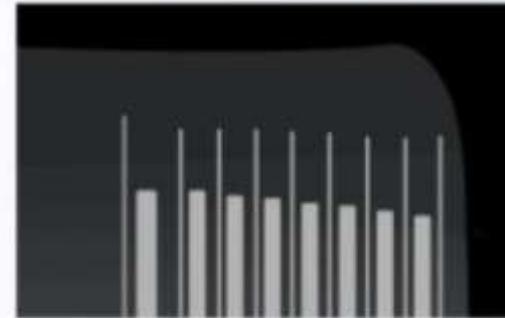
Abnormal

Normal

Main Cause



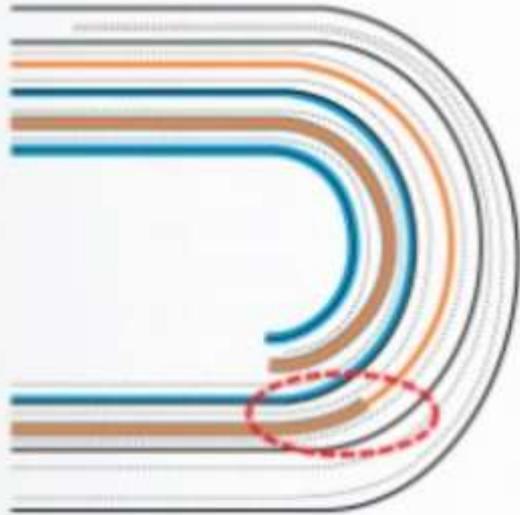
The negative electrode was deflected in the upper-right corner of the battery



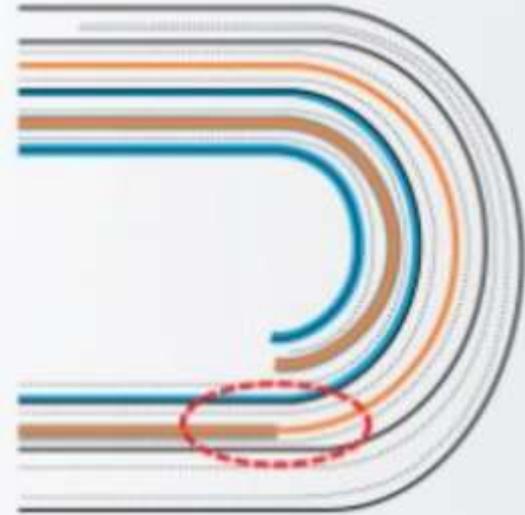
The negative electrode is not deflected

There was an issue with the upper right hand corner of the battery cell. “The main cause for the incidents was deflections in the negative electrodes

