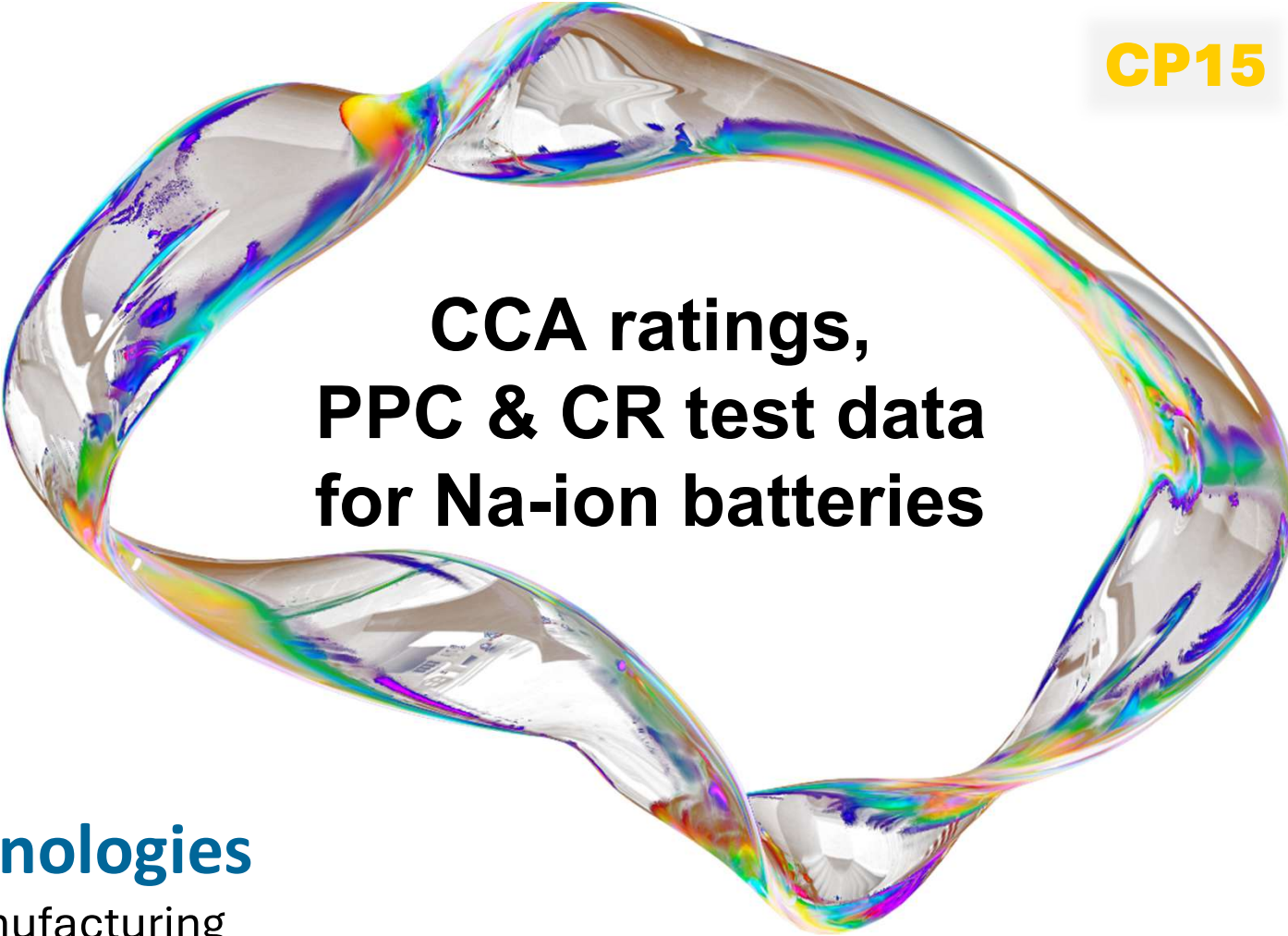


A large, abstract, colorful ring shape composed of many small, overlapping, translucent segments in various colors (red, orange, yellow, green, blue, purple) arranged in a circular pattern, resembling a molecular structure or a stylized ring.

