

Comparative Analysis of End-of-Life Performance of Charge Recovery and Pulse Power Characterization in Auxiliary Lead-Acid Batteries

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Industry Relevance

- 1 **Will a battery that passes IEC 60095-8 when new still pass at end of life?** Limits were set on new batteries; none of 9 aged at 60°C met the 8% two-hour minimum.
- 2 **Are the new limits realistic for aged lead batteries?** 8 of 11 batteries missed the two-hour voltage recovery check, 3 of them when new.
- 3 **How does lead compare with sodium-ion and lithium-ion under the same tests?** Some manufacturers now only hold sodium-ion data.

Customer Benefit

- 1 **Improved Confidence in OEM qualification.** An anonymized benchmark of 37 batteries shows how well aux batteries perform at EoL.
- 2 **Limits that fit real lead batteries.** Evidence for the IEC working group to validate EoL limits and agree on one EoL definition (contributors used five).

Project Funding

CBI 2026 · Aged-battery test data contributed by industry partners



12 V Automotive Auxiliary Battery

- Used for low-rate power supply while parking, after trip vehicle shutdown, software updates, and emergency features.
- Separate from traditional starting/cranking automotive batteries.
- AGM is most common, but AUX batteries are physically smaller than SLI (Starting, Lighting, and Ignition), meaning a much smaller capacity, **20-40 Ah compared to 80-100 Ah**.
- Up until recently, batteries were held to the same performance requirements as SLI batteries.
- New testing procedures outlined in IEC 60095-8.



What is PPC and CR?

Pulse Power Characterization (PPC)

High-rate discharge capability at partial state of charge and low temperature. Voltage for 2 seconds is measured against a specified minimum. Required at beginning and end of life.

Charge Recovery (CR)

Recovery from prolonged low-rate discharge under winter conditions. Two characteristics are measured:

- State of Charge (SOC) - capacity returned, as a percentage of nominal.
- State of Function (SOF) - pulse voltage improvement from baseline.

BOL

new baseline

MOL

partway through aging

EOL

aging complete

PROBLEM

IEC 60095-8 sets Charge Recovery limits using new batteries only, and neither PPC nor CR has industry-wide validation.

SOLUTION

Collect PPC and CR data at BoL (Beginning of Life), MoL (Middle of Life) and EoL (End of Life) from manufacturers worldwide. Benchmark aged performance against the new limits.

01 Global Survey

Collected raw performance data from international battery manufacturers.

02 Data Standardization

Cross-referenced raw test files against company metadata to ensure comparability. Anonymized for company privacy.

03 Data Analysis

Comparative benchmarking of aged battery performance under new IEC conditions.

04 Lifecycle Focus

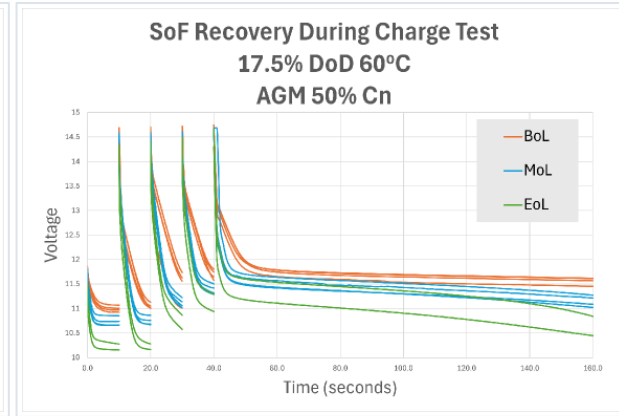
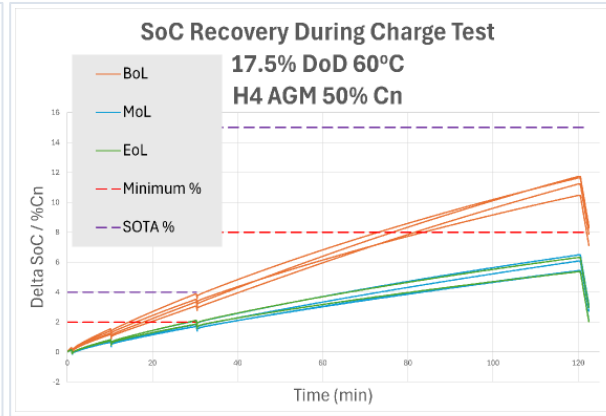
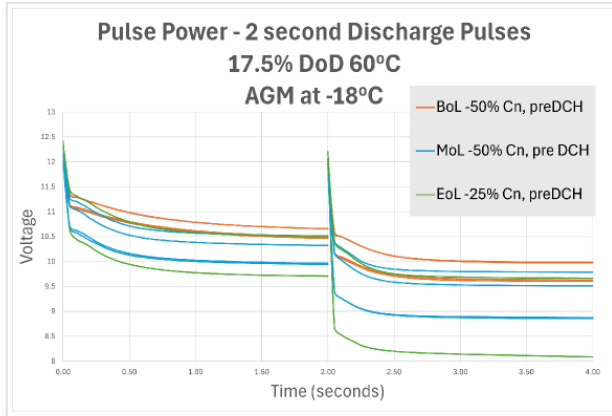
Evaluating various metrics at BOL, MOL, and EOL.

