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

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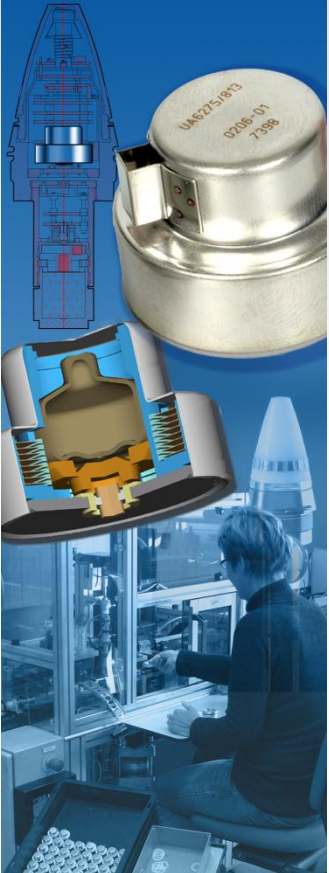
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- ▶ **Introduction Thales**
- ▶ **Current Products**
- ▶ **Developments current products :**
 - ▶ **Robustness improvements (resistance to flick ramming)**
- ▶ **Developments new products:**
 - ▶ **Multi stack to single cell; powering 3 V electronics**
 - ▶ **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).



Reserve Batteries Lithium-SOCl₂



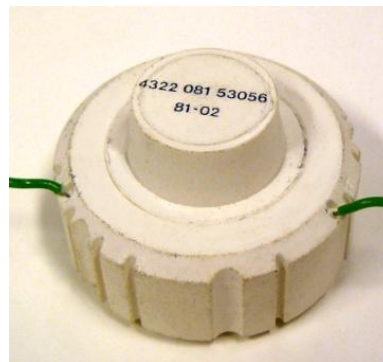
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THALES produces Lithium battery systems since 1970

- ▶ Lithium – Vanadium pentoxide (V₂O₅)



- ▶ Chromic acid



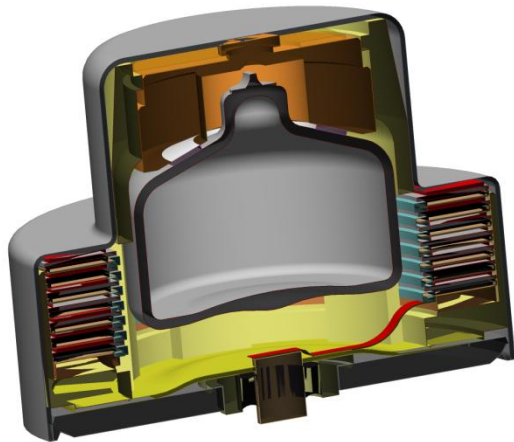
- ➔ Lithium - SOCl₂



Multi stack reserve Li-SOCl₂ batteries :

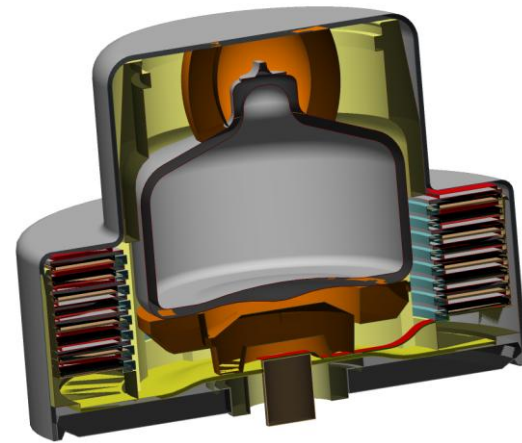
▶ UA 6215 Army artillery fuze battery.

- ▶ 6-9 cells, bipolar electrodes
- ▶ 2 x 4 cell stack in parallel option
- ▶ Release mechanism in the top



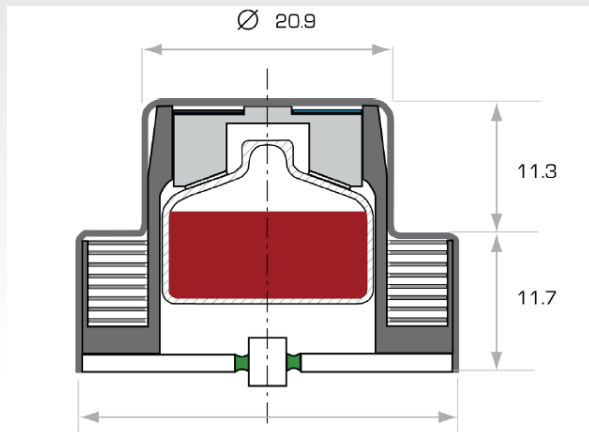
▶ UA 6275 Navy fuze battery.