Additional contributing factor

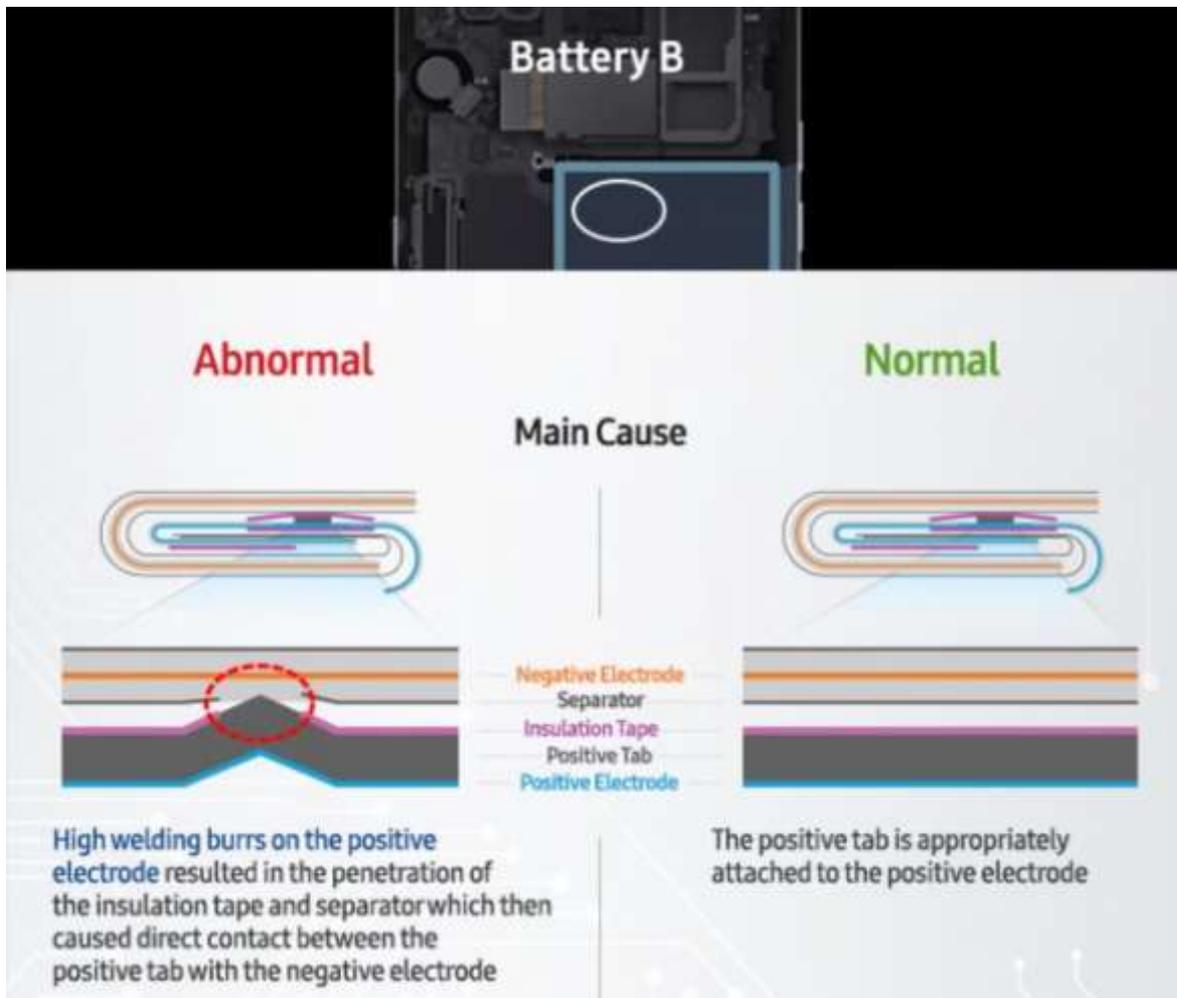


The tip of the negative electrode was incorrectly located in the curve, not the planar area

