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May 2025



**Extending Life in Extreme
Environments**

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See what separates

- Microporous Introduction
- Solutions for extreme environments
 - Absorbent Glass Mat (AGM) results
 - Enhanced Flooded Battery (EFB) results

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- Conclusions



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Our Products

See what separates



Ace-Sil®

Premium rubber separators for over **80 years** with **marked-leading** battery life performance (1934)



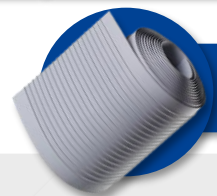
Flex-Sil®

Premium rubber separators for over **40 years** with **marked-leading** antimony suppression (1978)



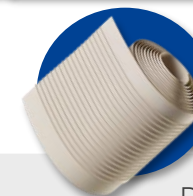
GlassForce®

Absorbent Glass Mat (AGM) separators provide excellent **cycle life, charge & discharge** performance (2019)



DuroForce®

PE separators provide excellent **oxidation resistance & low electrical resistance** (2000)



CellForce®

PE-rubber hybrid separators provide excellent **oxidation resistance & antimony suppression** (1999)

2025

IonForce®

Ultra-thin, coated wet process PE **lithium-ion** separators.



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Our Facilities

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Microporous Piney Flats, Tennessee

- Lead-Acid Battery Separators
- Li-ion Battery Separators Launching Q1, 2025



Microporous Mega Plant Danville, VA

- Li-ion Battery Separators
Launching 2026



Microporous Feistritz, Austria

- Lead-Acid Battery Separators



Extreme Environments

See what separates



AGM

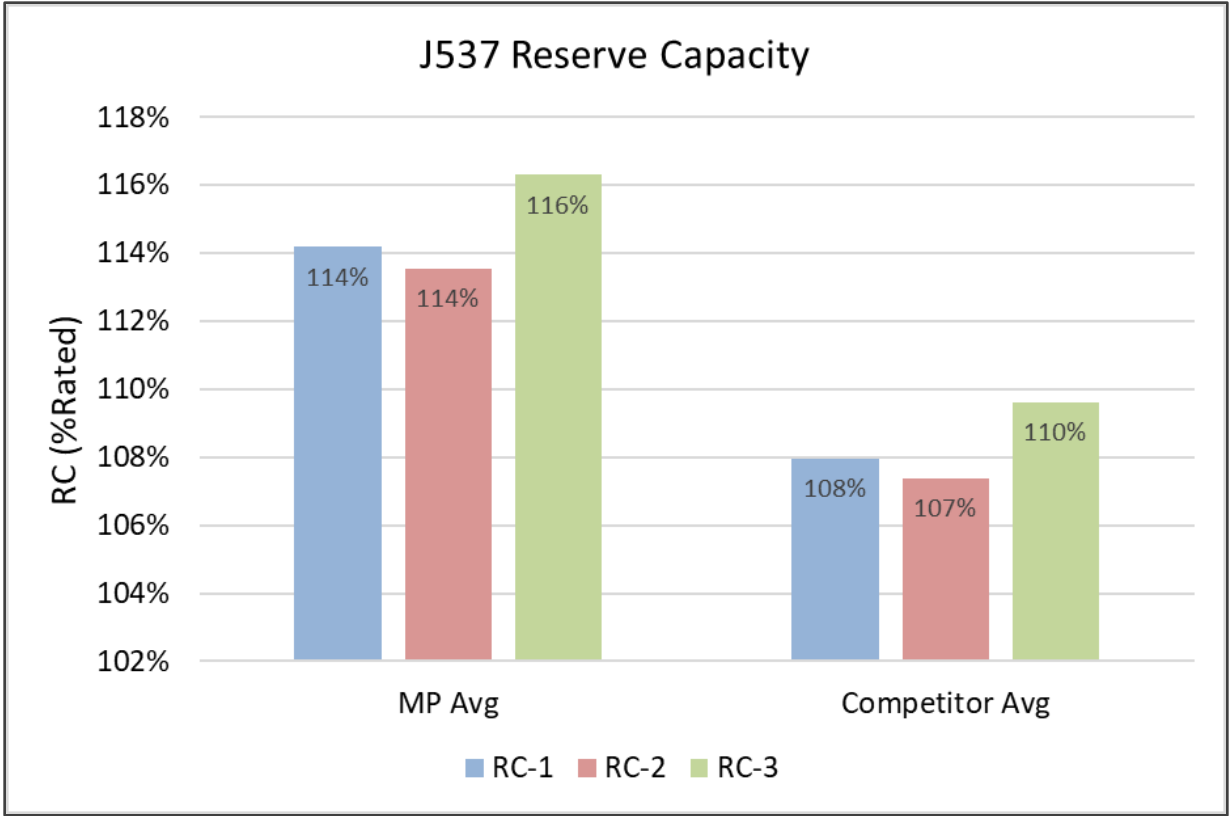


EFB

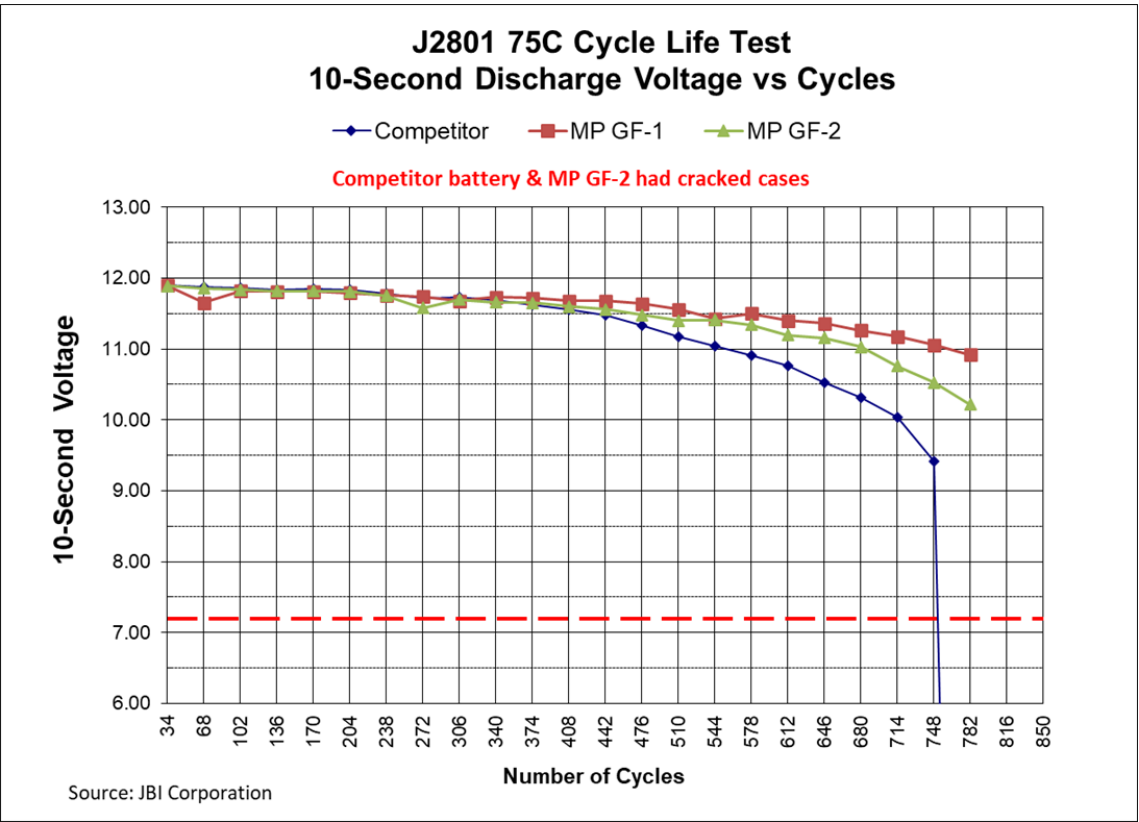


GlassForce® AGM - Higher Capacity, Longer Life

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Improvement in Reserve Capacity on J537 5 cycle test
Average of 3 batteries on test