Ongoing. We are still receiving data and welcome your company's contribution. **Company information is kept private and findings are anonymized.**

Contributing Manufacturers



Company A • Summary



Aging Condition Definition

MoL

9 Weeks

EoL

18 Weeks

IEC 60095-8 · PPC REQUIREMENTS

Table 18 – PPC requirements (PP1): Beginning of Life (BOL)

PP1 / BOL		Step #	03	06
		I / I _{cc}	0.2	0.4
Category	(% of Cn discharged)	T / °C	U _{2s1}	U _{2s2}
1, 2, 3	0%	25	≥ 11,9 V	≥ 11,3 V
1	50%	-18	≥ 10,3 V	≥ 9,3 V
2, 3	20%		≥ 10,7 V	≥ 9,8 V

Table 19 – PPC requirements (PP1): End of Life (EOL)

PP1 / EOL		Step #	03	06
		I / I _{cc}	0.2	0.4
Category	(% of Cn discharged)	T / °C	U _{2s1}	U _{2s2}
1	25%	-18	≥ 10,3 V	≥ 9,0 V
2, 3	10%		≥ 10,5 V	≥ 9,4 V

Battery	Condition	% of Cn Discharged	°C	U _{2s1} I / I _{cc} = 0.2	U _{2s2} I / I _{cc} = 0.4
1	BoL	0%	25	12.07 V	11.32 V
	BoL	50%	-18	10.46 V	9.60 V
	EoL	25%	-18	9.71 V	8.08 V
2	BoL	0%	25	12.08 V	11.32 V
	BoL	50%	-18	10.49 V	9.63 V
	EoL	25%	-18	N/A	N/A
3	BoL	0%	25	12.12 V	11.58 V
	BoL	50%	-18	10.66 V	9.98 V
	EoL	25%	-18	N/A	N/A
4	BoL	0%	25	12.18 V	11.63 V
	BoL	50%	-18	10.67 V	9.97 V
	EoL	25%	-18	10.51 V	9.66 V

IEC 60095-8 · CHARGE RECOVERY REQUIREMENTS

Table 22 – Charge recovery requirements

Functional Characteristics	Minimum requirement	For information: Typical performance of state-of-the-art automotive batteries
SOC Recovery after 30 minutes	$Q(30') \geq 2\% C_n$	$Q(30') \geq 4\% C_n$
SOC Recovery after 120 minutes	$Q(120') \geq 8\% C_n$	$Q(120') \geq 15\% C_n$
SOF Recovery after 1 minute	no requirement	$U_{10s}(1') - U_{10s}(0') \geq 0.2 \text{ V}$
SOF Recovery after 10 minutes	$U_{10s}(10') - U_{10s}(0') \geq 0.3 \text{ V}$	$U_{10s}(10') - U_{10s}(0') \geq 0.5 \text{ V}$
SOF Recovery after 30 minutes	$U_{10s}(30') - U_{10s}(0') \geq 0.5 \text{ V}$	$U_{10s}(30') - U_{10s}(0') \geq 0.7 \text{ V}$
SOF Recovery after 120 minutes	$U_{10s}(120') - U_{10s}(0') \geq 0.7 \text{ V}$	$U_{10s}(120') - U_{10s}(0') \geq 0.9 \text{ V}$

Functional Characteristic	Battery 1 EoL Minimum Requirement	Battery 2 MoL Minimum Requirement	Battery 3 MoL Minimum Requirement	Battery 4 EoL Minimum Requirement
SOC Recovery after 30 minutes	1.9 %	1.7 %	2.1 %	2.1 %
SOC Recovery after 120 minutes	5.4 %	5.4 %	6.5 %	6.3 %
SOF Recovery after 1 minute	0.01 V	0.02 V	0.01 V	0.002 V
SOF Recovery after 10 minutes	0.41 V	0.32 V	0.47 V	0.59 V
SOF Recovery after 30 minutes	0.78 V	0.58 V	0.76 V	1.02 V
SOF Recovery after 120 minutes	0.28 V	0.28 V	0.55 V	0.56 V

PPC - Pulse Power

At BoL all four sit within 0.21 V of each other. At EoL the two tested are 0.80 V apart. Loss roughly doubles for EoL across each pulse.

CR - Charge Recovery

No MoL or EoL sample reached the 8% requirement at 120 minutes. Results ranged 5.4 to 6.5%, about two-thirds of what the standard asks.

MoL and EoL returned the same 5.4%, so the loss appears before middle of life.

SoF recovery cleared the 10 and 30 minute checks on all four, but each sample failed the 120 minute check by a significant margin.

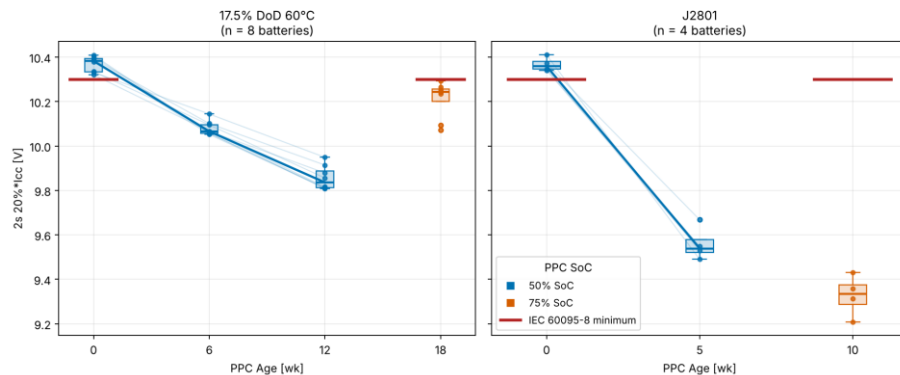
In-depth Charts on New Data

We recently received data examining 26 additional batteries from Company A. To show how all of our current data gathered can be further examined, the following charts will display a new method of analysis, plotting the BoL, MoL, and EoL results to view a different perspective of the aging results.

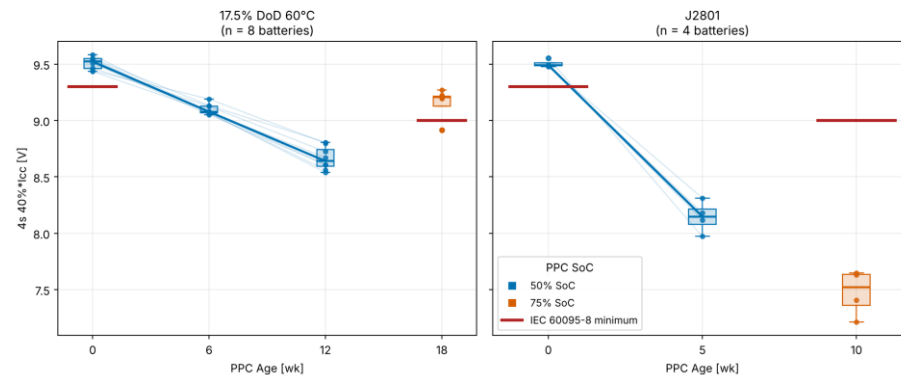
Aging Condition Definition (PPC)		MoL	EoL
	17.5% DoD 60°C	9 Weeks	18 Weeks
	J2801	5 Weeks	10 Weeks