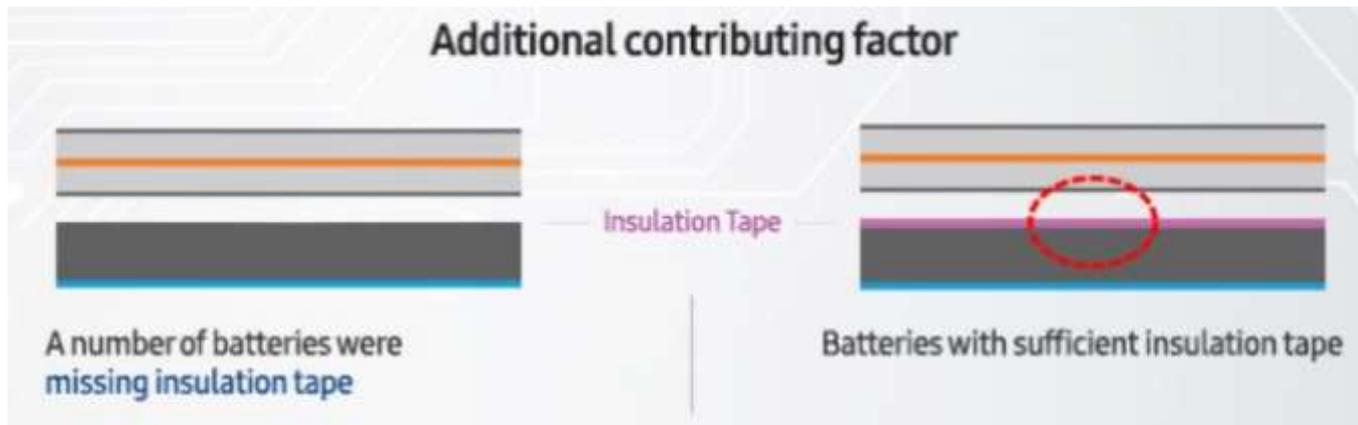


The tip of the negative electrode is correctly located within the planar area

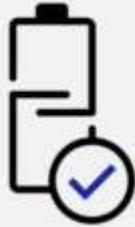
-adding incorrect positioning of the negative electrode tip also led to a higher likelihood of incidents



melted copper on the negative electrode area. There were welding issues that led to contact between the positive and negative layers, resulting in short circuits



- **Samsung said it has improved its processes and faults would not happen again**
- **Samsung said it has developed a battery check protocol and has invited researchers and academics to provide analysis to ensure battery safety**
- **In a bid to regain customer confidence, Samsung said it implemented a range of quality control and safety measures for their handsets, including an 8-point battery safety check**



Durability Test

It starts with enhanced battery testing, including overcharging tests, nail puncture tests and extreme temperature stress tests.



Visual Inspection

We visually inspect each battery under the guideline of standardized and objective criteria.



X-Ray

We use X-ray to see the inside of the battery for any abnormalities.



Charge and Discharge Test

The batteries undergo a large-scale charging and discharging test.



TVOC Test

(Total Volatile Organic Compound)
We test to make sure there isn't the slightest possibility of leakage of the volatile organic compound.



Disassembling Test

We disassemble the battery to assess its quality, including the battery tab welding and insulation tape conditions.



Accelerated Usage Test

We do an intensive test simulating accelerated consumer usage scenarios.



ΔOCV Test

(Delta Open Circuit Voltage)
We check for any change in voltage throughout the manufacturing process from component level to assembled device.

- **Samsung said 96 per cent of 3 million devices sold and activated globally had been returned**
- **Samsung took a \$US5.3 billion loss from its operating profit due to the Note 7 debacle - one of the worst technology recalls in recent times**



Koh Dong-jin, president of Samsung Electronics' Mobile Communications Business, speaks during a news conference at its headquarters in Seoul to summarize findings on a review of the disastrous launch of the Galaxy Note 7. (Kim Hong-Ji/Reuters)

What Should We Learn?

- Battery safety event damage is huge and in most cases is not proportional to the battery cost
- Damage is higher when the device market is larger
- The damage is huge as well as when the device mission is critical (Like in Space or Military)
- Companies with no deep pockets will may bunkrapt because of battery safety event damage
- Batteries are not just another component and there is a need to understand them from all aspects including the safety before designing them into a device