Consistent performance after 10 weeks on ongoing 75°C
life cycle test



Extreme Environments

See what separates



AGM

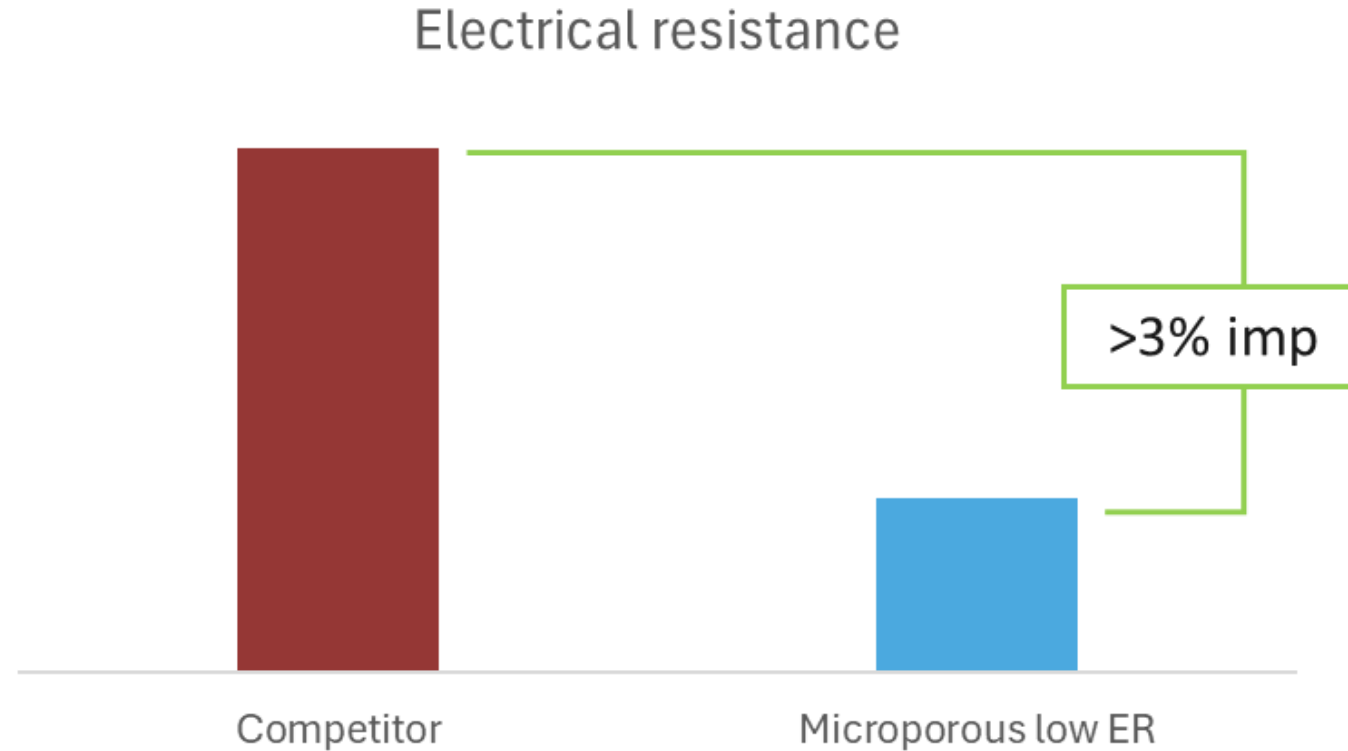


EFB



Lower ER -> Longer Cycle Life?

See what separates



- Successfully lowered electrical resistance
- Unfortunately, improvements not consistently seen during battery cycling



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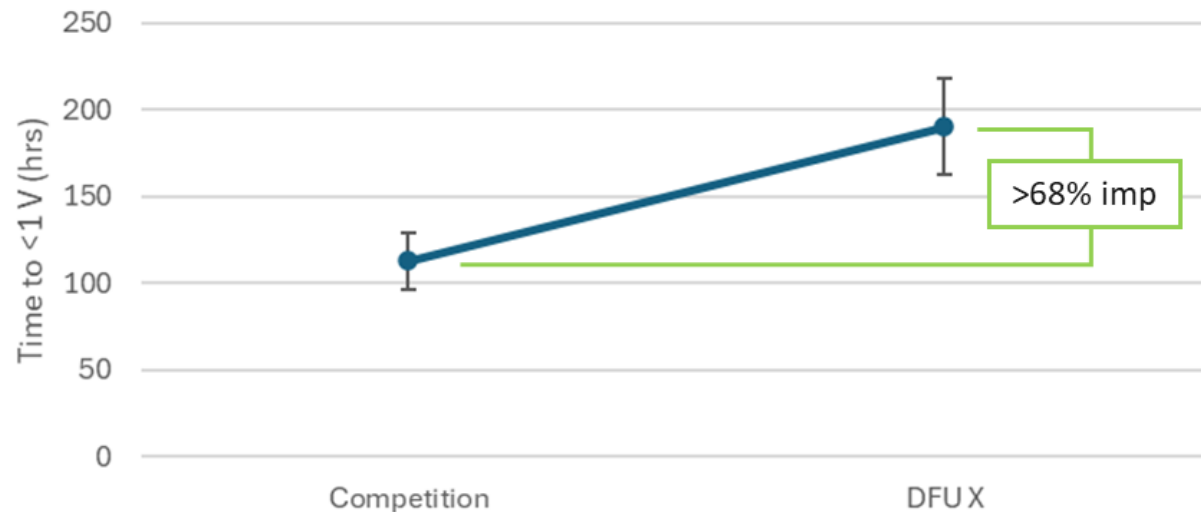
What *DOES* Extend Cycle Life?

