



Next Generation BA5X90 Battery

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SAFT

Agenda

- 1 Saft Overview
- 2 Saft Hybrid Technology overview
- 3 BA5X90 performance
- 4 Future Development (next generation systems)
- 5 Questions

Saft is focused on the needs of our soldiers

- Saft has been a major supplier for the US Army for batteries used by the soldiers for last 20+ years
- We have supplied millions of batteries to the soldiers to support their critical missions
- Saft offers a wide range of high energy/high power technologies used by the soldiers in multiple applications
 - > Li-SO₂
 - > Li-MnO₂
 - > Li-Ion
- We understand the military market and its unique requirements



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Saft Hybrid Cathode Systems



Program History

- In 2008, through funding provided by the US military, Saft started a development program to create a cathode system capable of delivering higher discharge capacities with similar properties to current Lithium MnO_2 systems
- The new design utilizes a mix of MnO_2 and CF_x (carbon-mono fluoride) as cathode material with similar cell components and construction as in Li-MnO_2
 - > Capable of delivering significantly higher energy density
 - More capacity and lower weight burden
 - Increased performance at low temperature
 - > Similar level of safety as standard MnO_2

Why Hybrid Technology?

Lithium MnO₂

- Low to high drain rate
- Good energy density
- No startup delay
- Low cost

Lithium CFx

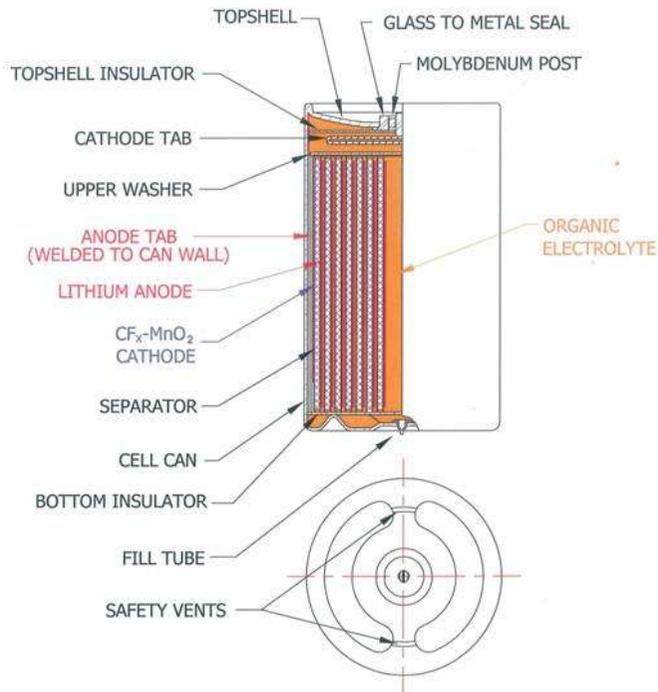
- Low drain rate
- High energy density
- Excellent at low temperature
- High material cost

Hybrid MnO₂/CFx

- Low to high current discharge
- 350-400 Wh/kg
- No Startup Delay
- Excellent low temperature performance
- Lower cost than pure CFx

LH33550 Cell Design

- Lithium Limited Design
- Hardware- **Same as Li/MnO₂**
- Cathode Active Material: EMD:CFx
- 25 μ Tri-layer Separator
- Safety Vent
- Total Cell Weight: 106 grams
- Nominal OCV: 3.17 volts
- Cell internal Resistance: $\sim 75\text{m}\Omega$ (Based on 10A/5S Pulse)
- Rated Capacity
 - At 2A Rate at 21°C: 14.5 Ah
 - At 250mA Rate at 21°C: 15.5 Ah