CCA ratings, PPC & CR test data for Na-ion batteries

Na-ion Battery Technologies

Innovating – Designing – Manufacturing
Yukiyasu Nagata

Workshop on Automotive Low-Voltage Battery Advancements (ALBA 26), 19-20 May 2026, Mainz, Germany

ALBA 26

CCA ratings, PPC & CR test data for Na-ion batteries

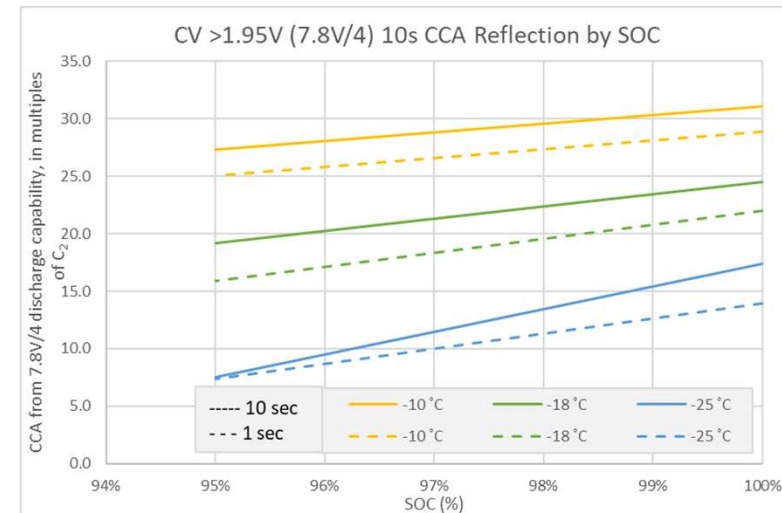
1. How should we determine the CCA rating for SIB (NFPP) ?

Which duration?

- **10s are enough**, even for LAB auxiliary and backup (IEC 60095-8)
- Minimum voltage occurs around first second, followed by self-heating rise
→ requirement should be for **“any time”** rather than end of 10s only

Which temperature ?

- LAB are often tested at -18 °C only but OEMs require cranking and FuSa performance down to -25 °C ... -40 °C (depending on application)
- temperature dependence for CCA of all LABs is “similar” but SIB and LIB are new and show broad variation
- Use **constant-voltage discharge at 7.8V** to determine $CCA = f(T)$



Which SOC ?

- Legacy (LAB) tests are at 100% SOC, but **92%...95% SOC** seems better for SIB (NFPP)
- Steep increase of OCV for SOC 95%→100% causes strong sensitivity
- avoid overstated label values that would not reflect design use at SOC < 95%



CCA ratings, PPC & CR test data for Na-ion batteries

2. How can we adopt PPC and CR test methods for SIB (NFPP) ?

PPC = pulse power characterization

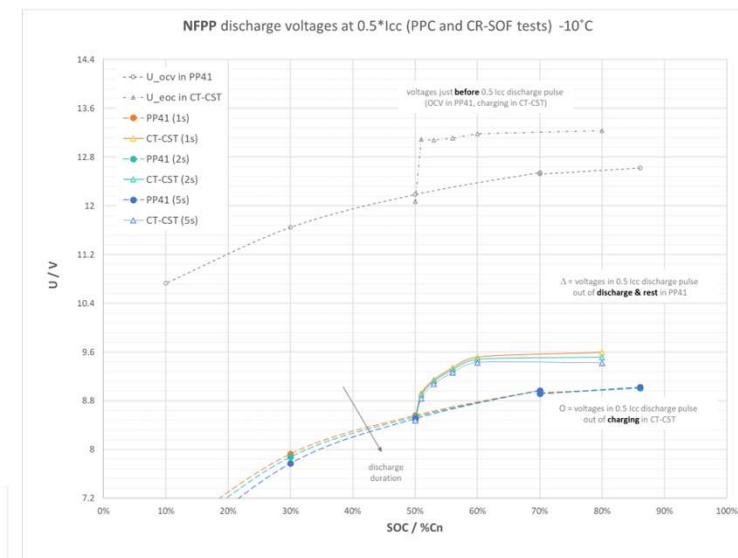
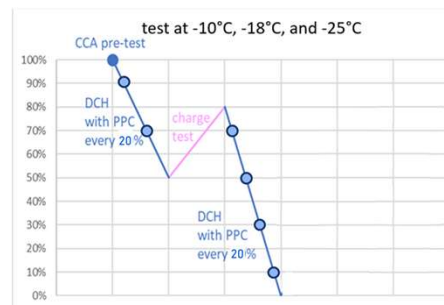
- characterize discharge pulse performance at variable SOC and temperature
- SIB vs. LFP: flatness $U(t)$ curves for the pulse duration has less impact
- SIB exhibits excellent performance even at very low temperatures