See what separates

Oxidation Resistance by Simulated Electrochemical Cell

Constant 5A at 75C until Voltage <1V

Vertical bars denote 95% confidence intervals



- Post cycling analysis showed a correlation between oxidation resistance and longer cycle life
- Cell testing let us determine optimal chemical and process parameters for a separator to surpass the competitor
- This new separator became known as DuroForce® Ultra™ X ("DFU X") as it provides **EXTRA** protection to extend life in the most challenging conditions



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Battery Testing Details

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- Separators tested:
 - Control: VW qualified competitor's EFB separator from production
 - Test: Microporous DuroForce® Ultra™ X
 - Profile: QI (see photo)
 - Dimensions: 0,9 x 0,25 mm
- Batteries tested:
 - 12V, 55Ah, L1 EFBs
 - 1 control and 1 test battery per test
- Testing protocol:
 - VW 75073: 2020-03
 - 7,5 - Cycles with 50% depth of discharge at $(40 \pm 1)^\circ\text{C}$ in water bath
 - 7,7 - Overcharging at constant voltage
 - 7,11 - Thermal stability test at $(75 \pm 2)^\circ\text{C}$

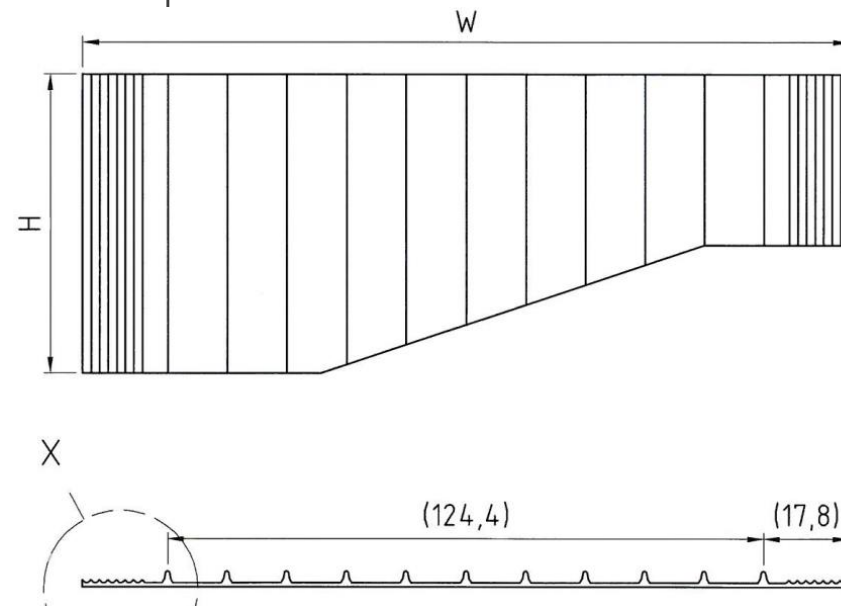


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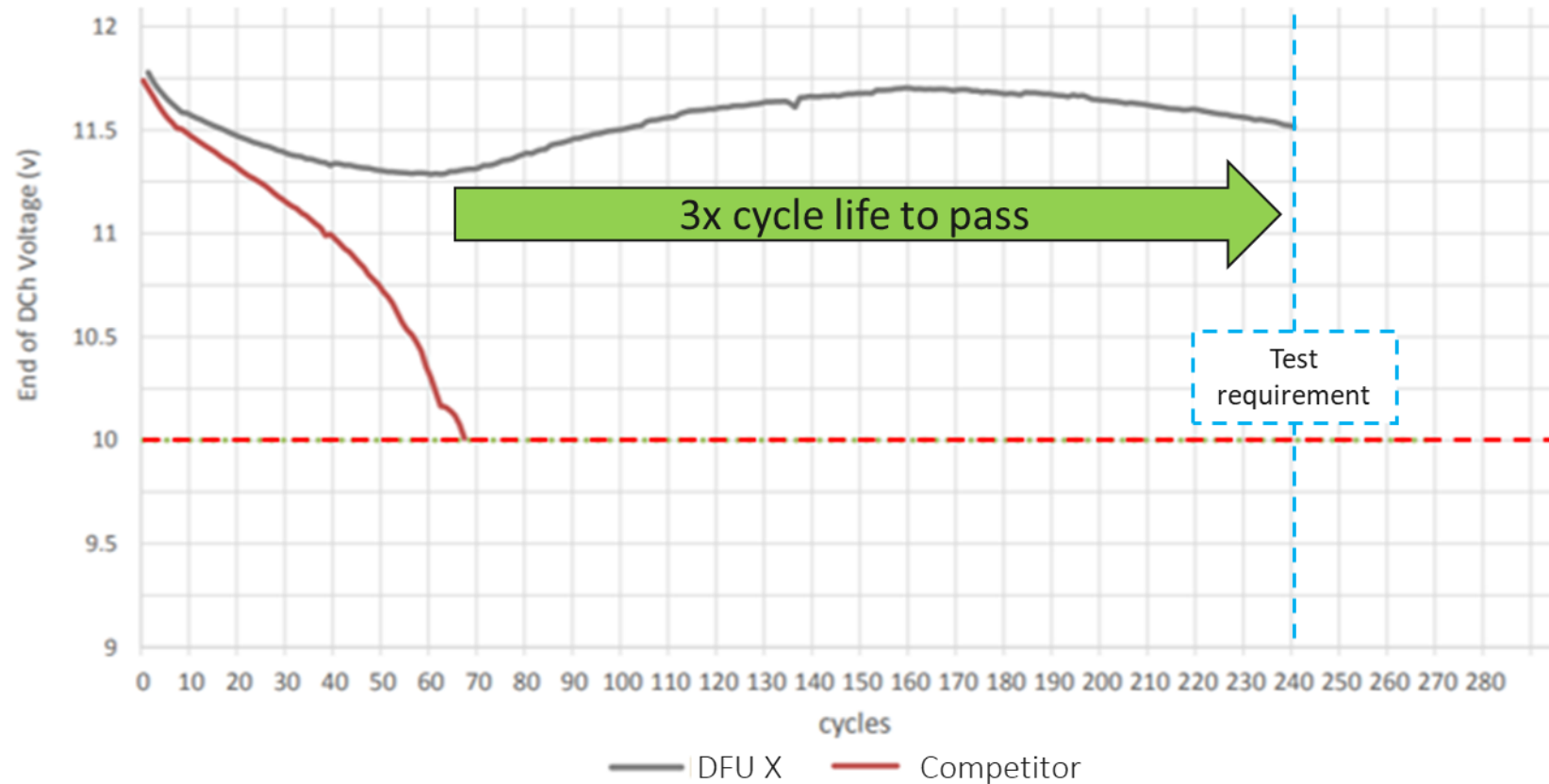
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7.5 - Cycles with 50% depth of discharge (40°C) “Positive Plate Degradation Test”

See what separates



7.5 - Cycles with 50% depth of discharge (40°C) “Positive Plate Degradation Test”