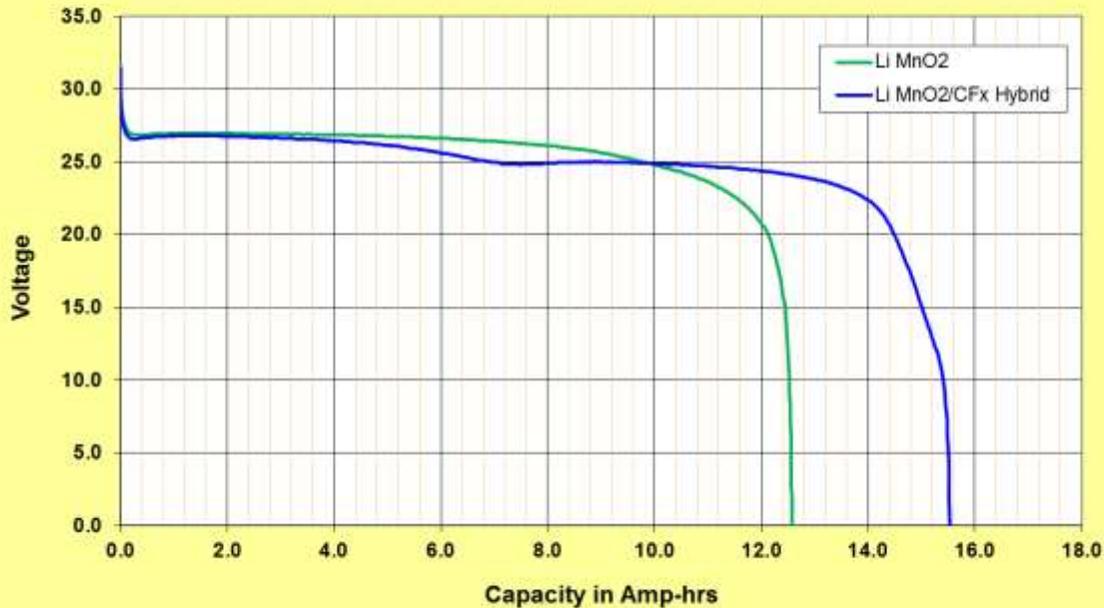


BX590 Performance

Saft Generation I BA5X90 I Test (MIL-PRF-49471B)



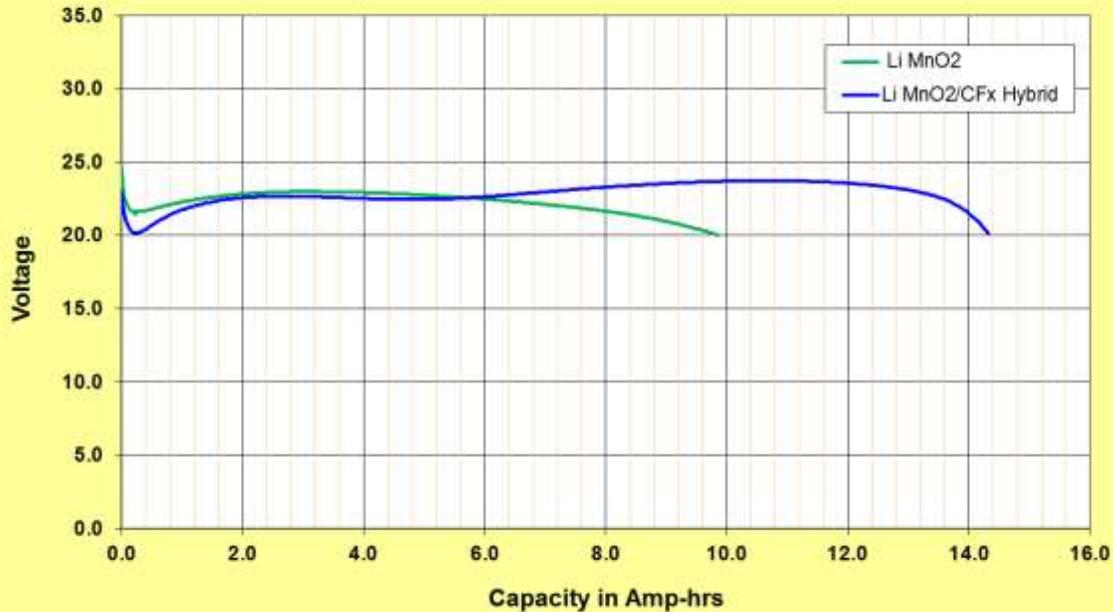
Voltage Profile of Lithium MnO₂ and New Lithium MnO₂/ CFx Hybrid
BA5X90 Battery Discharged at 2 Amperes and 21C