CR = charge recovery

- charging current / voltage is usually limited for cell protection
- SOF tests (discharge pulses during recharge) should be scheduled for fixed Δ SOC intervals, not fixed times
- hysteresis depends on technology

mixed (time-optimized) test plan from IEC SG2

- new results will be shown in breakout session



CV CCA Test Method

How should we determine the CCA rating for SIB (NFPP) ?

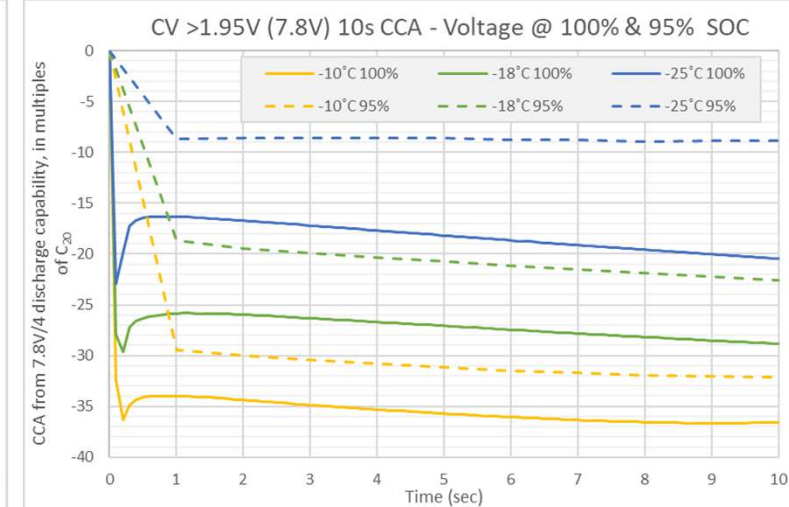
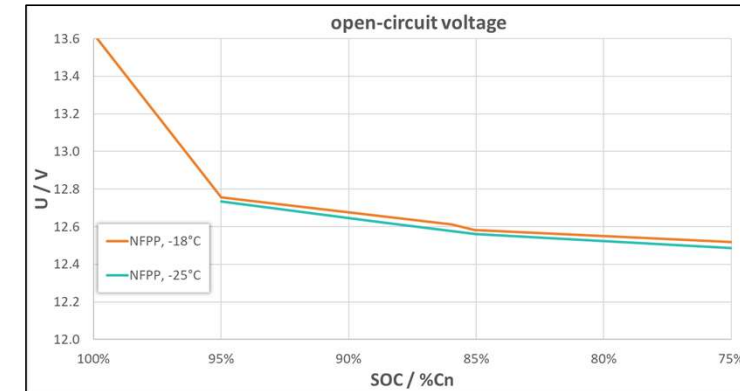
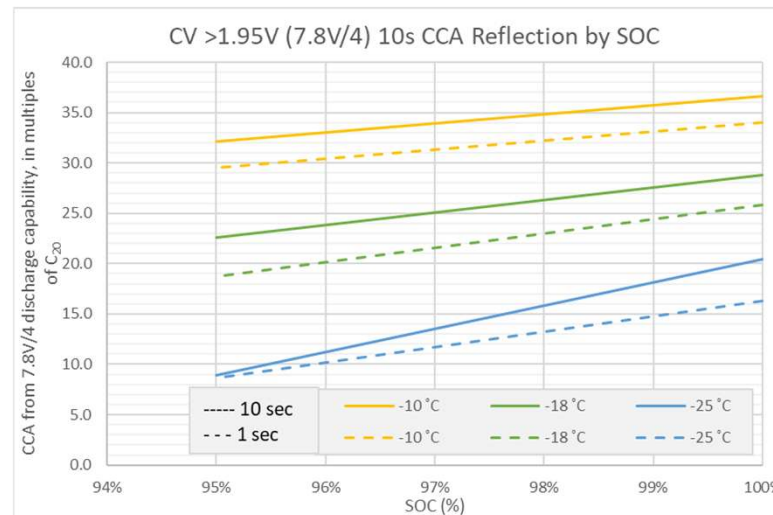
Legacy method: Fully charge the battery, then apply CCA for 10s (or longer)

