

High-energy, rechargeable microbatteries



Advanced silver-zinc battery technology

The better battery.

The advertisement features a hiker on the left and two coin-sized batteries on the right. The batteries are silver with 'ZPOWER' and a plus sign visible. The background is a gradient of blue and green.

The advantages of silver-zinc batteries in portable electronics applications

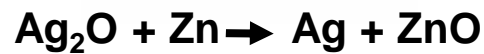
Silver-Zinc Rechargeable Batteries

- **50 year history in aerospace and military**
- **Benefits**
 - High energy density
 - Safe, water based chemistry
 - Mercury-free, recyclable materials
- **Challenges**
 - Zinc shape change
 - Separator degradation
 - Cost of silver

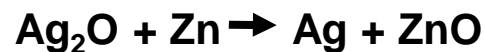


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Existing Silver-Zinc Batteries



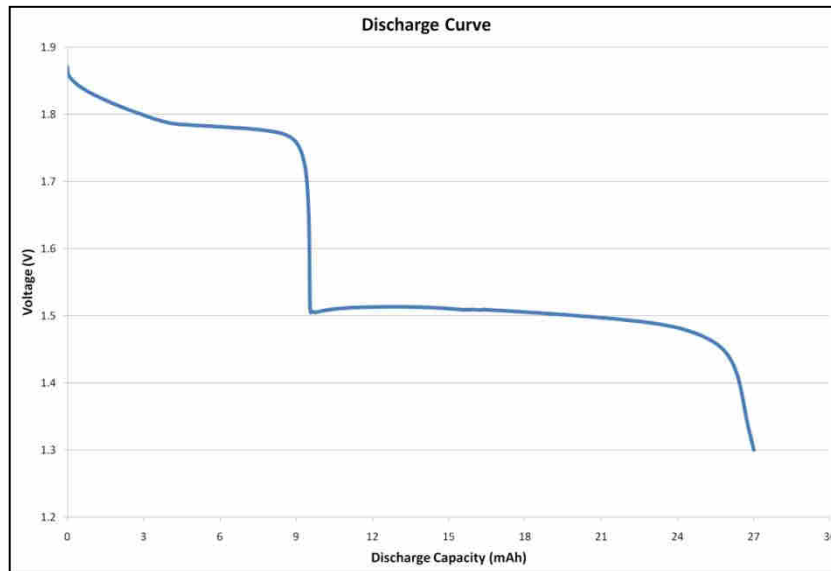
- **Primary battery**
 - 1.5V nominal
 - Low drain rate, high energy
 - Watch & hearing aid applications
 - Renata, Energizer, Sony



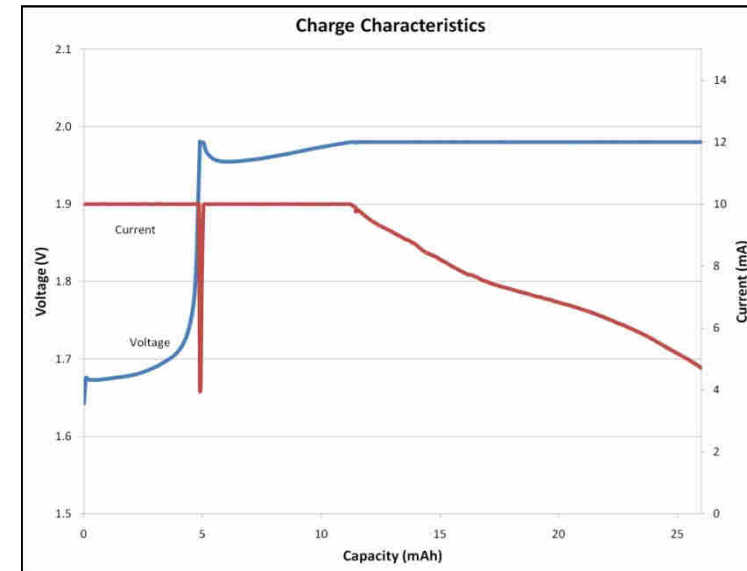
- **Secondary battery**
 - 1.6V nominal
 - High drain rate, high energy
 - Military & aerospace applications
 - Yardney, BST, Eagle-Picher

