Nickel-Zinc Technology Overview

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NICKEL-ZINC HISTORY

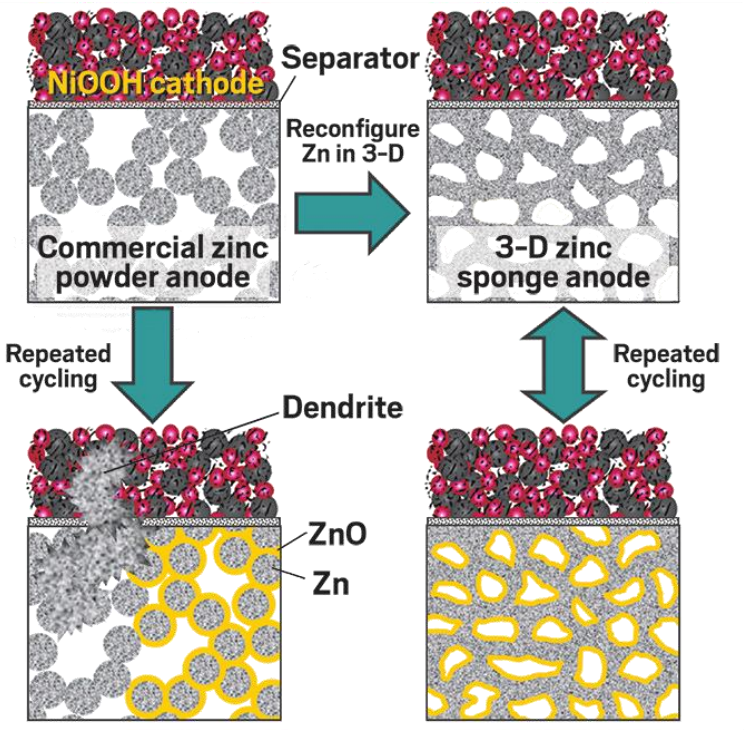
- Originally developed and patented by Thomas Edison in 1901 (patent #684,201)
- Early NiZn batteries provided small number of discharge/recharge cycles
- Performance was limited by cyclic capability due to instability of the zinc electrode
- Typical failure modes – dry out, zinc migration, and dendritic shorts
- Renewed interest in rechargeable zinc batteries on both scientific and commercialization fronts
- NiZn chemistry has ~50% higher energy density than VRLA
- Submarine community – safety and power density most important factors for next gen



By Unknown - http://www.nickel-iron-battery.com/, Public Domain, https://commons.wikimedia.org/w/index.php?curid=14798819

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NIZN PRESENT DAY AND FEATURES



- Additional cell/battery design improvements have further increased performance/cycle life
- Strategies to tame zinc instability include optimized electrolyte formulations, sophisticated charging protocols, advanced electrode designs, etc.
- Applications include trucking, micro-hybrid vehicles, Uninterruptible Power Supplies, grid storage, data centers
- Cells, manufacturing, and chemistry are scalable
- Chemistry is flexible to provide wide range of power and energy services
- Supply chain – Zinc is globally mined and refined in 50 countries so supply is secure and conflict free

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NIZN FUTURE

- Non-toxic
- Non-flammable
- Safe (No Thermal Runaway)
- Wide operating temperature range
- Low maintenance
- Flexible storage requirements
- Zinc producers and zinc battery manufacturers joined together to launch the Zinc Battery Initiative; a partnership to raise awareness of the many safety, performance and sustainable advantages of zinc batteries (2020)



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NIZN ELECTROCHEMISTRY

- **Anode Material: Zinc/Zinc Oxide**
- **Electrolyte: Aqueous KOH**
- **Cathode Material: Nickel Hydroxide / Nickel Oxyhydroxide**