Problem:

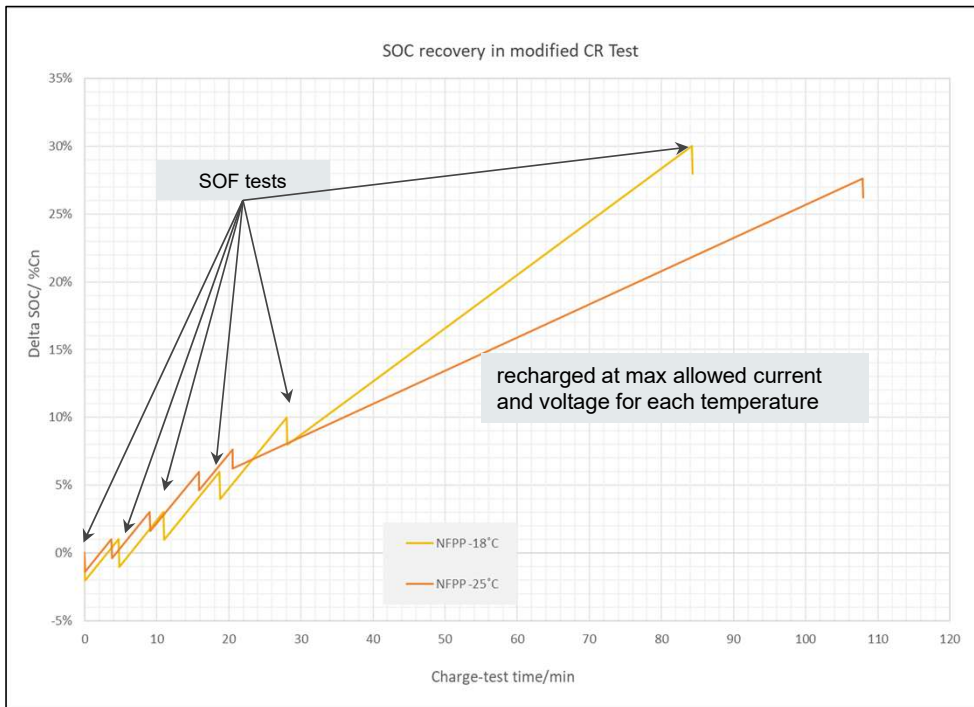
- NFPP results change strongly above 95% SOC, caused by OCV rise
- CCA test at 100% SOC tends to overstate partial SOC behavior (PSOC)
- PPC performance would be weak, or CCA needed to be downrated

Proposal: Define CCA test around 90%...95% SOC

Min C_{20} rate	100% SOC	95% SOC
-10°C	33.98	29.48
-18°C	25.84	18.70
-25°C	16.31	8.66