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Silver-Zinc Discharge & Charge Profile



*Size XR41 AgZn cell, 1.5mA discharge rate, room temp

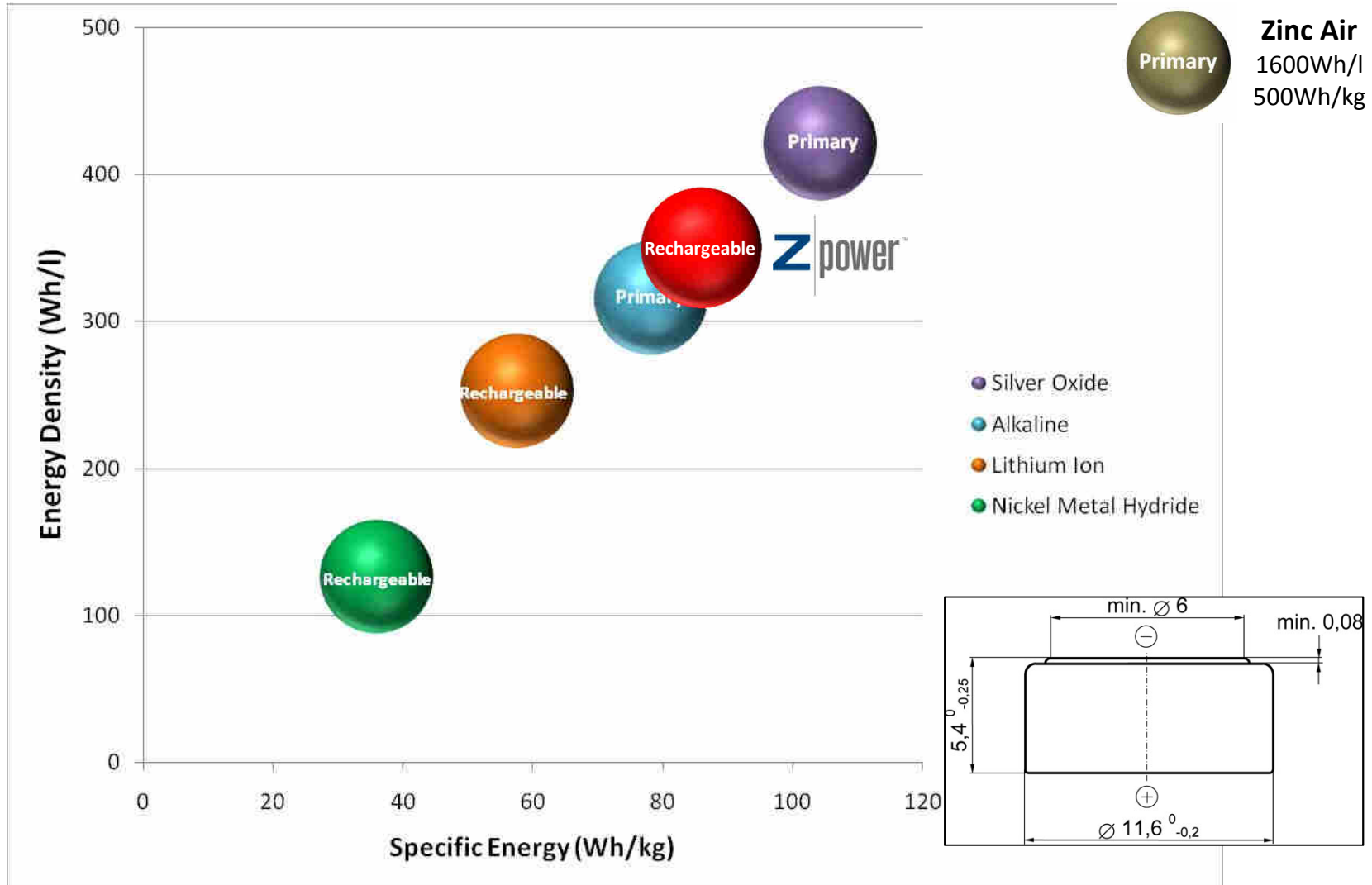


*Size XR41 AgZn cell, room temp charge



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Energy Densities Of Primary & Secondary Chemistries Commercial Button Cell Sizes PR44/SR44/LR44/XR44