Anode: $Zn + 2\,OH^- \rightleftarrows Zn(OH)_2 + 2\,e^-$

Cathode: $2\,NiOOH + 2\,H_2O + 2\,e^- \rightleftarrows 2\,Ni(OH)_2 + 2\,OH^-$

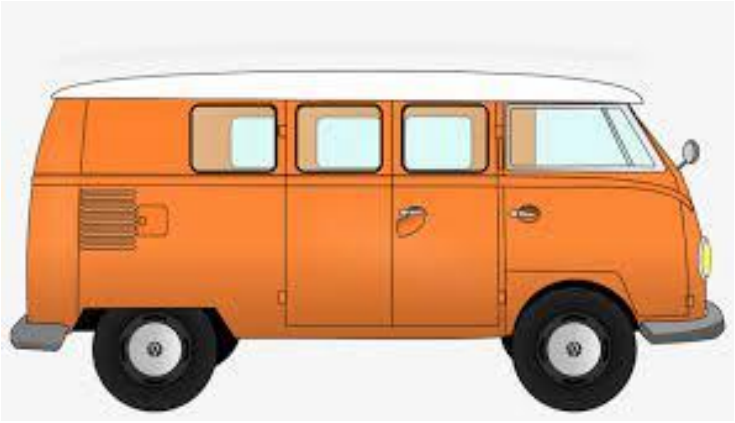
Overall Reaction: $Zn + 2\,NiO(OH) + H_2O \rightleftarrows ZnO + 2\,Ni(OH)2$

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BENEFITS – ENVIRONMENTAL

- Most recyclable chemistry available
- Safe and free from toxic materials
- Boundless Impact Research and Analytics Climate Impact Profile on ZincFive NiZn batteries gave 9.4/10 climate impact score (2020 Report)
- Recyclability may help reduce cost in future
- Lead-Acid one of the top pollution problems





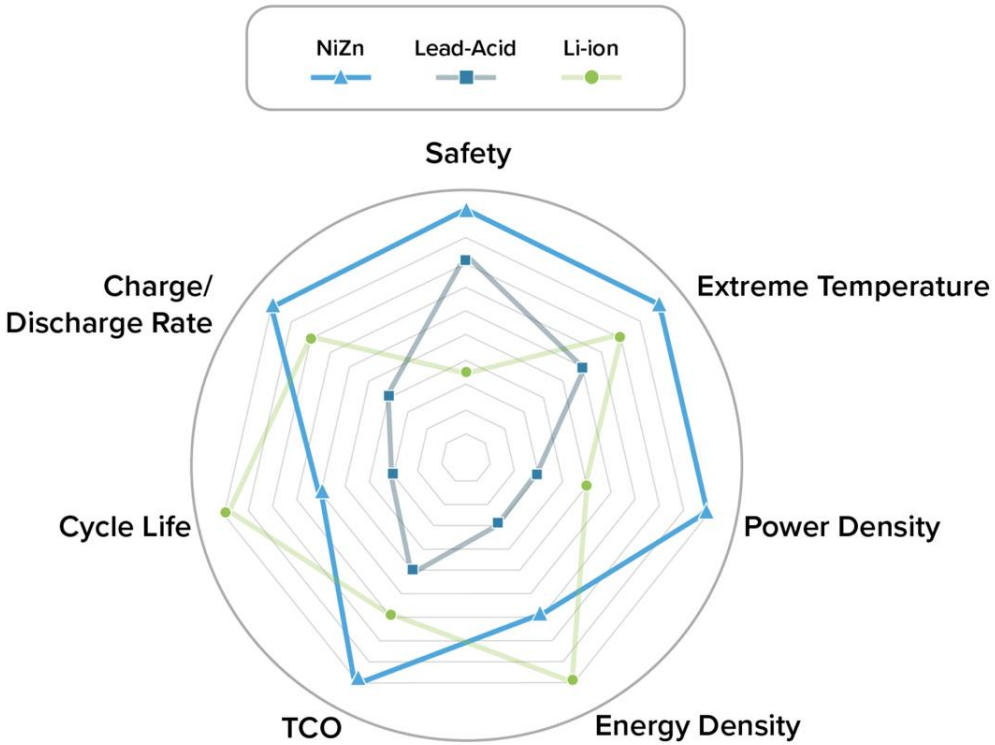
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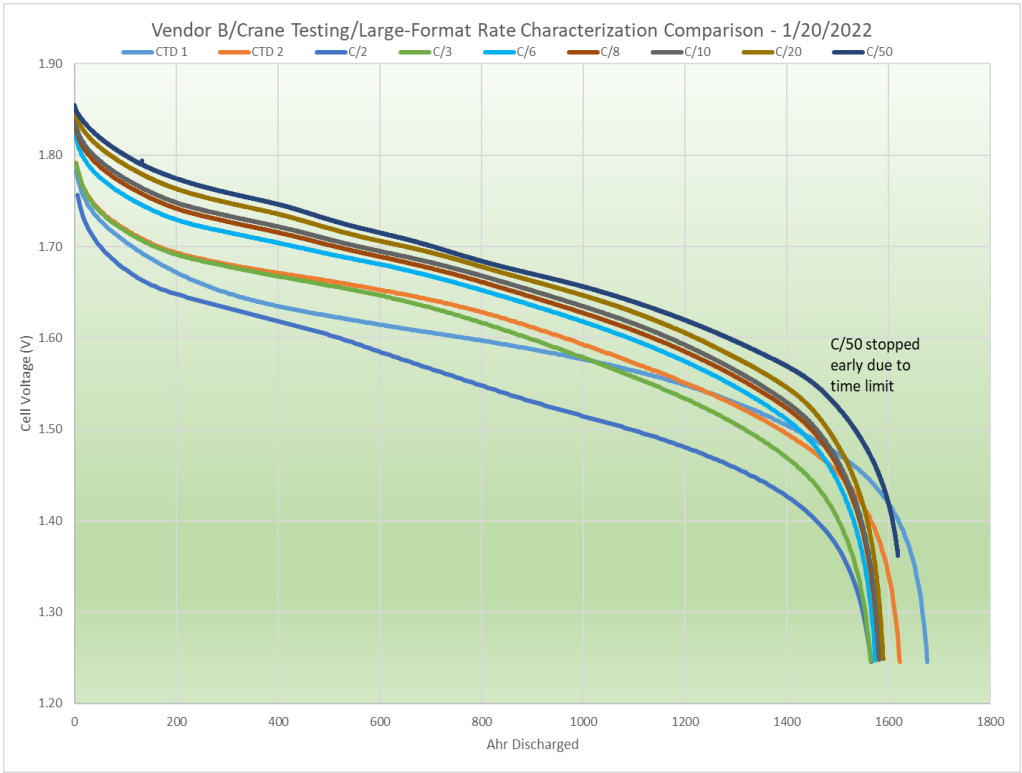