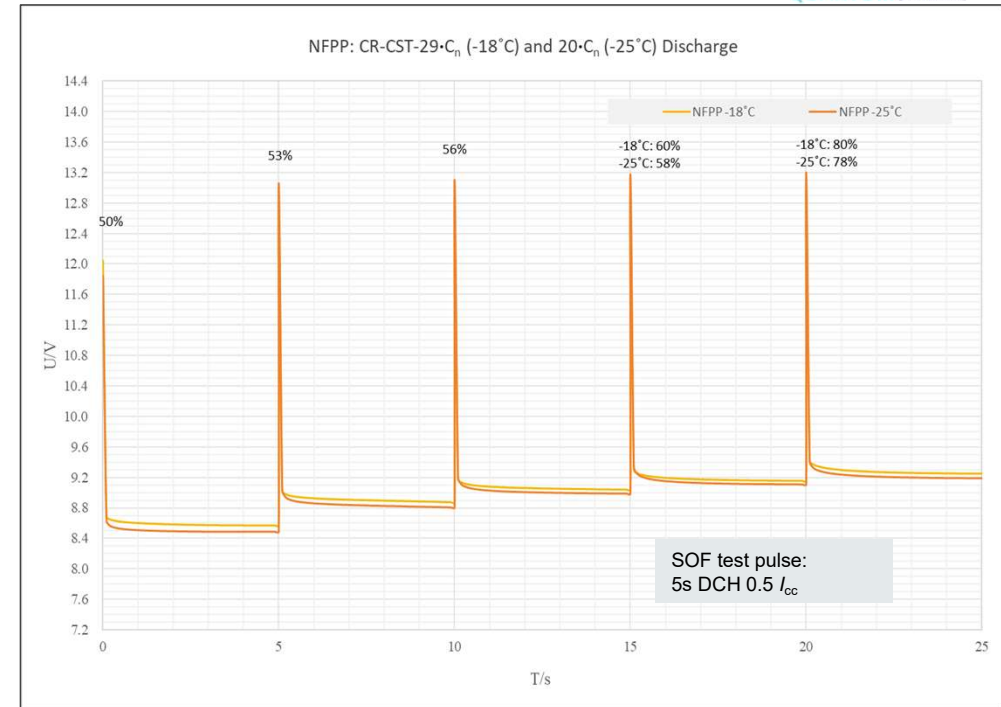
Charge recovery test results: SIB



SOC Recovery

- Safety limit: I_{cha} & V_{cha} = various rating was applied.

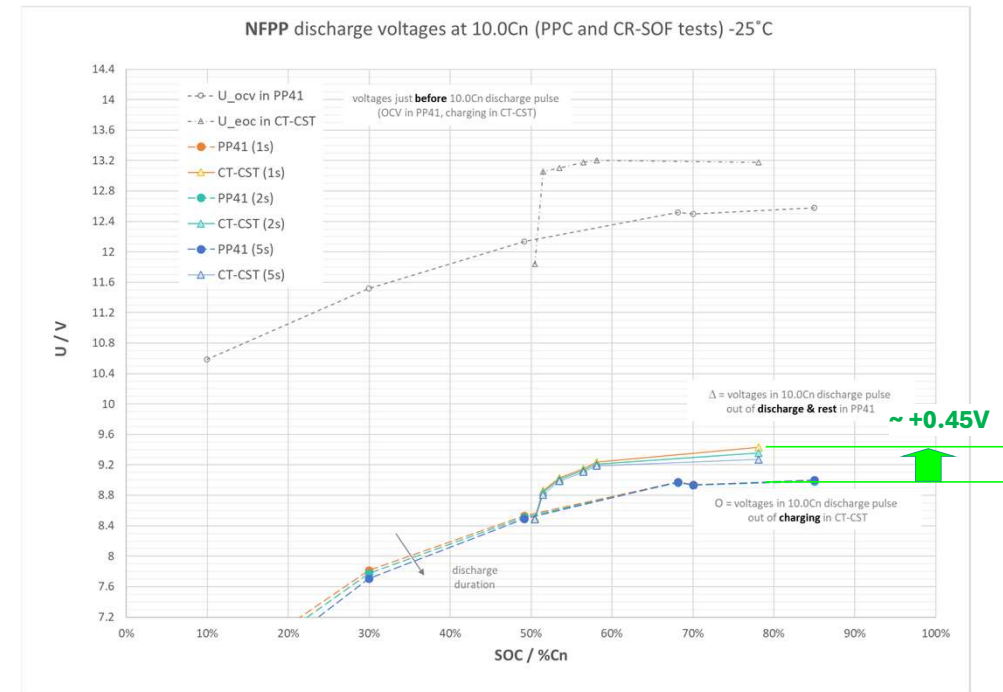
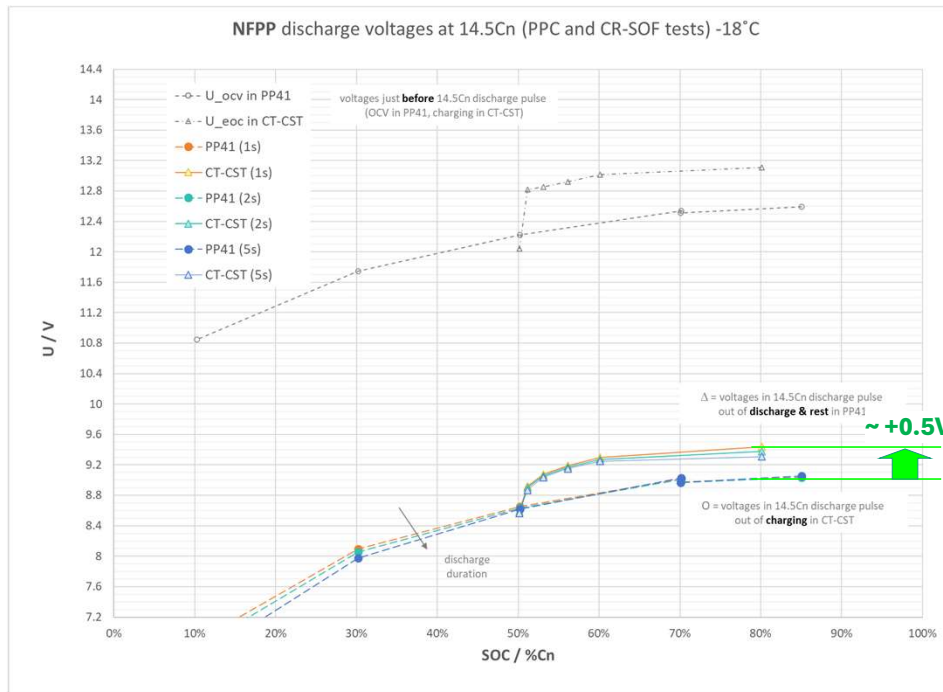
	-18°C	-25°C
3% Recovery	10.9 min	9.0 min
30% Recovery	84.2 min	107.9 min