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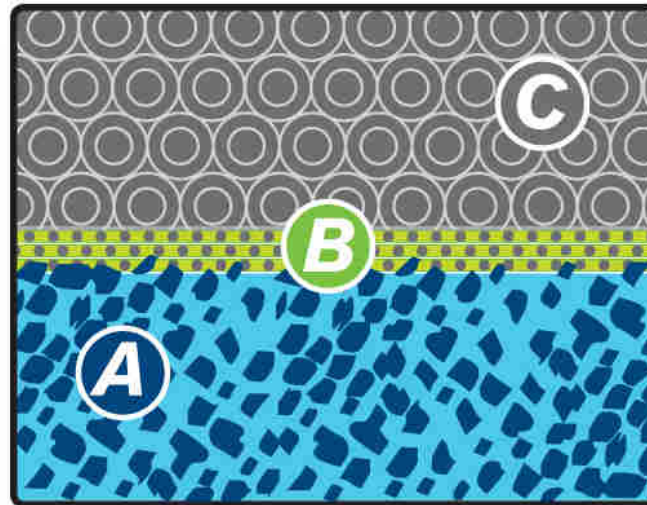
Advancing Silver-Zinc in Three Key Areas

C Nano-Particle Silver Cathode

The silver cathode in ZPower batteries is coated with nano particles. This nano-technology enhances conductivity for lower internal resistance.

A Composite Polymer Zinc Anode

The zinc anode in ZPower batteries is a composite polymer electrode which inhibits shape change and dendrite growth. In the past, shape change and dendrite growth in traditional silver-zinc cells was frequently an issue. These issues have been resolved with ZPower silver-zinc technology.

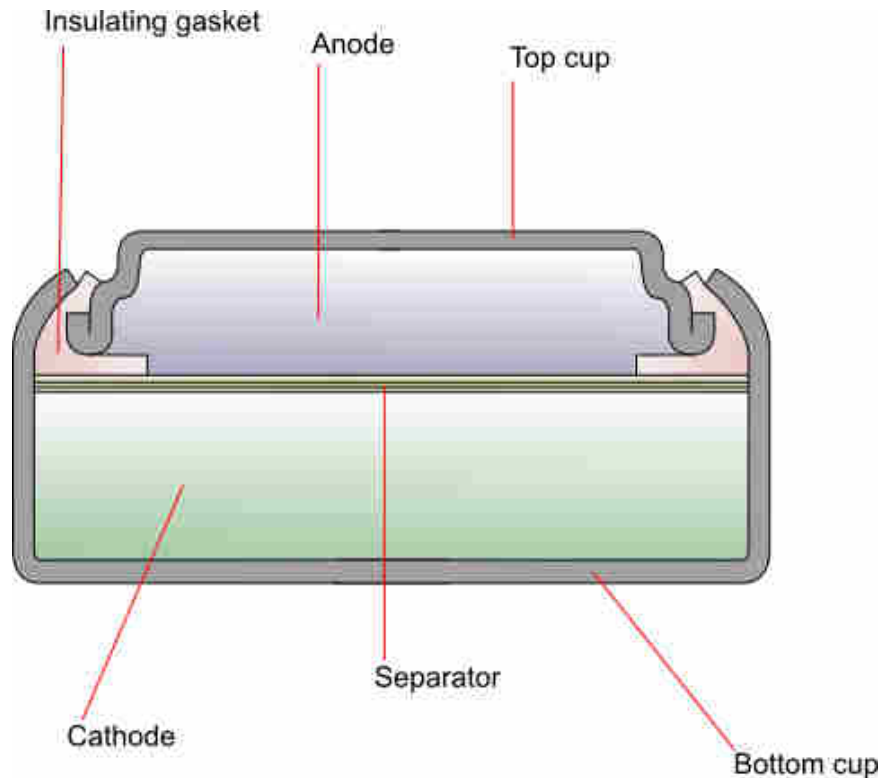


B Multi-Functional, Layered Separator

ZPower has created a highly-effective separator stack that resists dendrite growth from the zinc anode, while simultaneously resisting degradation from the silver cathode. At the same time, it allows ions to move freely between electrodes to minimize the cell's internal resistance. This results in a superior silver-zinc battery cell which offers long life and quick charge time.

