

94Ah cell

Overview of 94Ah 0.5C charge cell

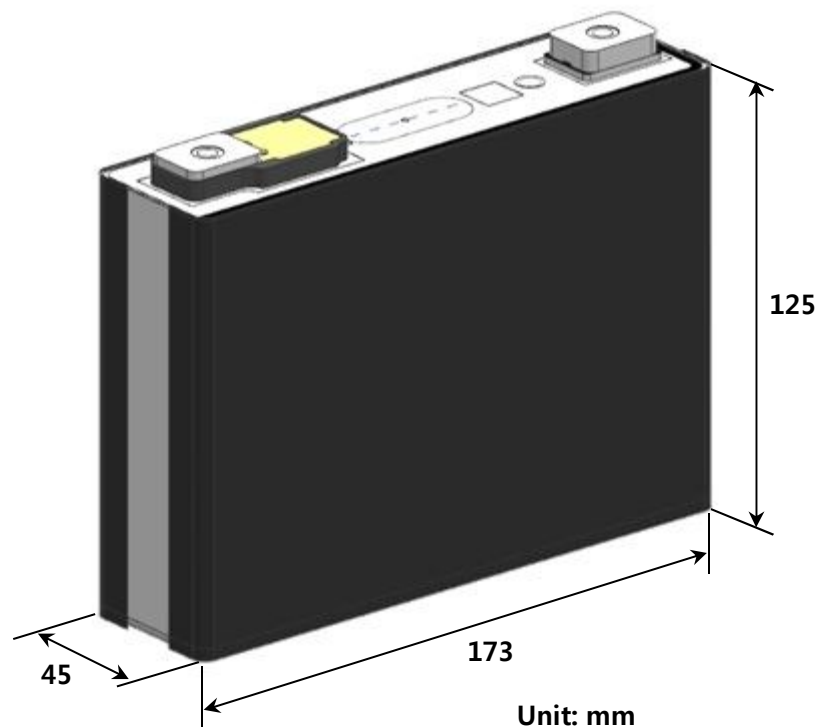


March 2016

SAMSUNG SDI



Introduction of 94Ah cell



Items		Specification (BOL)
Capacity		min. 94 Ah (ave. 96.5 Ah)
Energy	Wh	ave. 355 Wh
	Wh/kg	ave. 175 Wh/kg
	Wh/L	ave. 365 Wh/L
Voltage (max. / nominal / min.)		4.15 V / 3.68 V / 2.7 V
Discharge power	10 s at 25°C, SOC 50%	ave. 3648 W
Discharge DC-IR		ave. 0.73 mΩ
Cycle life (0.5C/1C, 25°C, DOD 100%)		> ave. 4000 cycle at SOH 80% (estimation)
Calendar life (@ SOC 100%, 60°C)		ave. 2.5 years
Abuse test	Nail penetration	≤ L4 (GB/T certification)
	Crush	≤ L4 (GB/T certification)
	Heat exposure @ 150°C for 30 min	≤ L4 (GB/T certification)
	Overcharge	≤ L4 (GB/T certification)
Parallel connection		1P and 2P
Dimension (L x W x H, mm) without insulation film		173 x 125 x 45 (0.973 L)
Weight		max. 2.06 kg (ave. 2.02 kg)

Validation: Performance and Life

Item		Condition	Unit	Spec.	C sample (average value)
General	Rated capacity	1/3C at 25°C (31.3 A)	Ah	min. 94 (outgoing)	96.44
		1/3C at -25°C (31.3 A)		-	76.26
	Energy	1/3C at 25°C (31.3 A)	Wh	min. 345.92	354.21
		3C at 25°C (31.3 A)		-	329.06
		1/3C at 25°C (31.3 A)		-	258.38
	Cell weight	With insulation film	kg	max. 2.06	2.034
Performance	Discharge power	5 s at 25°C, SOC 90% (V_{\min} : 3.72 V & I_{\max} : 413 A)	W	-	1546
		30 s at 25°C, SOC 90% (V_{\min} : 3.72 V & I_{\max} : 294 A)		-	1102
		30 s at 25°C, SOC 20% (V_{\min} : 3.13 V & I_{\max} : 290 A)		-	959
		30 s at -25°C, SOC 20% (V_{\min} : 2.0 V & I_{\max} : 77 A)		-	158
	DC-IR	5 s at 25°C, SOC 90%	mΩ	-	0.66
		30 s at 25°C, SOC 90%		-	0.91
		30 s at 25°C, SOC 20%		-	0.98
		30 s at -25°C, SOC 20%		-	20.06
Life	Cycle life	25°C, 0.5C/1C, DOD 80% (EOL: SOH 80%)	cycles	> 3500	2500 (at SOH 90%), DOD 100%
	Calendar life	60°C, SOC 100% (EOL: SOH 80%)	years	-	> 2.5
	Self discharge	Capacity retention at SOC 100%, 30 days		≤ 2.5%	1.6%