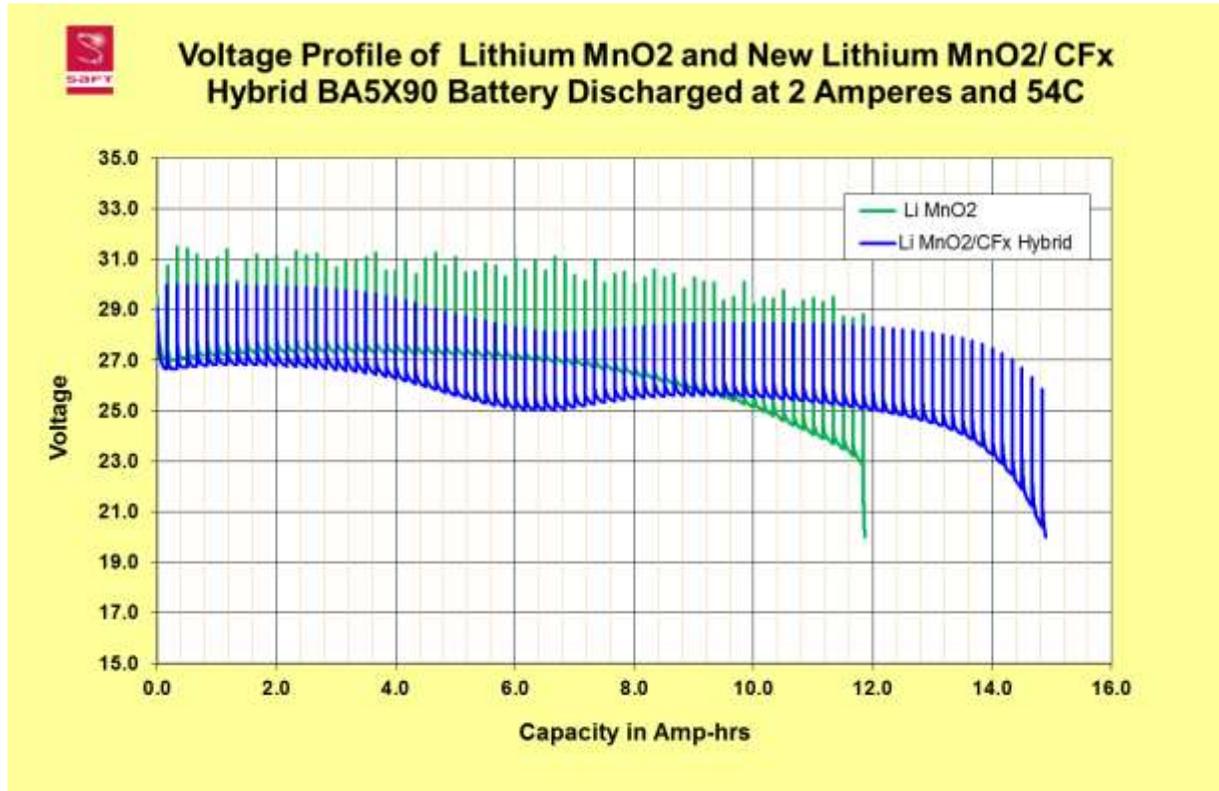
Saft Generation L BA5X90 I Test (MIL-PRF-49471B)



Voltage Profile of Lithium MnO₂ and New Lithium MnO₂/CFx Hybrid BA5X90 Battery Discharged at 2 Amperes and -29C



Saft Generation H BA5X90 I Test (MIL-PRF-49471B)



Ongoing Development

Areas of ongoing development

- Management of heat generation
 - > CFx material generates heat throughout the discharge of the battery and must be managed
- Increase the energy density by lowering the weight burden through the use of low weight materials
- Higher active material content through
 - > Elimination of void/unused space
 - > Higher cathode loading through increased densification

BA5X90's Capacity and Energy Density Comparison

Chemistry	Capacity	Weight	Energy Density
	(Amp hrs)	(grams)	Wh/kg
LiSO ₂	8.5	1020	215
LiMnO ₂	12.0	1420	245
Hybrid (Today)	14.5	1280	285
			
Next Gen Hybrid (Future)	15.5	1110	350

2A Discharge at 21 C

Relative cost comparison on BAX590 batteries

- Comparing different BX590 technologies in relation to dollars spent / energy delivered the traditional BA5590(SO₂) still has a clear advantage. The newer technologies with enhanced energy density comes with a significant premium

> BA 5590 (SO₂) 100

> BA 5390 (MnO₂) 140

> BAX590 (Mixed Oxide) TBD

– (higher than the current technologies)

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 - > Dr. Bernard Simon
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Questions