- ▶ 6-9 cells, bipolar electrodes
- ▶ Release mechanism at the bottom

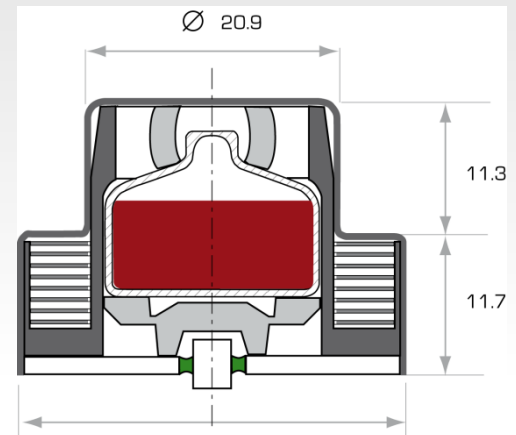


To reduce the risk of early fracture of ampoules due to radial and axial(-) forces (drop test / flick ramming), robustness has been improved:

UA 6215 : Army

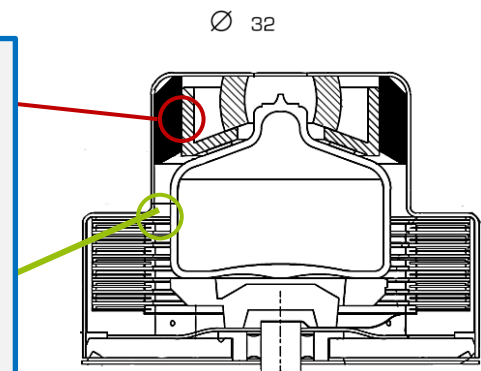
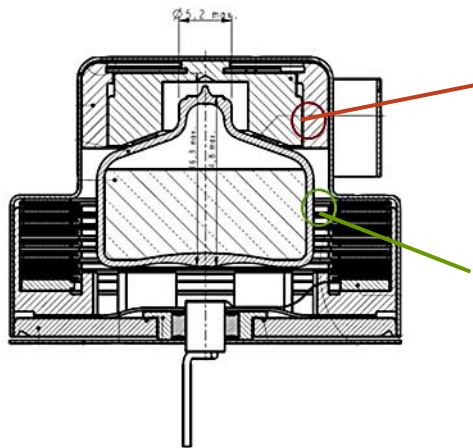


UA 6275 : Navy



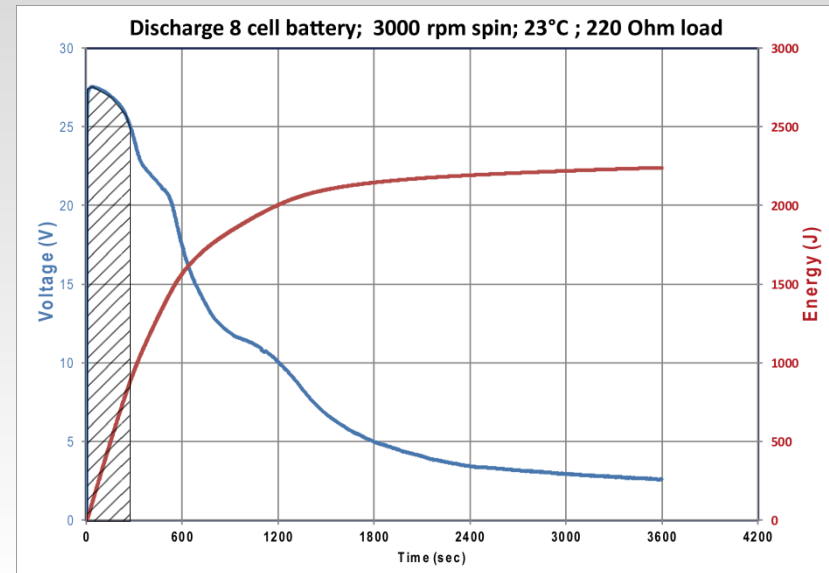
Improvements :