Company A · PPC Results at -18°C

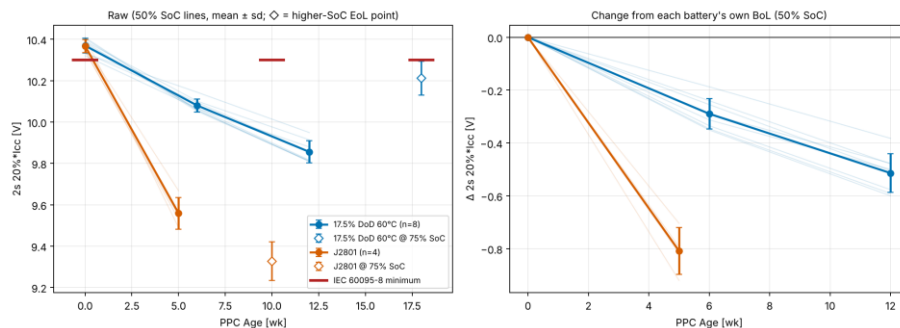
PPC results by aging procedure – 2s 20%*Icc [V] | -18 °C



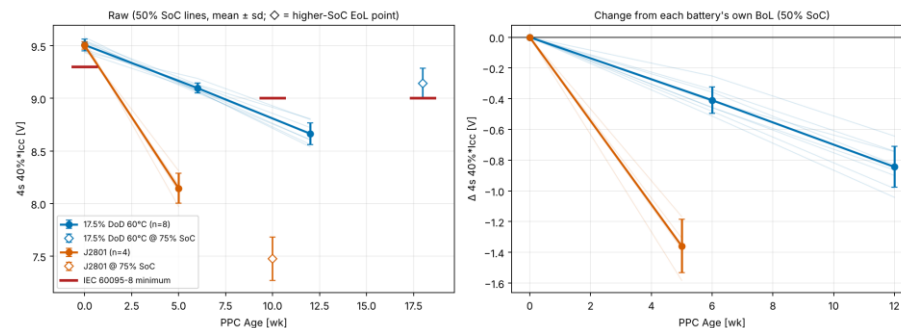
PPC results by aging procedure – 4s 40%*Icc [V] | -18 °C



PPC – aging procedures overlaid – 2s 20%*Icc [V] | -18 °C

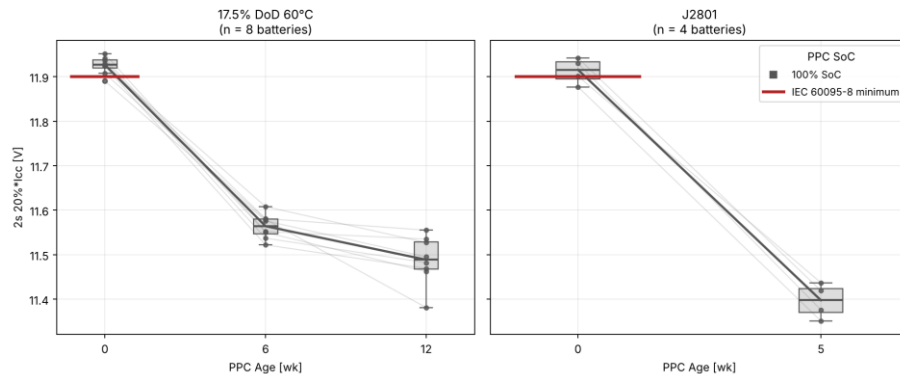


PPC – aging procedures overlaid – 4s 40%*Icc [V] | -18 °C

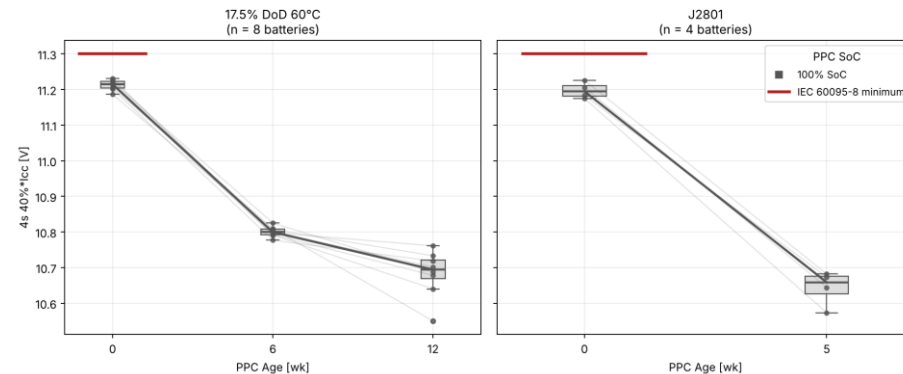


Company A · PPC Results at 25°C

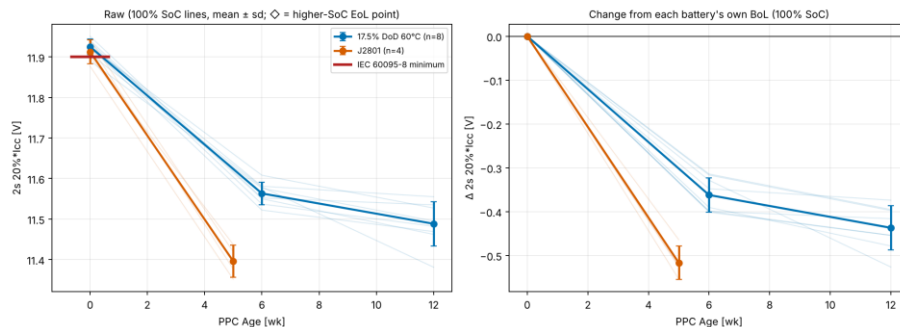
PPC results by aging procedure – 2s 20%*I_{cc} [V] | 25 °C