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Button Cell Construction

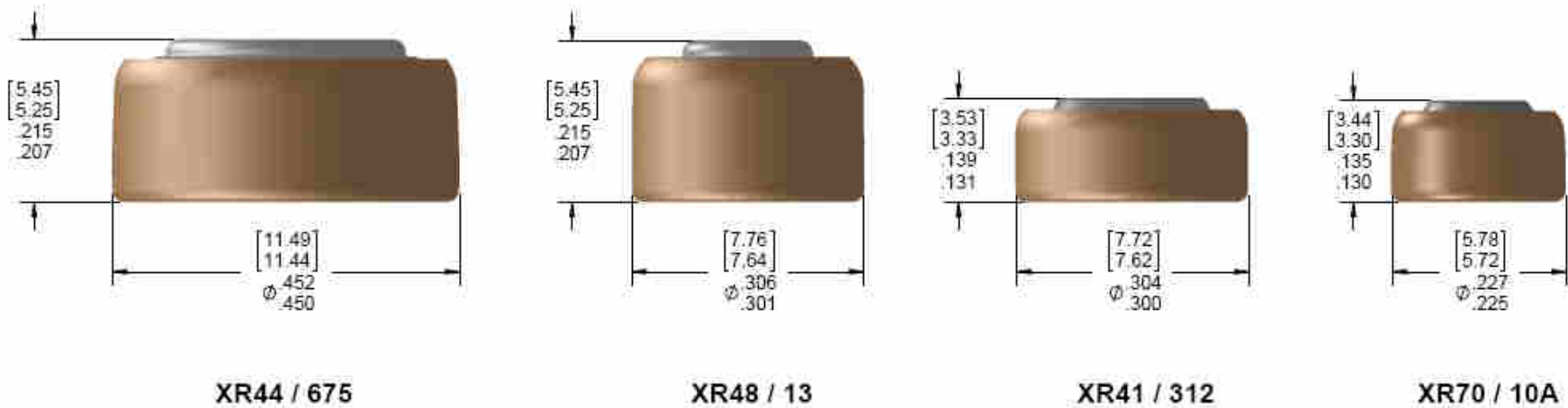


- **Reliable design with long history**
- **Top and bottom cup**
 - Material selection for strength & corrosion
 - Crimping process is critical
- **Gasket design is critical**
 - Material selection
 - Radial & axial compression
 - Electrical insulation
 - Rechargeable electrode flexing
- **Interface area determines maximum charge rates**

ZPower AgZn	Lithium Ion	NiMH*
25-40mA/cm ²	3-5mA/cm ²	10-25mA/cm ²

* NiMH has low charge efficiency
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Button Cell Dimensions & Specifications