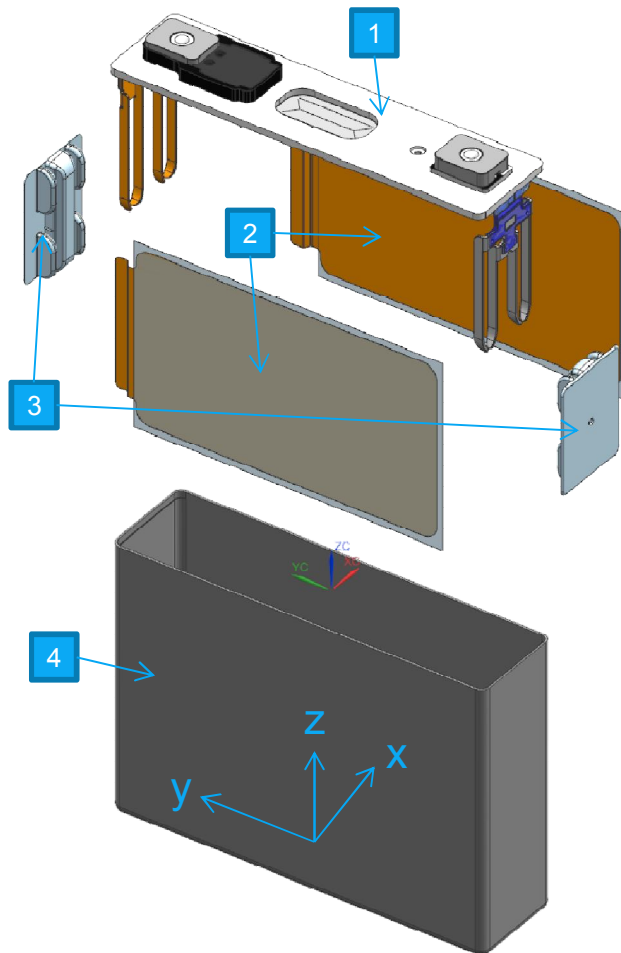
Validation: Safety (abuse tests)

Items	Test condition		Criteria	C sample	
				DV (Ulsan)	PV (Xian)
Nail penetration	SOC 100%, Nail diameter: 3 mm, speed 40 mm/sec (QC/T condition)		QC/T Pass	5L4	4L4, 1L5
Controlled crush test	SOC 100%, Crush: 15% and 50% of cell height or force of 1000 times cell mass	Y+	Information	-	2L2, 3L4
		Y-		-	4L2, 1L4
		Z+		5L3	2L2, 6L3, 1L4, 1L5
		X	QC/T Pass (EUCAR Level 4 ↓)	5L2	-
Thermal stability test	SOC 100%, heat-up: rate 5°C/min until 150°C, Holding 30 min at 150°C	5L4		3L2, 2L3, 3L4	
Overcharge test	CC/CV mode, 0.5C, 6 V, cutoff: SOC 200% (2P set)	5L2		8L2	
Overdischarge test	SOC 100%, CC mode, 1C, 2.5 hr	5L2		8L2	
External short circuit test	SOC 100%, Resistance 0.2 mΩ, Holding for 10 min	5L2		8L2	

Validation: Environmental tests

Test item	Test Method		Criteria	C sample							
				DV (Ulsan)				PV (Ulsan)			
				Retention rate (%)			Level	Retention rate (%)			Level
				Capa.	OCV	AC-IR		Capa.	OCV	AC-IR	
Drop	SOC 100%, Drop at 1.0±0.05 m height on concrete surface		EUCAR Lv ≤ L2				12L1, 3L2				X: 5L2, Y: 5L2, Z: 5L2
Random vibration	5 → 200 Hz for 21h (-40~60℃) for each X, Y and Z axis	SOC 0%	EUCAR Lv ≤ L2	99.7	100.8	100.1	5L0	99.73	99.54	95.07	5L2
		SOC 100%		97.8	99.9	104.5	5L0	99.58	99.42	94.24	5L2
Thermal shock in air	SOC 100%, 60 / -40℃, each temperature for 2 hr hold, 100 cycles	98.32		99	99.15	5L1	98.9	99.2	99.6	5L2	
Damp heat, steady state	SOC 100%, Temp : 60±2℃, Humidity : 93+2/-3 RH%, Storage for 56 days	98.25		97.89	103.72	5L1	97.74	97.82	107.6	5L2	
Damp heat, cyclic	SOC 100%, Chamber temp.: 25℃→55℃ 3 hr, 55℃ 9 hr, 55℃→25℃ 3 hr, 25℃ 9 hr Humidity: 93+2/-3%, 9 cycles	98.0		99	98.4	5L1	99.8	99.2	102.7	5L2	
Change of temperature	SOC 100%, Chamber temp.: 25℃→-40℃ 6.5 hr, -40℃ 12 hr, -40℃→60℃ 10 hr, 60℃ 14.5 hr, 60℃→25℃ 3.5 h, 25℃ 1.5 hr, 35 cycles	90.18		99.92	97.42	5L1	99.8	97.8	100.5	5L2	
Mechanical shock	SOC 100%, Half-sine shock, 60 g, 45 ms ±X,Y,Z each direction 10 time (Total 60 times)	97.4		99.9	103.2	5L0	99.4	99.8	100.8	5L2	