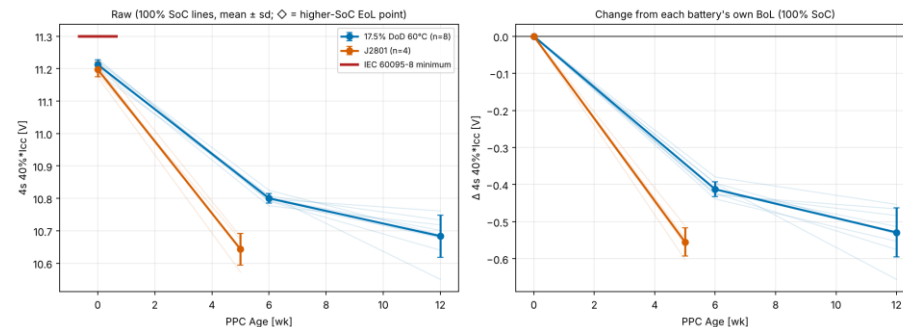
PPC results by aging procedure – 4s 40%*I_{cc} [V] | 25 °C



PPC – aging procedures overlaid – 2s 20%*I_{cc} [V] | 25 °C

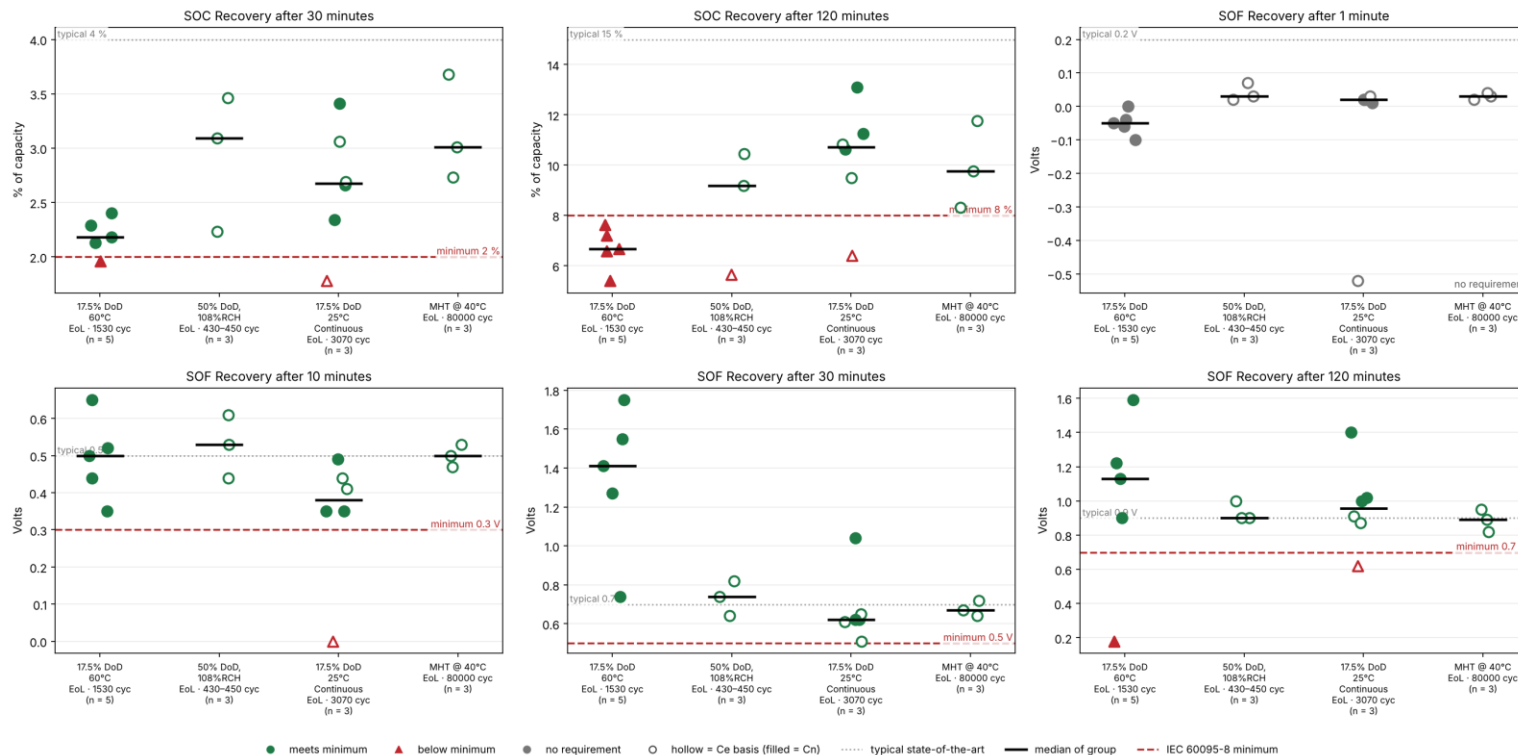


PPC – aging procedures overlaid – 4s 40%*I_{cc} [V] | 25 °C



Company A · CR Results

Charge recovery at EoL vs. IEC 60095-8 Table 22, by aging procedure



PPC - Pulse Power

J2801 seems to age the batteries much quicker than the 17.5% DoD aging.