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BENEFITS – ENERGY

- **2X Power Density compared to lead-acid**
- **Lighter Package compared to lead-acid**
- **No need for redundant safety measures (lithium)**



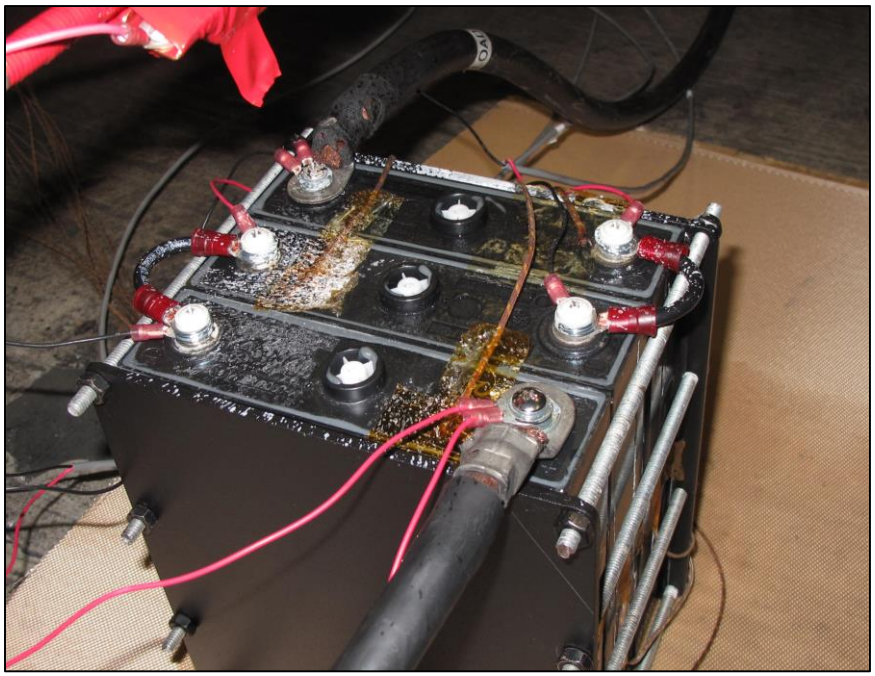


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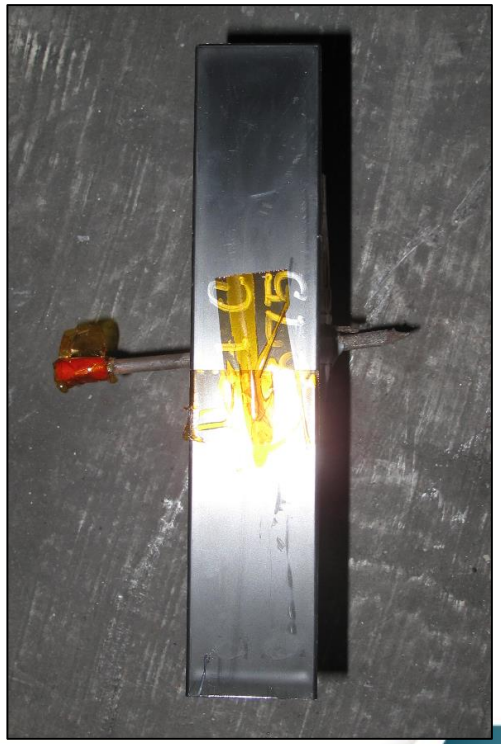
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BENEFITS – SAFETY

- No thermal runaway
- No toxic materials
- No aggressive events in nail penetration, short circuit, or (extreme) overcharge