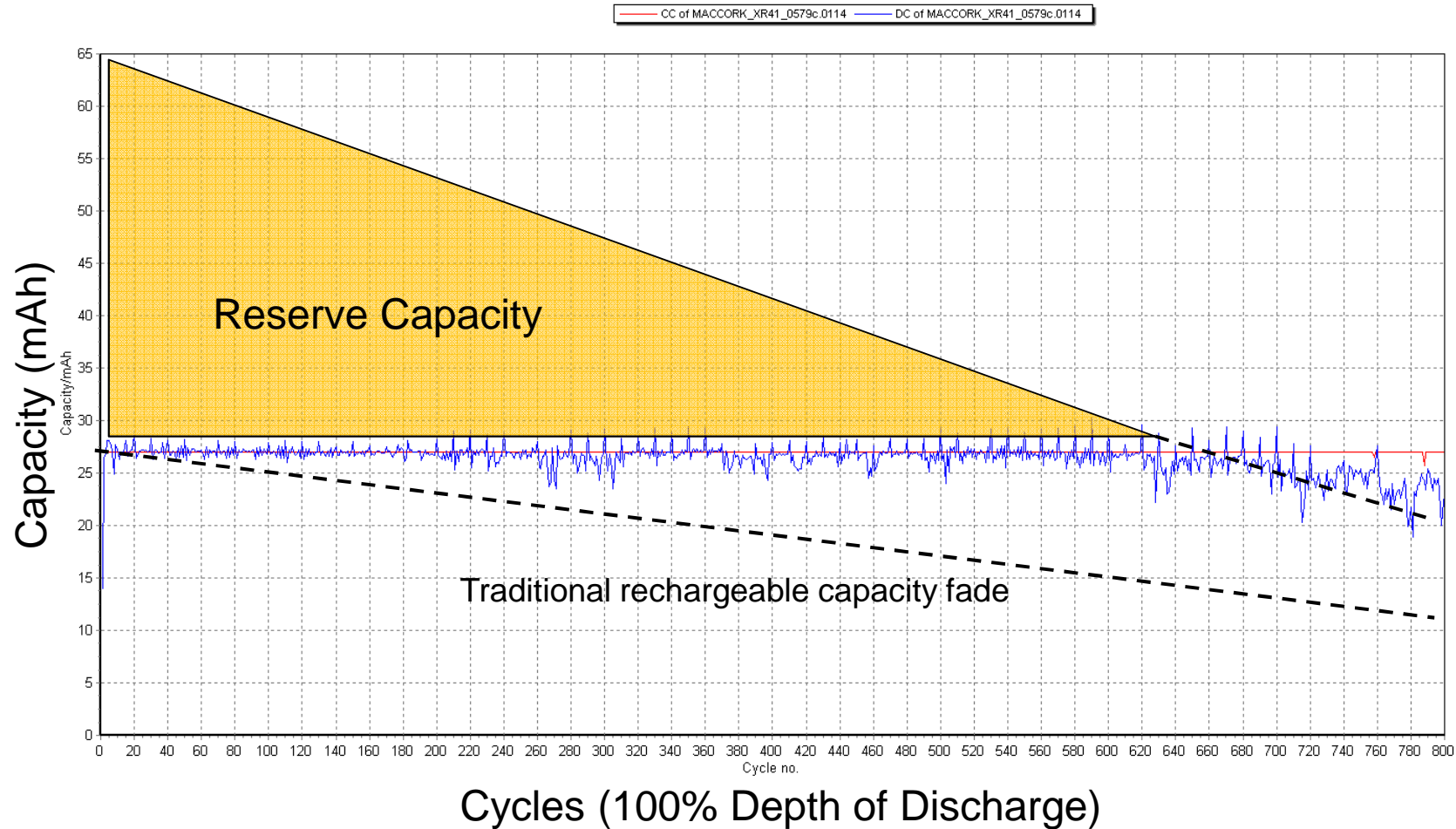


	AgZn XR44	AgZn XR48	AgZn XR41	AgZn XR70
Cell Capacity (mAh)	120	35	28	18
Cell Energy (mWh)	200	60	47	30

**Additional sizes are possible for future designs;
Sizes that match existing silver-oxide batteries are easiest**

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Silver-Zinc Cycle Life & Capacity Fade