At 25°C the voltage decline flattens, at -18°C it continues relatively steadily

The 17.5% DoD batteries tend to diverge more with aging

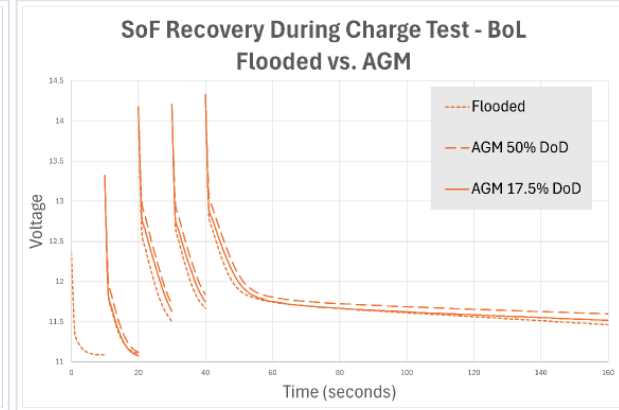
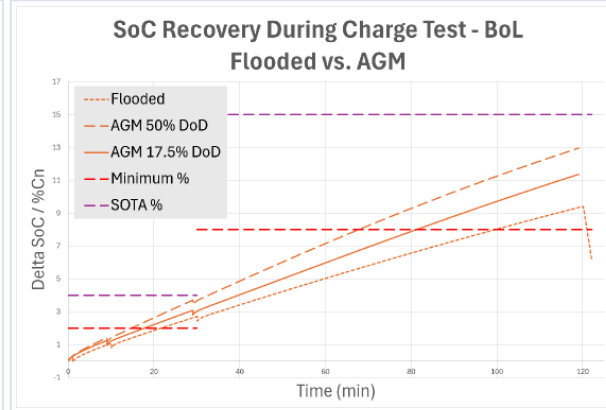
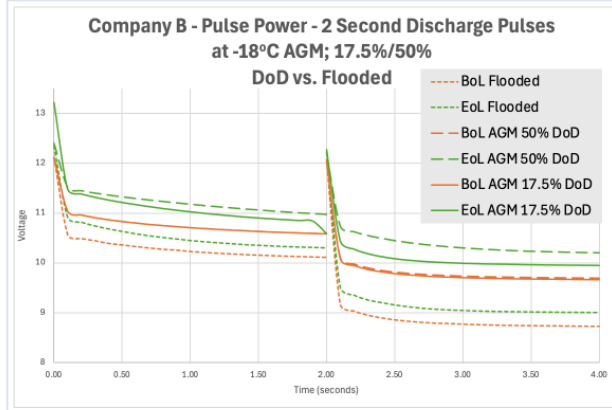
CR - Charge Recovery

MHT passes every requirement

SOF at 30 and 120 minutes goes up from BoL to MoL, even as the SOC recovery decays

None of the 60°C procedure batteries meet the SOC Q(120') minimum of 8%

Company B • Summary



Aging Condition Definition

EoL (Flooded)

3 Units of Endurance Cycle

EoL (AGM)

360 Cycle at 50% DoD
18 Weeks at 17.5% DoD

IEC 60095-8 · PPC REQUIREMENTS

Table 18 – PPC requirements (PP1): Beginning of Life (BOL)

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2, 3	20%		≥ 10,7 V	≥ 9,8 V

Table 19 – PPC requirements (PP1): End of Life (EOL)

PP1 / EOL		Step #	03	06
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Category	(% of Cn discharged)	T / °C	U _{2s1}	U _{2s2}
1	25%	-18	≥ 10,3 V	≥ 9,0 V
2, 3	10%		≥ 10,5 V	≥ 9,4 V

Battery	Condition	% of Cn Discharged	°C	U _{2s1} I / I _{cc} = 0.2	U _{2s2} I / I _{cc} = 0.4
B1 Flooded	BoL	0%	25	11.25 V	10.05 V
	BoL	50%	-18	10.11 V	8.73 V
	EoL	25%	-18	10.31 V	9.01 V
B2 AGM 50% DoD	BoL	0%	25	12.08 V	11.35 V
	BoL	50%	-18	10.58 V	9.69 V
	EoL	25%	-18	10.98 V	10.21 V
B3 AGM 17.5% DoD	BoL	0%	25	12.22 V	11.38 V
	BoL	50%	-18	10.58 V	9.66 V
	EoL	25%	-18	10.58 V	9.95 V

IEC 60095-8 · CHARGE RECOVERY REQUIREMENTS

Table 22 – Charge recovery requirements

Functional Characteristics	Minimum requirement	For information: Typical performance of state-of-the-art automotive batteries
SOC Recovery after 30 minutes	$Q(30') \geq 2\% C_n$	$Q(30') \geq 4\% C_n$
SOC Recovery after 120 minutes	$Q(120') \geq 8\% C_n$	$Q(120') \geq 15\% C_n$
SOF Recovery after 1 minute	no requirement	$U_{10s}(1') - U_{10s}(0') \geq 0.2 \text{ V}$
SOF Recovery after 10 minutes	$U_{10s}(10') - U_{10s}(0') \geq 0.3 \text{ V}$	$U_{10s}(10') - U_{10s}(0') \geq 0.5 \text{ V}$
SOF Recovery after 30 minutes	$U_{10s}(30') - U_{10s}(0') \geq 0.5 \text{ V}$	$U_{10s}(30') - U_{10s}(0') \geq 0.7 \text{ V}$
SOF Recovery after 120 minutes	$U_{10s}(120') - U_{10s}(0') \geq 0.7 \text{ V}$	$U_{10s}(120') - U_{10s}(0') \geq 0.9 \text{ V}$

Functional Characteristic	Battery 1 Flooded Minimum Requirement	Battery 2 AGM 50% DoD Minimum Requirement	Battery 3 17.5% DoD Minimum Requirement
SOC Recovery after 30 minutes	2.7 %	3.7 %	3.0 %
SOC Recovery after 120 minutes	9.4 %	N/A	N/A
SOF Recovery after 1 minute	0.02 V	N/A	N/A
SOF Recovery after 10 minutes	0.42 V	0.60 V	0.55 V
SOF Recovery after 30 minutes	0.58 V	0.72 V	0.67 V
SOF Recovery after 120 minutes	0.38 V	0.48 V	0.44 V

PPC - Pulse Power

The flooded sample failed at BoL and only just passed at EoL. Both AGM samples passed at both stages. Chemistry separated the results more than aging did.

All three recorded equal or higher pulse voltages at EoL than at BoL, since EoL is measured at 25% pre-discharge against 50% at BoL.