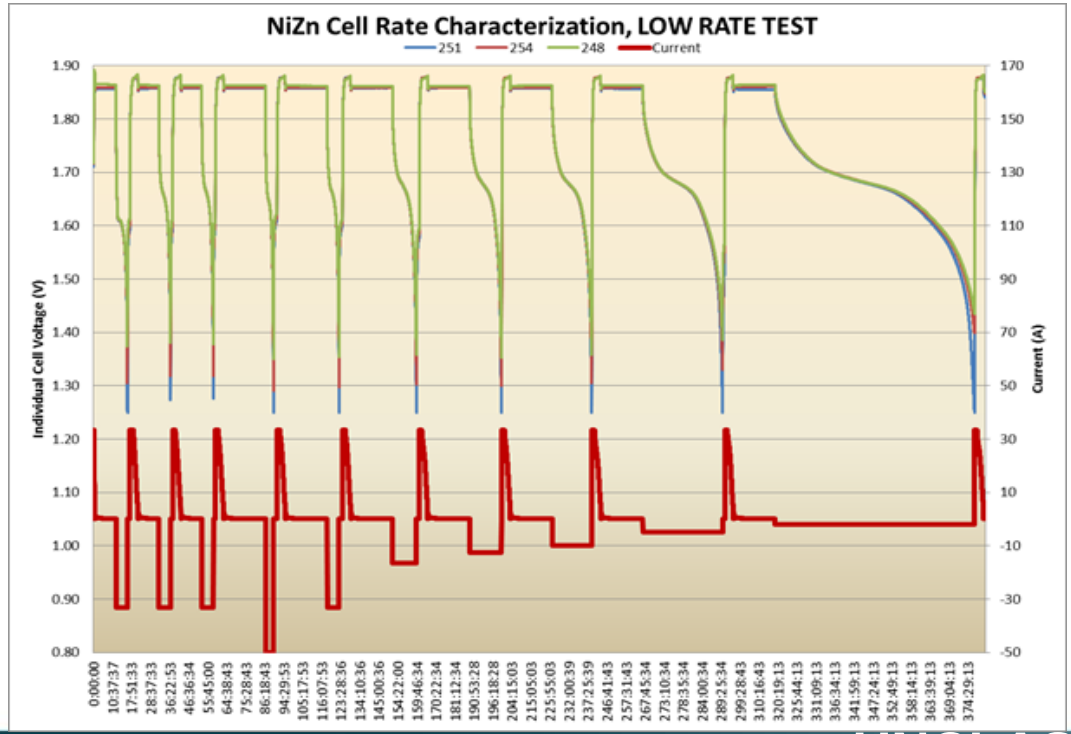


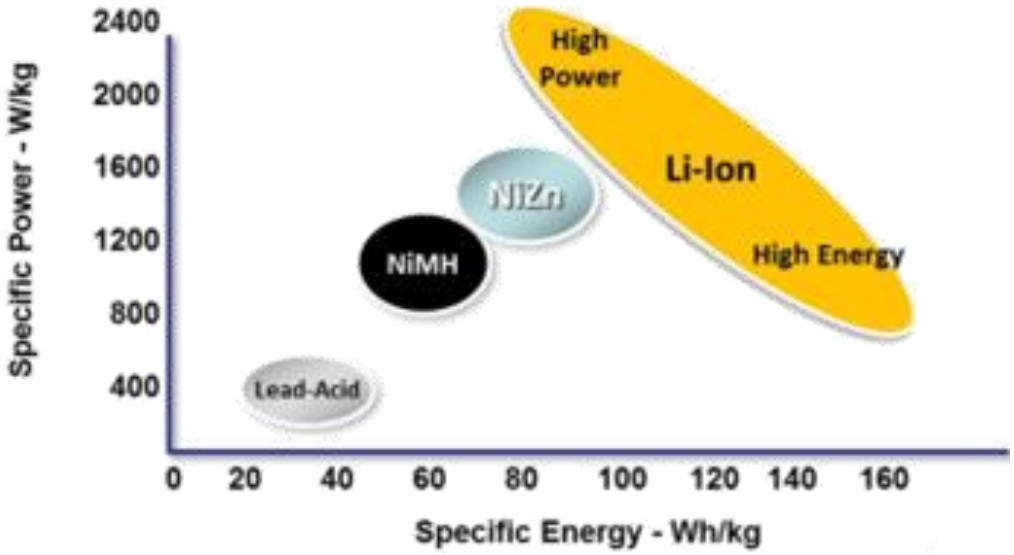


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MSB NICKEL-ZINC T&E

- Submarine community – safety/energy density/reliability important factors
- NSWC Crane has been evaluating NiZn chemistry since 2015 via multiple vendors
- In comparison to VRLA, small-format testing shows increase in capacity; ≈ 50% higher energy density; likely same or better cycle life; increased safety
- Operational Cycle Life, Design Optimization, Orientation, Safety Testing ongoing for small, mid, and large-format cells (100Ah – 1,350Ah)





Sources: Ricardo Consulting, AABC, PowerGenix estimates