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



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 oversized 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:

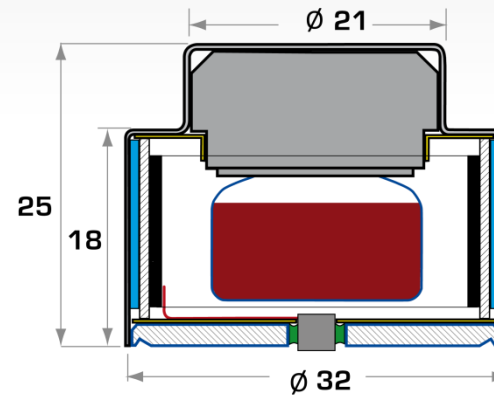
Example of typical requirement for application with improved (3V) electronics:

- ▶ 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.

Current capability (@3V)	750 mA
Life time (>3 V)	200 s



DOWNSCALING Ø32 X 25 MM SINGLE CELL BATTERY : Ø13 x 15

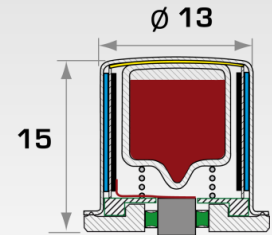
Typical application requirement:

- ▶ Dimension 15 x 13 mm
- ▶ Current 100 mA
- ▶ Operational time 100 s
- ▶ Power 30 J

100 Joule Battery

The cell housing of Ø 13 x 15 mm contains a single wrap of electrodes with an effective surface area of 3.8 cm².

Current capability (@3V)	175 mA
Life time (>3 V)	200 s



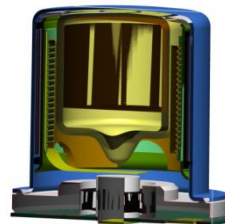
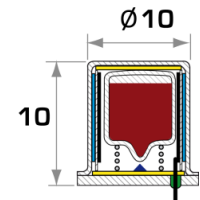
DESIGN GOAL:

- ▶ Dimension Ø10 x 10 mm
- ▶ Current 50 mA
- ▶ Operational time <30 s
- ▶ Power > 5 J

20 Joule Battery

This battery is the miniaturized version of the 100 joule version. The ampoule dimensions are reduced even further.

Current capability (@3V)	125 mA
Life time (>3 V)	50 s



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.



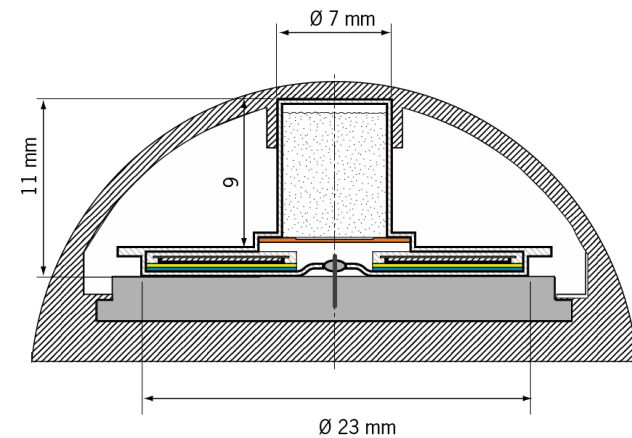
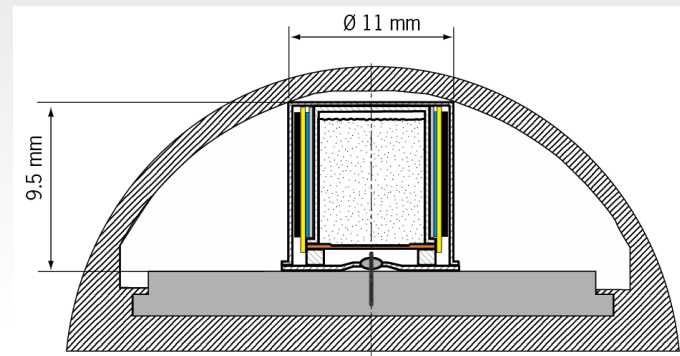
Development in single cell batteries :

► 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 it's Lithium-Thionylchloride batteries to meet future developments in fuze applications**
- ▶ **Developments are focussed 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**

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Thank you for your attention