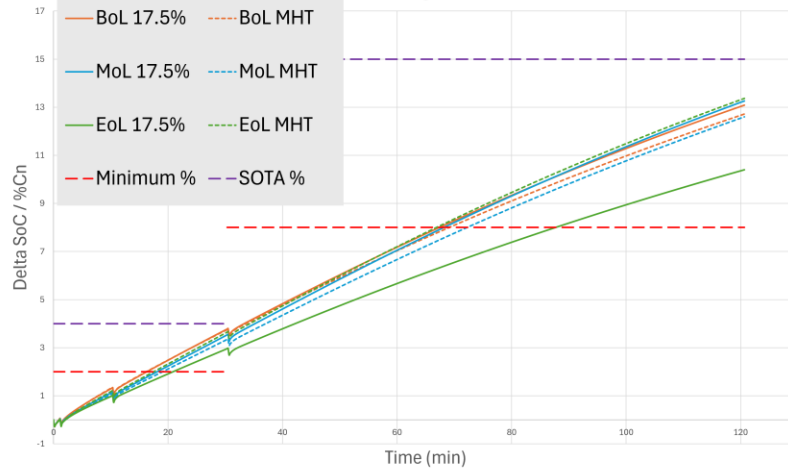
CR - Charge Recovery

BoL data only, no aging comparison available.

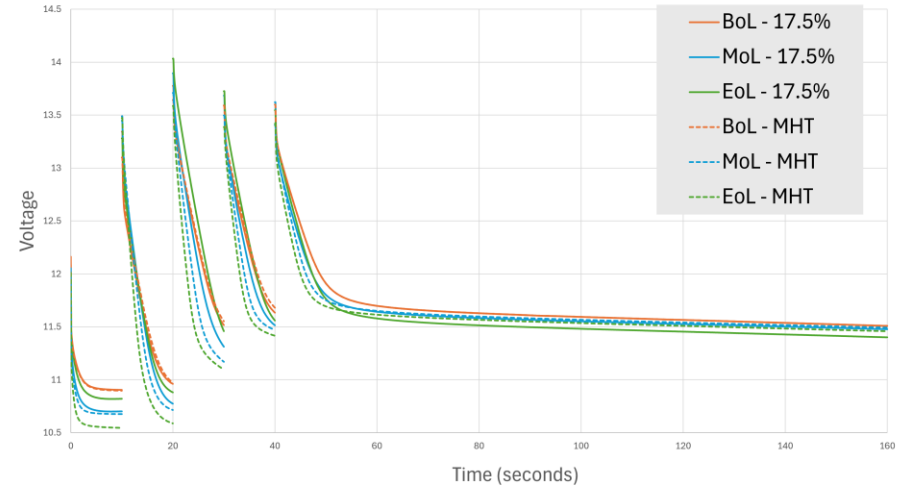
SoF cleared 10 and 30 minutes, then failed at 120 on all three.

Company C • Summary

Company C - SoC Recovery During Charge Test
17.5% DoD 25°C vs. Micro Hybrid Test
H4 AGM



Company C - SoF Recovery During Charge Test
17.5% DoD vs. Micro Hybrid Test



Aging Condition Definition

EoL (17.5% DoD)

18 Units

EoL (MHT)

12000 Cycles

IEC 60095-8 · CHARGE RECOVERY REQUIREMENTS

Table 22 – Charge recovery requirements

Functional Characteristics	Minimum requirement	<i>For information: Typical performance of state-of-the-art automotive batteries</i>
SOC Recovery after 30 minutes	$Q(30') \geq 2\% C_n$	$Q(30') \geq 4\% C_n$
SOC Recovery after 120 minutes	$Q(120') \geq 8\% C_n$	$Q(120') \geq 15\% C_n$
SOF Recovery after 1 minute	no requirement	$U_{10s}(1') - U_{10s}(0') \geq 0.2 \text{ V}$
SOF Recovery after 10 minutes	$U_{10s}(10') - U_{10s}(0') \geq 0.3 \text{ V}$	$U_{10s}(10') - U_{10s}(0') \geq 0.5 \text{ V}$
SOF Recovery after 30 minutes	$U_{10s}(30') - U_{10s}(0') \geq 0.5 \text{ V}$	$U_{10s}(30') - U_{10s}(0') \geq 0.7 \text{ V}$
SOF Recovery after 120 minutes	$U_{10s}(120') - U_{10s}(0') \geq 0.7 \text{ V}$	$U_{10s}(120') - U_{10s}(0') \geq 0.9 \text{ V}$

Functional Characteristic	Battery 1 17.5% DoD Minimum Requirement	Battery 2 MHT Minimum Requirement
SOC Recovery after 30 minutes	2.9 %	3.6 %
SOC Recovery after 120 minutes	10.4 %	13.3 %
SOF Recovery after 1 minute	0.06 V	0.04 V
SOF Recovery after 10 minutes	0.64 V	0.55 V
SOF Recovery after 30 minutes	0.74 V	0.87 V
SOF Recovery after 120 minutes	0.58 V	0.91 V

PPC - Pulse Power

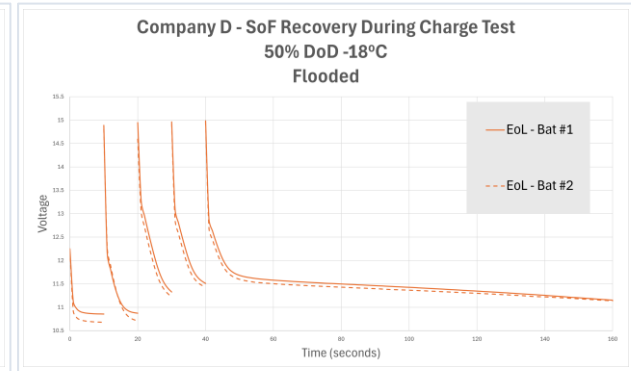
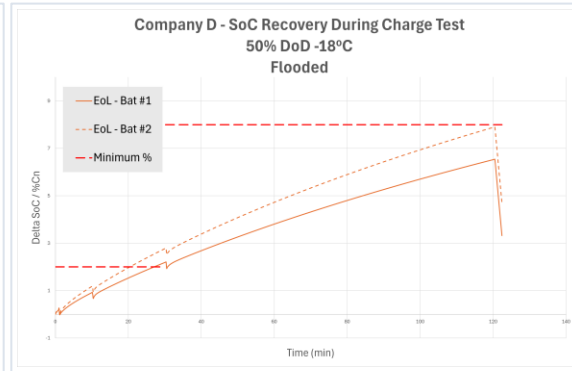
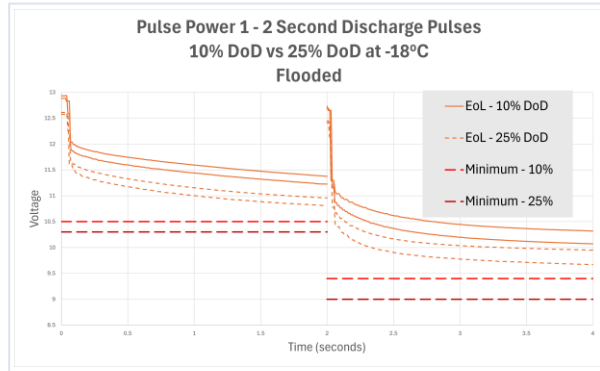
No data provided