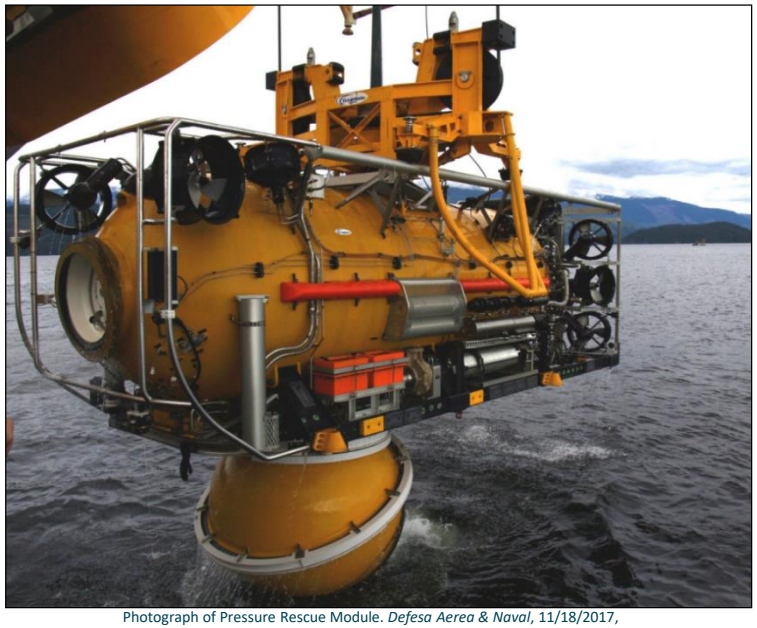
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CONCLUSION

- Sustainable, High Power Density
- Unparalleled Safety
- Lower Weight
- Increase Awareness of Zinc-Based Batteries
- Future is Bright



Photograph of F/A-18C/D Hornet. *Military.com*, 3/24/2022, https://www.military.com/equipment/f-18c-d-hornet



Photograph of Pressure Rescue Module. *Defesa Aerea & Naval*, 11/18/2017, http://www.defesaaereanaval.com.br/us-navy-prepara-o-mini-submarino-srds-para-eventual-uso-nas-buscas-do-ara-san-juan/.



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THANK YOU

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