SOF Recovery

- NFPP: almost flat $U_{dch}(t) \rightarrow$ insensitive against pulse duration: similar as LAB

Charge recovery test results: SIB



comparison SIB vs. AGM

- SOF gain after “fresh charge” slightly less than AGM but qualitatively similar (linear decay during PSOC discharge)
- CR: voltage from PPC test from SOF quickly up +0.5V (hysteresis similar to LAB)

comparison SIB at various temperature

- Similar dc resistance (slope of discharge voltage over I_{DCH})
- Level of recovery differ due to the different charge limitation used
- SOC dependency getting steep below 40%

□ Conclusion / Next steps



- Observations about NFPP
 - NFPP has exponential curve above 95% SOC. This condition will create some difference in I_{cc} capability. This needs to discuss in IEC meeting for standard procedure for CCA rating test.
 - In winter condition, the safety limits for charging voltage and current limit recovery of SOC and SOF.
 - 12V charging systems can hardly regulate battery current because output depends on temperature, speed, and the parallel connection with all 12V loads, but voltage: Will the BMS output the desired safe voltage setpoint along with certain charge current level?
 - NFPP show some SOF boost in freshly charged batteries, too, qualitatively like LAB.
- IEC CR methodology can be applied / extended for technology comparison:
 - At very low temperature (-18°C and less), LAB charging rate is inherently slow, whereas NFPP needs to be limited for safety and cycling reasons.
 - SOF tests provide a good indication how fast function is restored, but they should be scheduled after steps of $\%C_n$ recovery (rather than fixed time intervals).
 - This CR methodology needs to be reviewed with OEM for the benefit in their view.