See what separates



DFU X



Competitor

- Tear downs showed significant sulfation on the competitor's positive plates



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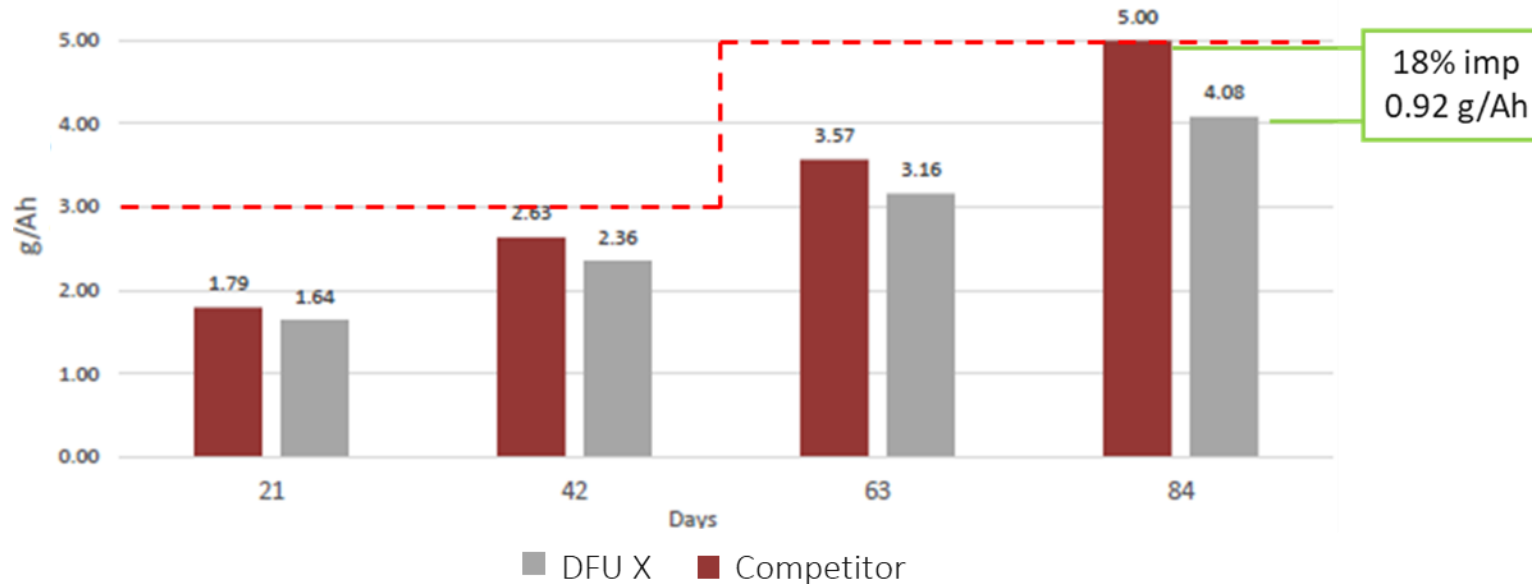
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7.7 – Overcharging at constant voltage (60°C) “Waterloss test”

See what separates



- 18% improved waterloss compared to the competitor
- Both passed the EFB 42-day requirement, while only DFU X passed the 84-day hot climate requirement