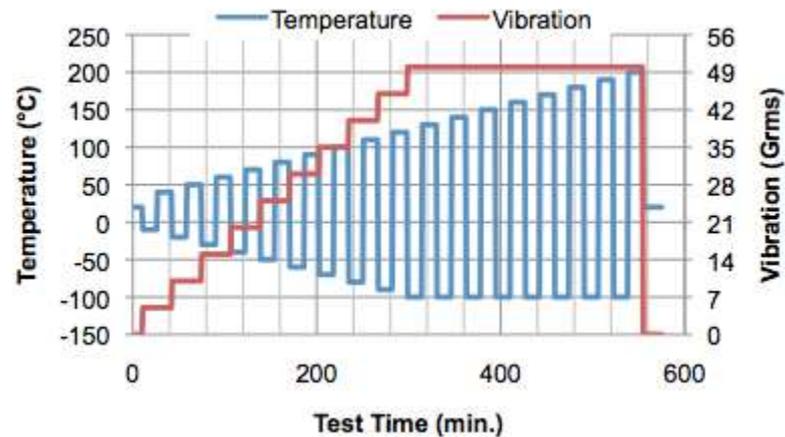
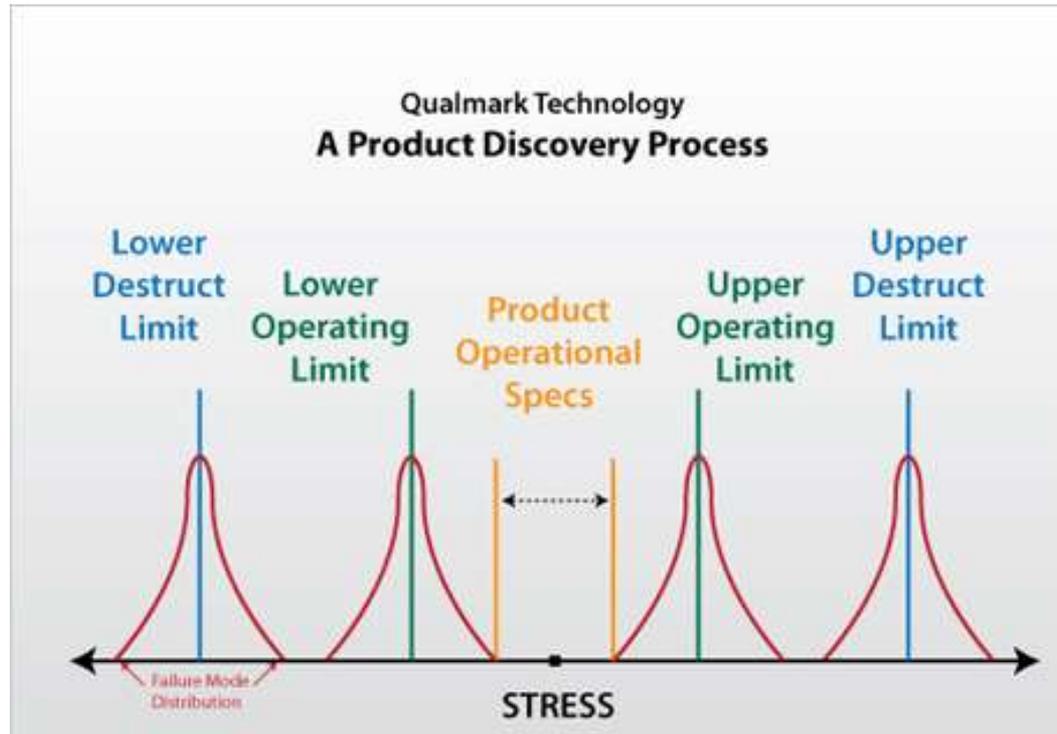


Recommendations

- Cells/batteries makers should review and improve their cells/batteries safety validation process
- Testing for specs are not sufficient and shouldn't be the only safety validation process
- HALT-HASS testing technics can add to the cells/batteries robustness and make them safer
- Based on the potential damage to run the battery safety validation on 2 separate independent labs
- Running several months pilot before marketing starts

In the race for performance we never should forget Safety!!!

Halt-Hass



Halt-Hass Machine



Battery Testing

Battery testing affects the lives of both civilians and service people by enforcing performance and safety standards. Halt HASS tests from Qualmark use combined testing scenarios in a testing chamber to stress multiple failure types. The standards below use Highly Accelerated Life Testing and Highly Accelerated Stress Screen to push batteries to their limits in both consumer and industrial applications. Contact a Qualmark Professional Services representative to learn more about how we can help you design a program to meet standards such as IEC 62133.

Testing Standards

▶ J2464

▶ UL 2054

▶ UL 1642

▶ IEC 62660-2



Thank You for Your Attention



Shmuel De-Leon
Shmuel De-Leon Energy Ltd
www.sdle.co.il
shmuel@sdle.co.il

Information for presentation obtained by:

1. Public web sources.
2. Shmuel De-Leon Battery/Energy Sources DataBase ® (Includes 29000 cell PDF data sheets) <http://www.sdle.co.il/Default.asp?sType=0&PageId=45580>