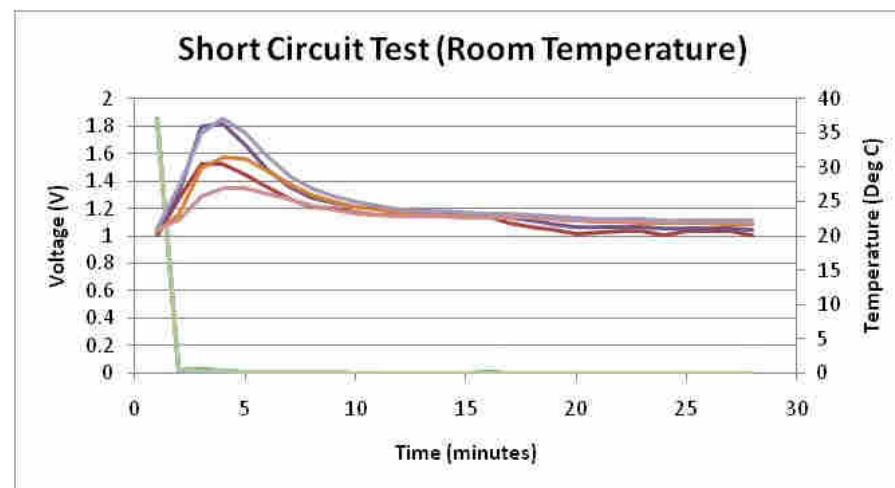


*Size XR41 AgZn cell, room temp charge/discharge

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Safe, Water-Based Chemistry

- KOH/H₂O based electrolyte like other alkaline chemistries
- Chemistry not susceptible to thermal runaway
- Short circuit testing results in minimal cell heating
- Not subject to proposed FAA battery travel restrictions



*Size XR48 AgZn cell, room temp (20°C) short circuit test per UL2054

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Silver-Zinc As A Clean Technology



- **Mercury-free design**
 - Upcoming environmental regulations
 - Recycling-friendly
- **Recycling**
 - Silver and zinc can be reused
 - Economical due to silver-content
 - Existing silver recycling infrastructure
 - Easier to meet European battery recycling targets
- **Reduces landfill waste**
 - Rechargeable vs. primary
 - Packaging waste

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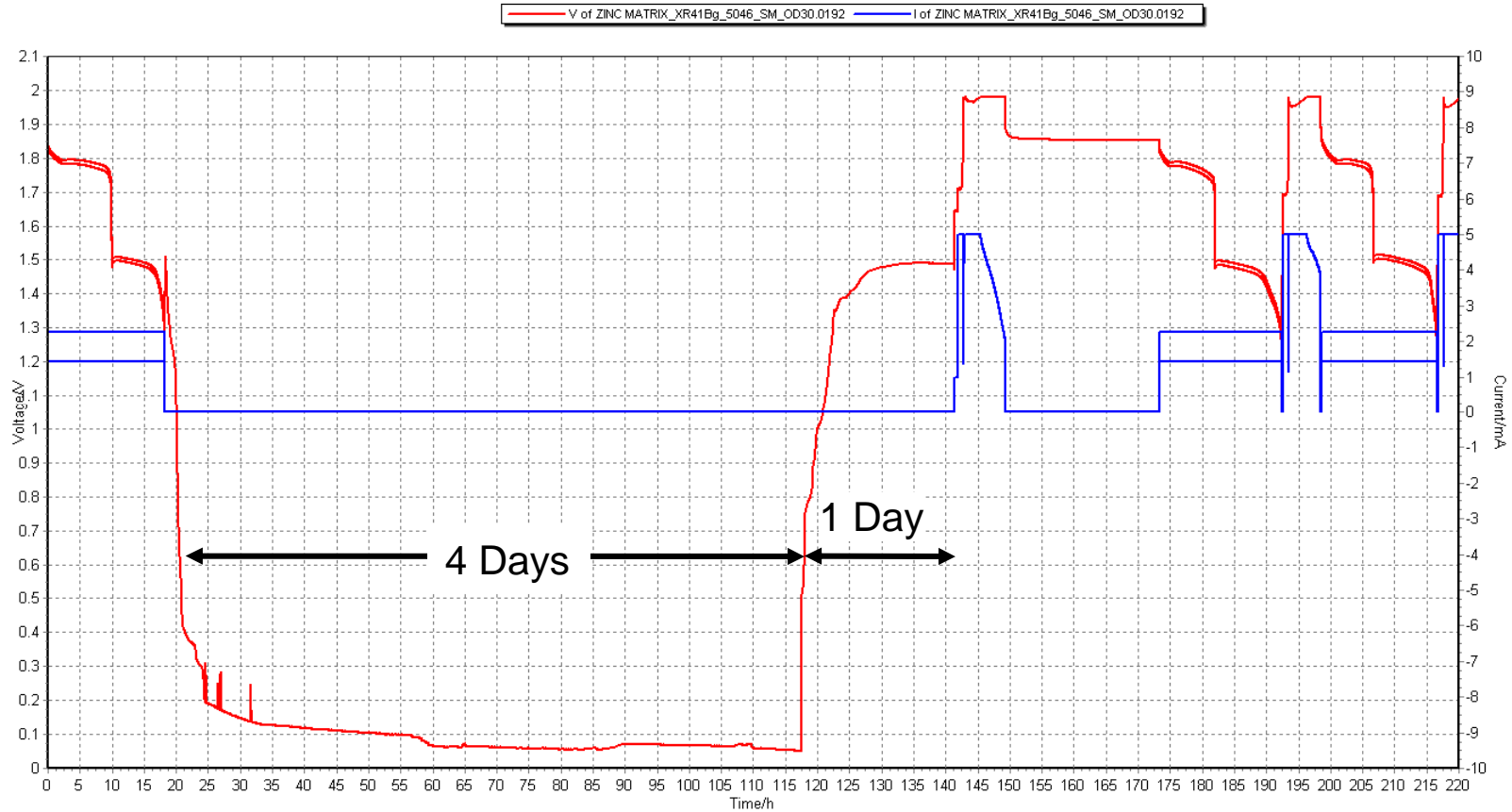
Silver-Zinc Self-discharge Rate

