Tailoring the size and performance of a reserve lithium battery for the next generation fuzes

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Introduction Thales

Current Products

Developments current products:
- Robustness improvements (resistance to flick ramming)

Developments new products:
- Multi stack to single cell; powering 3 V electronics
- Small single cell battery

Outlook future developments

Conclusions
1948  **Philips Usfa B.V.** manufacturing army and navy fuzes, later also optronics en coolers.

1988  **Signaal Usfa** part of **Hollandse Signaalapparaten B.V.** (Cryo, Optronics, Fuzes & Batteries)

1990  **Signaal Usfa** member of the **Thomson-csf** (Cryo, Optronics, Fuzes & Batteries)

2000  **Signaal Usfa B.V.** separate legal entity with Fuzes, Batteries & Battery Packs

2001  **Thales Munitronics B.V.**
Part of the Thales Group of companies (Fuzes, Batteries & Packs)

2005  Closure of Thales Munitronics B.V.

2007  Production resumed under **Thales Cryogenics**, existing lithium batteries only (no self-funded R&D).
THALES produces Lithium battery systems since 1970

- Lithium – Vanadium pentoxide ($V_2O_5$)

- Chromic acid

- Lithium - SOCl$_2$
Multi stack reserve Li-SOCl₂ batteries:

- **UA 6215** Army artillery fuze battery.
  - 6-9 cells, bipolar electrodes
  - 2 x 4 cell stack in parallel option
  - Release mechanism in the top

- **UA 6275** Navy fuze battery.
  - 6-9 cells, bipolar electrodes
  - Release mechanism at the bottom
To reduce the risk of early fracture of ampoules due to radial and axial(-) forces (drop test / flick ramming), robustness has been improved:

**UA 6215 : Army**

- Close tolerance gap to avoid balancing of ampoule
- Increase gap ampoule/structure from 0.3 to 1.4 mm

**UA 6275 : Navy**

- Radial drop height increased 1.5 mtr (5ft) to >4.5 mtr (15ft)
- Radial shock 8000g / 0.3 s

**Improvements:**
CURRENT MULTI CELL BATTERIES:

- Typical 8 cell battery will provide 2200 J
- Energy density (chemical system only) 860 kJ/kg (240 Wh/kg)

Current battery is overdesigned for typical fuze applications.

Remaining energy available for:

- Higher current rating
- Longer flight times
Disadvantages of stacked cells:
- Complexity
- Losses due to not fully utilizing all cells and/or internal parasitic currents
- High energy content, overkill

Increasing application of lower voltage electronics (2.5 - 3V)
- Single cell design in Li-SOCl₂ is feasible
- Very efficient DC-DC converters available for higher voltage requirements

Advantages of single cell design:
- Simple design; no common electrolyte path (internal short circuit)
- Spin / Non-spin independent
- Large surface area → higher current density
- Dimensional freedom, miniaturization
CURRENT MULTI CELL BATTERY → SINGLE CELL:

Example of typical requirement for application with improved (3V) electronics:

- Typical current: 350 mA
- Operational time: 200 s
- Power requirement: 210 J

500 Joule Battery
In the standard UA 6215 housing a single wrap of electrodes replaces the multi cell stack.

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<table>
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<tbody>
<tr>
<td>Current capability [@3V]</td>
<td>750 mA</td>
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<tr>
<td>Life time [@3 V]</td>
<td>200 s</td>
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DOWNSCALING Ø32 X 25 MM SINGLE CELL BATTERY : Ø13 x 15

Typical application requirement:
- Dimension 15 x 13 mm
- Current 100 mA
- Operational time 100 s
- Power 30 J

DESIGN GOAL:
- Dimension Ø10 x 10 mm
- Current 50 mA
- Operational time <30 s
- Power > 5 J
Design goal for 30 and 40 mm Fuze applications:

- **Dimensions:** Ø 10 mm x 10 mm height.
- **Voltage level:** > 3.0 V
- **Typical Power requirements:**
  - 20 mA constant current level
  - Peak currents 50 mA / 200 ms
- **Current density level:** 50 mA/cm²
- **Operational temperature range:** -46°C to +70°C
- **Set back acceleration:** 10,000 - 65,000 g
- **Operational time:** < 30 s
Challenges:

- Glass ampoule no longer feasible
  - Minimum wall thickness is limited, making it increasingly difficult to shatter the ampoule
  - Internal volume ampoule insufficient for cell filling

- Metal Container
  - Very thin walls possible (compared to glass)
  - Integrated in battery housing

- Spin and Non spin applications possible
  - Cell can be positioned right under electrolyte container opening, allowing for immediate wetting of the complete cell
  - Cell can be wrapped around electrolyte container, standing in electrolyte pool once activated;

- Production techniques for high volume small batteries.
Development in single cell batteries:

- Replacement of glass container with metal container
  - Use the battery stainless steel housing to form an electrolyte container.
  - Close welding the container after filling

- Placement of the cell stack:
  - Vertically around container part (wrap)
  - Horizontally below the internal opening of the container
Thales is actively tailoring its Lithium-Thionylchloride batteries to meet future developments in fuze applications.

Developments are focused on:

- Single cell battery; current size ➔ smaller (10 x 10 mm)
- Alternative electrolyte containers; ➔ metal (stainless steel)
- Alternative activation / electrolyte release mechanisms;
- Lithium batteries for small caliber fuze are a promising prospect.
Thank you for your attention