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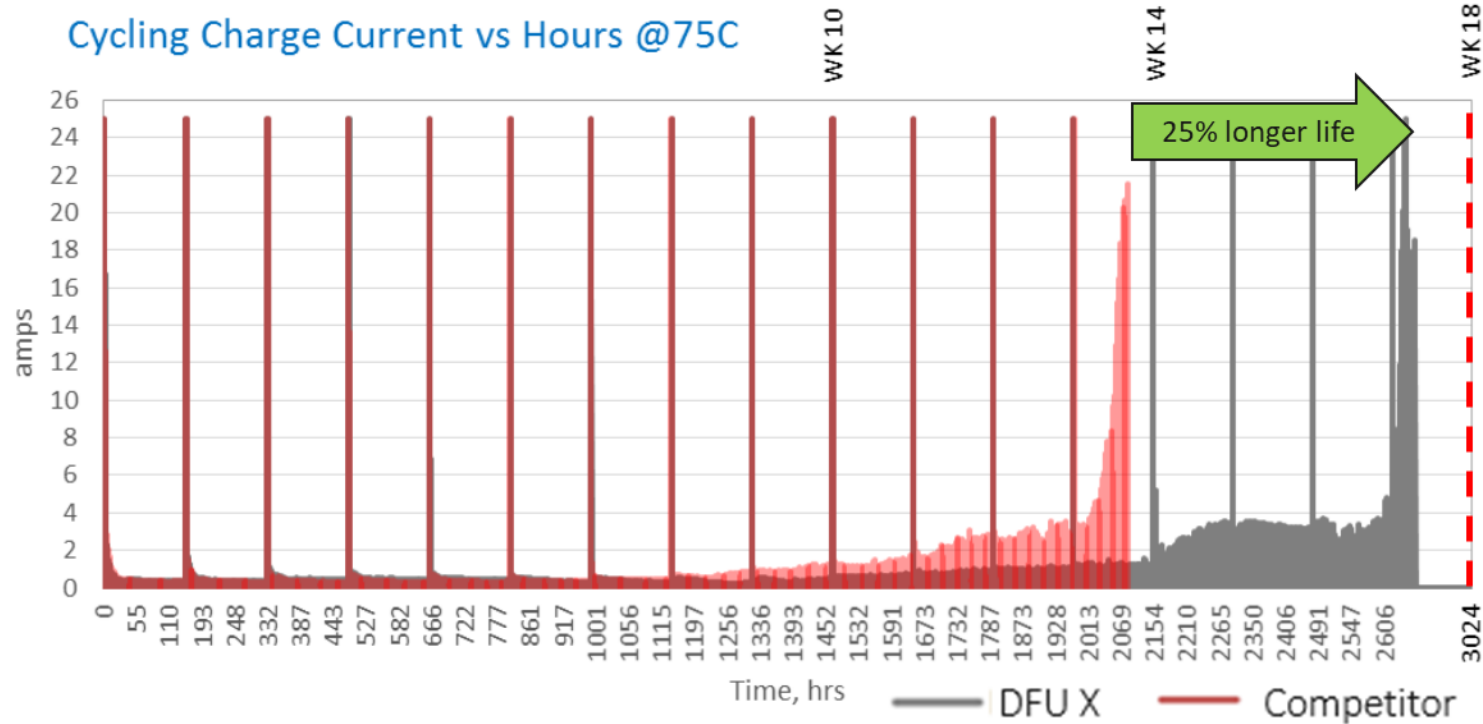
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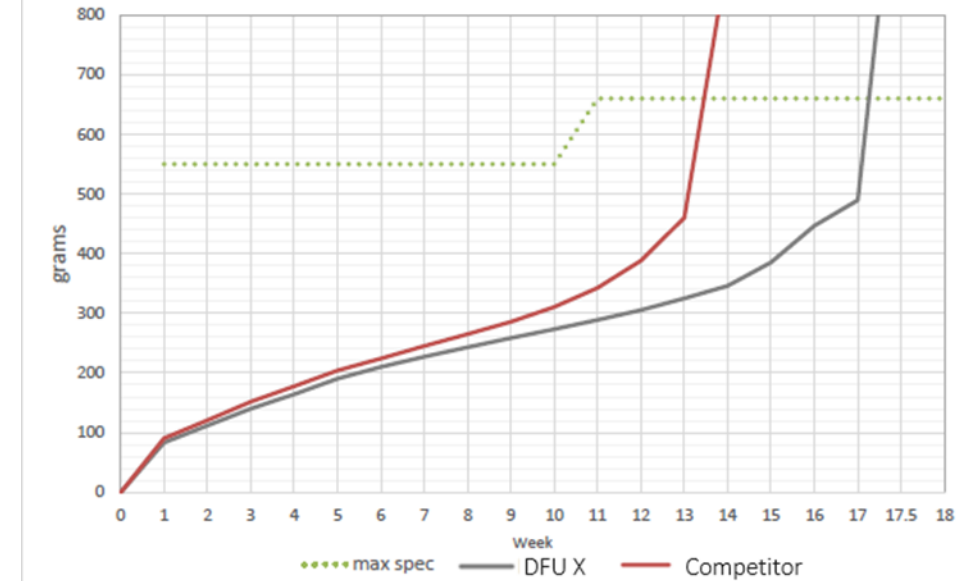
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See what separates

Cycling Charge Current vs Hours @75C



Weightloss vs Week @ 75C



- DFU X cycled 25% longer than the competitor
- DFU X almost met the 18-week requirement, but ended mere days before



7.11 – Thermal stability test (75°C) “Cell connector test”

See what separates



DFU X



Competitor

- Both separators had tears in the crease area after tear down
- The competitor also had some tears in the backweb



Conclusions

See what separates

- Microporous has AGM and EFB solutions for batteries facing the most challenging environments
- Our AGM, GlassForce®, has shown higher capacity and longer cycle life than the competition
- Our new DuroForce® Ultra™ X formula has shown promising results in all testing to-date compared to the competition and is currently being qualified at VW





MICROPOROUS™

See what separates
at booth # K07

See what separates