- Cells in room temperature storage
- Cells charged to full capacity prior to going into storage
- First discharge test results

Days In Storage	Storage Date	Last Charge Capacity	Discharge Capacity	Monthly Self-Discharge Rate		Days In Storage	Storage Date	Last Charge Capacity	Discharge Capacity	Monthly Self-Discharge Rate
166 days	15-Jan-10					105 days	17-Mar-10			
	663	27	26.9	0.07%			2258	27	25.5	1.59%
	664	27	26.6	0.27%			2259	27	25	2.12%
	665	27	24.8	1.47%			2260	27	26.9	0.11%
	666	27	25.3	1.14%			2261	27	27.5	-0.53%
	Average	27	25.9	0.74%			Average	27	26.2	0.82%
	Max	27	26.9	1.47%			Max	27	27.5	2.12%
	Min	27	24.8	0.07%			Min	27	25.0	-0.53%

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Recovering Over-Discharged Silver-Zinc Batteries



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Qualification Testing On Silver-Zinc

Safety	Environmental	Mechanical	Electrical	Performance
Short circuit	High temperature storage	Mechanical durability	Over-discharge recovery	Pulse discharge
Abnormal charge	Humidity + Temperature	Over-discharge leakage	Self-discharge	Operational temperature
Crush	Corrosion	Vibration		Cycle life
Impact	Chemical compatibility	Impact		Impedance
Drop		Thermal cycling		
Shock				
Vibration				
Projectile	Qualification tests are tailored to product design and use cases			
Heating				
Temperature cycling				
Low pressure				

UL2054/IEC62133

Applications For Silver-Zinc

- **Form-factor sensitive devices**
 - Higher value associated with miniaturization
 - Battery run time is a differentiating feature
 - Battery is the largest component
- **Rechargeable battery fits usage profile**
 - Device can be conveniently recharged
 - Storing/replacing batteries is inconvenient
 - Add capability to a device currently using primary battery
- **Safe performance is critical**
 - Thermal runaway cannot be tolerated



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Silver-Zinc Summary

- **New rechargeable chemistry alternative**
 - Safe, high energy density chemistry
 - Excellent choice for form-factor sensitive designs
 - Charge algorithm postpones capacity fade until end of life
- **Assembly capacity for 1 million pcs/year**
 - Samples available now in size XR41 and XR48
 - ISO9001 quality system in place by mid-2011
- **Multiple semiconductor companies working on silver-zinc compatible charging IC's**