Modified PPC & CR test plan at QST

- Cold-cranking tests (CV I_{cc} to 1.95V)
- PPC adoption: 1-step and 2-step profiles during all continuous discharging and charging steps
- CR adoption: charge steps limited by %C_n (not time)
- DCA adoption, I_d and I_c of DCA(EN): DCA_{pp} at 80% SOC out of discharging and charging
- Samples: pouch cells

PP41

no.	T / °C	Step	t	U / V	I / A I _{cc}	Description	Result of measurement	-10°C	-18°C	-25°C
51	T _{test}	PAU	90 min			Record 1sec	U(end of step)	x	x	x
52	T _{test}	DCH	2 sec	> 1.5	0.1	Record 100ms	U(1s), U(2s)	x	x	x
53	T _{test}	PAU	10 min			Record 1sec	U(end of step)	x	x	x
54	T _{test}	DCH	2 sec	> 1.5	0.3	Record 100ms	U(1s), U(2s)	x	x	x
55	T _{test}	PAU	20 min			Record 1sec	U(end of step)	x	x	x
56	T _{test}	DCH	5 sec	> 1.5	0.5	Record 100ms	U(1s), U(2s), U(5s)	x	x	x
57	T _{test}	PAU	45 min			Record 1sec	U(end of step)	x	x	x
58	T _{test}	DCH	2 sec	> 1.5	0.7	Record 100ms	U(1s), U(2s)	x	x	x
59	T _{test}	PAU	60 min			Record 1sec	U(end of step)	x	x	x
60	T _{test}	DCH	30 sec	>2.25	0.5	Record 100ms	U(end of step)	x	x	x
61	T _{test}	DCH	2 sec	> 1.5	0.5	Record 100ms	U(1s), U(2s)	x	x	x
62	T _{test}	PAU	90 min			Record 1sec	U(end of step)	x	x	x

CT-CST

no.	T / °C	Step	t (sec)	t (sec)	t (sec)	Description	Result of measurement
72	T _{test}	DCH	5	5	5	pulse test: use temperature-adjusted I _{cc} and voltage limit as spec. Record 100ms	U _{5s} and U _{10s}
73	T _{test}	PAU	10	10	10	relaxation, Record 1sec	
74	T _{test}	CHA	#VALUE!	#VALUE!	#VALUE!	recharge to specified Ah at max allowed rate and voltage per temperature to reach 51% SOC, Record 100ms	
75	T _{test}	DCH	5	5	5	pulse test: use temperature-adjusted I _{cc} and voltage limit as spec. Record 100ms	U _{5s} and U _{10s}
76	T _{test}	PAU	10	10	10	relaxation, Record 1sec	
77	T _{test}	CHA	#VALUE!	#VALUE!	#VALUE!	recharge to specified Ah at max allowed rate and voltage per temperature to reach 53% SOC, Record 100ms	
78	T _{test}	DCH	5	5	5	pulse test: use temperature-adjusted I _{cc} and voltage limit as spec. Record 100ms	U _{5s} and U _{10s}
79	T _{test}	PAU	10	10	10	relaxation, Record 1sec	
80	T _{test}	CHA	#VALUE!	#VALUE!	#VALUE!	recharge to specified Ah at max allowed rate and voltage per temperature to reach 56% SOC, Record 100ms	
81	T _{test}	DCH	5	5	5	pulse test: use temperature-adjusted I _{cc} and voltage limit as spec. Record 100ms	U _{5s} and U _{10s}
82	T _{test}	PAU	10	10	10	relaxation, Record 1sec	
83	T _{test}	CHA	#VALUE!	#VALUE!	#VALUE!	recharge to specified Ah at max allowed rate and voltage per temperature to reach 60% SOC, Record 100ms	
84	T _{test}	DCH	5	5	5	pulse test: use temperature-adjusted I _{cc} and voltage limit as spec. Record 100ms	U _{5s} and U _{10s}
85	T _{test}	PAU	10	10	10	relaxation, Record 1sec	
86	T _{test}	CHA	#VALUE!	#VALUE!	#VALUE!	recharge to specified Ah at max allowed rate and voltage per temperature to reach 80% SOC, Record 100ms	
87	T _{test}	DCH	5	5	5	pulse test: use temperature-adjusted I _{cc} and voltage limit as spec. Record 100ms	U _{5s} and U _{10s}
88	T _{test}	PAU	10	10	10	relaxation, Record 1sec	



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