CR - Charge Recovery

Both procedures passed every minimum requirement, with the exception of the final SOF measurement for 17.5% DoD

Additionally, the 17.5% DoD at EoL noticeably trailed the MHT, especially in the SOC recovery

Company D • Summary



Aging Condition Definition

EoL

66 Cycles
50% DoD, 40°C

IEC 60095-8 · PPC REQUIREMENTS

Table 18 – PPC requirements (PP1): Beginning of Life (BOL)

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		I / I _{cc}	0.2	0.4
Category	(% of Cn discharged)	T / °C	U _{2s1}	U _{2s2}
1, 2, 3	0%	25	≥ 11,9 V	≥ 11,3 V
1	50%	-18	≥ 10,3 V	≥ 9,3 V
2, 3	20%		≥ 10,7 V	≥ 9,8 V

Table 19 – PPC requirements (PP1): End of Life (EOL)

PP1 / EOL		Step #	03	06
		I / I _{cc}	0.2	0.4
Category	(% of Cn discharged)	T / °C	U _{2s1}	U _{2s2}
1	25%	-18	≥ 10,3 V	≥ 9,0 V
2, 3	10%		≥ 10,5 V	≥ 9,4 V

Battery All Flooded Batteries	Condition	% of Cn Discharged	°C	U _{2s1} I / I _{cc} = 0.2	U _{2s2} I / I _{cc} = 0.4
B1	EoL	10%	-18	11.37 V	10.32 V
	EoL	25%	-18	10.81 V	9.67 V
B2	EoL	25%	-18	10.95 V	9.95 V
	EoL	10%	-18	11.22 V	10.07 V

IEC 60095-8 · CHARGE RECOVERY REQUIREMENTS

Table 22 – Charge recovery requirements

Functional Characteristics	Minimum requirement	<i>For information: Typical performance of state-of-the-art automotive batteries</i>
SOC Recovery after 30 minutes	$Q(30') \geq 2\% C_n$	$Q(30') \geq 4\% C_n$
SOC Recovery after 120 minutes	$Q(120') \geq 8\% C_n$	$Q(120') \geq 15\% C_n$
SOF Recovery after 1 minute	no requirement	$U_{10s}(1') - U_{10s}(0') \geq 0.2 \text{ V}$
SOF Recovery after 10 minutes	$U_{10s}(10') - U_{10s}(0') \geq 0.3 \text{ V}$	$U_{10s}(10') - U_{10s}(0') \geq 0.5 \text{ V}$
SOF Recovery after 30 minutes	$U_{10s}(30') - U_{10s}(0') \geq 0.5 \text{ V}$	$U_{10s}(30') - U_{10s}(0') \geq 0.7 \text{ V}$
SOF Recovery after 120 minutes	$U_{10s}(120') - U_{10s}(0') \geq 0.7 \text{ V}$	$U_{10s}(120') - U_{10s}(0') \geq 0.9 \text{ V}$

Functional Characteristic	Battery 1 50% DoD Minimum Requirement	Battery 2 50% DoD Minimum Requirement
SOC Recovery after 30 minutes	2.2 %	2.8 %
SOC Recovery after 120 minutes	6.5 %	7.9 %
SOF Recovery after 1 minute	0.02 V	0.03 V
SOF Recovery after 10 minutes	0.47 V	0.54 V
SOF Recovery after 30 minutes	0.66 V	0.75 V
SOF Recovery after 120 minutes	0.83 V	0.92 V

PPC - Pulse Power

Both Flooded batteries passed every EoL requirement, at both 10% and 25% pre-discharge

As expected, the 10% pre-discharge results were higher than the 25% results

No BoL data was provided, so the change with aging cannot be measured

CR - Charge Recovery

In comparison to the EoL AGM results from Company C, the Flooded batteries provide a noticeably lower SOC Recovery, causing both batteries to fail the Q(120') requirement

SOF Recovery trails slightly at 10 and 30 minutes, but all of the batteries still pass the requirements outlined by IEC, including at 120 minutes

Current Data Summary

Battery Type	Aging Procedure	Battery	PPC BoL	PPC EoL	CR Stage	CR SoC	CR SoF
Flooded	Endurance Cycle Test IEC 60095-8 9.7.3; 3 units	Company B, B1	FAIL	PASS	BoL	PASS	FAIL
	50% DoD, 40°C 66 cycles	Company D, B1	N/A	PASS	EoL	FAIL	PASS
		Company D, B2	N/A	PASS	EoL	FAIL	PASS
AGM	17.5% DoD, 60°C 15 to 18 weeks	Company A, B1	PASS	FAIL	EoL	FAIL	FAIL
		Company A, B2	PASS	N/A	MoL	FAIL	FAIL
		Company A, B3	PASS	N/A	MoL	FAIL	FAIL
		Company A, B4	PASS	PASS	EoL	FAIL	FAIL
	50% DoD; 360 cycles	Company B, B2	PASS	PASS	BoL	PASS*	FAIL
	17.5% DoD; 18 weeks	Company B, B3	PASS	PASS	BoL	PASS*	FAIL
	17.5% DoD, 25°C; 18 units EN 50342-6 7.4	Company C, B1	N/A	N/A	EoL	PASS	FAIL
	Micro Hybrid Test; 12000 cycles EN 50342-6 7.2	Company C, B2	N/A	N/A	EoL	PASS	PASS

* = Data incomplete (120 minute result not provided) CR Stage = life stage of the CR results shown

PPC / CR Aged Battery Data Collection

Battery Type	Aging Type	PPC MoL Data Collected + Upcoming	PPC EoL Data Collected + Upcoming	CR MoL Data Collected + Upcoming	CR EoL Data Collected + Upcoming
AGM	> 10% DoD Cycle	0+1	3+3	1+1	3+3
	Shallow Cycle	0+1	1+2	1+1	5+2
	High Temperature	12+1	11+1	9+2	7+2
	Other	4+0	6+0	0+0	6+0
EFB	> 10% DoD Cycle	0+1	4+1	0+1	0+1
	Shallow Cycle	0+1	0+1	0+1	0+1
	High Temperature	0+1	0+1	0+1	0+1
	Other	0+1	0+1	0+1	0+1
Flooded	> 10% DoD Cycle	0+0	6+0	0+0	4+0
	Shallow Cycle	0+1	1+1	0+2	0+1
	High Temperature	0+1	0+1	0+1	0+1
	Other	0+0	0+0	0+0	0+0

Not shown by type: one more contributor has promised PPC EoL and CR EoL data for 9 batteries (battery type not yet specified).

1 The dataset is too small to draw definite conclusions

Four of 30 companies contacted provided usable data. 37 batteries total, 30 from one company. To make stronger claims, we need a higher volume in samples and more complete datasets.

2 Continue the methodology as data arrives

The analysis pipeline is built and repeatable. Additional datasets can be processed and benchmarked without rework.

3 Standardize EoL and MoL definitions

Contributors defined end of life five different ways across three norms, and two cited no norm at all. Middle of life has no definition in the standard. Without a common endpoint, cross-company comparison is limited.

4 Evaluate EoL Requirements

Reduced pre-discharge at EoL allows aged batteries to record higher pulse voltages than they did when new. Worth confirming the requirement is testing what it intends to.

All plots are script-generated with consistent style, scales, and legends for both PPC and CR.

PRIMARY COMPARISONS

Battery type

All companies combined, to identify degradation patterns by battery type.

Company

Checks the consistency of results within and across data sources.

SECONDARY COMPARISONS

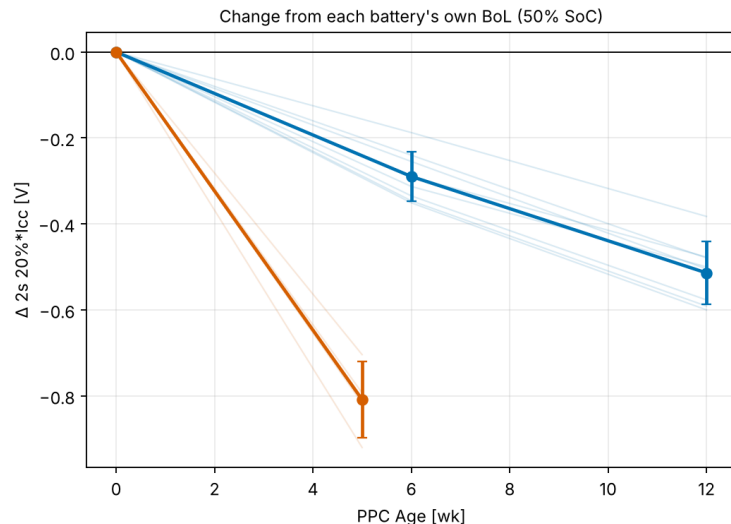
Temperature

Requested at ALBA26. Applied once the primary comparisons identify patterns of interest.

Aging procedure

Groups results by aging procedure, as shown for Company A (J2801 and 17.5% DoD).

Plot convention: color indicates life stage (BoL, MoL, EoL); line style indicates DoD.



Company A PPC at -18°C, change from each battery's BoL

● 17.5% DoD 60°C (n=8) ● J2801 (n=4)

Planned Analyses

1 Degradation rate

Fit trends across the full aging test rather than comparing BoL, MoL, and EoL as discrete points.

2 Factor and offset from BoL

Quantify how far MoL and EoL fall below BoL: a factor for SOC recovery, an offset for SOF recovery.

3 Capacity and cold cranking

Correlate SOC and SOF recovery with degradation in capacity (Ce) and cold-cranking performance (Icc).

4 PPC and CR agreement

Determine whether both tests indicate the same aging behavior for the same unit.

5 Unit-to-unit variance

Quantify repeatability where multiple units of the same battery type are available.

Lead-Acid

Collection ongoing (Flooded, EFB, AGM)

Sodium-Ion

Not requested, but availability validated

Lithium-Ion

Not requested

1 Common framework

Apply the lead-acid plot conventions, primary comparisons, and summary metrics to all three chemistries for direct visual and statistical comparison.

2 Cross-chemistry metrics

Compare degradation trends on a common scale, using time to recovery threshold by life stage.

3 Sample size

Fewer units per group are expected initially. Unit-to-unit variance will establish confidence in single-sample results; secondary comparisons follow as samples allow.

4 Test applicability

Are PPC and CR, as defined for lead-acid, directly applicable to these chemistries, or are analogous metrics required? To be evaluated with the ALBA group.



Industry data survey

Scan to access the survey

Contributing Data

Additional datasets strengthen every comparison in this study.

1 Raw test data

PPC and CR results at BoL, MoL, and EoL, in CSV or a similar format.

2 Metadata

Battery type, aging procedure, and key performance values at BoL and EoL.

3 Confidentiality

Company information is kept private and all findings are anonymized.

We welcome contributions of lead-acid, Sodium-Ion, and Lithium-Ion auxiliary battery data.

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Dr. Eckhard Karden



Dr. Begüm Bozkaya



Dr. Matt Raiford

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