Structure of mechanical parts



Item	Part name	Function
1	Cap assembly	1. Current path (interface) to outer circuit 2. Safety: external short (fuse), overcharge (OSD), over pressure (vent)
2	NSD	1. Safety: nail penetration
3	Side retainer	1. Safety: Mechanical shock, Crush (Y-direction)
4	Can	1. Main housing (jelly roll protection)

※ Operation pressure
 * OSD: 0.3 MPa
 * Vent: 0.7 MPa

Allowable current limitation for continuous and pulse charge

Temperature (°C)	Discharge Operating Current Limit			Charge Operating Current Limit		
	I _{max} (Operation)	Continuous Current Limit		I _{max} (Operation)	Continuous Current Limit	
		Duration (sec)	I _{rms} limit		Duration (sec)	I _{rms} limit
			I _{rms} (A)			I _{rms} (A)
60	413	150	223	270	100	47
55	413	150	223	270	100	47
50	413	150	223	270	100	47
45	413	150	223	270	100	47
40	413	150	223	270	100	47
35	413	150	210	270	100	47
30	413	150	196	270	100	47
25	413	150	180	270	100	47
20	413	150	166	270	100	47
15	413	150	153	270	100	41
10	413	150	136	270	100	32
5	413	150	124	270	100	24
0	413	150	108	237	100	18
-5	413	150	93	185	100	12
-10	413	150	77	125	100	7.2
-15	413	150	74	62	100	4.3
-20	413	150	62	33	100	2.7
-25	413	150	57	22	100	1.7
-30	413	150	46	7	100	1
-40	413	150	33	1	100	0.4

※ Duration for pulse of operating current limit and rest after pulse current

* Example) Charge operating current limit at 25°C

I_s = specific current higher than continuous current limit

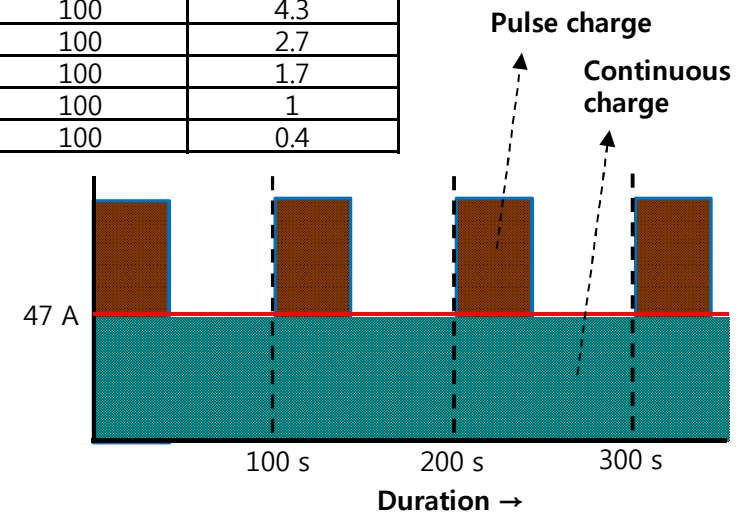
T = duration for I_s

— $I_s^2 \times T = (I_{\text{max-continuous}})^2 \times \text{duration of continuous current limit}$

(? A)² × T = (47 A)² × 100 s

• T = ?? s

• min. Rest after pulse = 100 s – ?? = ??? s



* Example) Charge at 25 °C

Allowable current limitation for charge and discharge (cell, BOL)

Charge 5 sec

T\SOC	0%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	100%
40°C	270	270	270	270	270	270	270	270	270	270	266	155	
25°C	270	270	270	270	270	270	270	270	270	270	204	118	
5°C	107	107	107	107	107	107	107	107	107	107	78	44	
-10°C	32	32	32	32	32	32	32	32	32	32	24	14	
-25°C	8	8	8	8	8	8	8	8	8	8	5	3	

Charge 30 sec

T\SOC	0%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	100%
40°C	175	175	175	175	175	175	175	175	175	175	175	107	
25°C	111	111	111	111	111	111	111	111	111	111	111	83	
5°C	44	44	44	44	44	44	44	44	44	44	44	36	
-10°C	13	13	13	13	13	13	13	13	13	13	13	12	
-25°C	3	3	3	3	3	3	3	3	3	3	3	2	

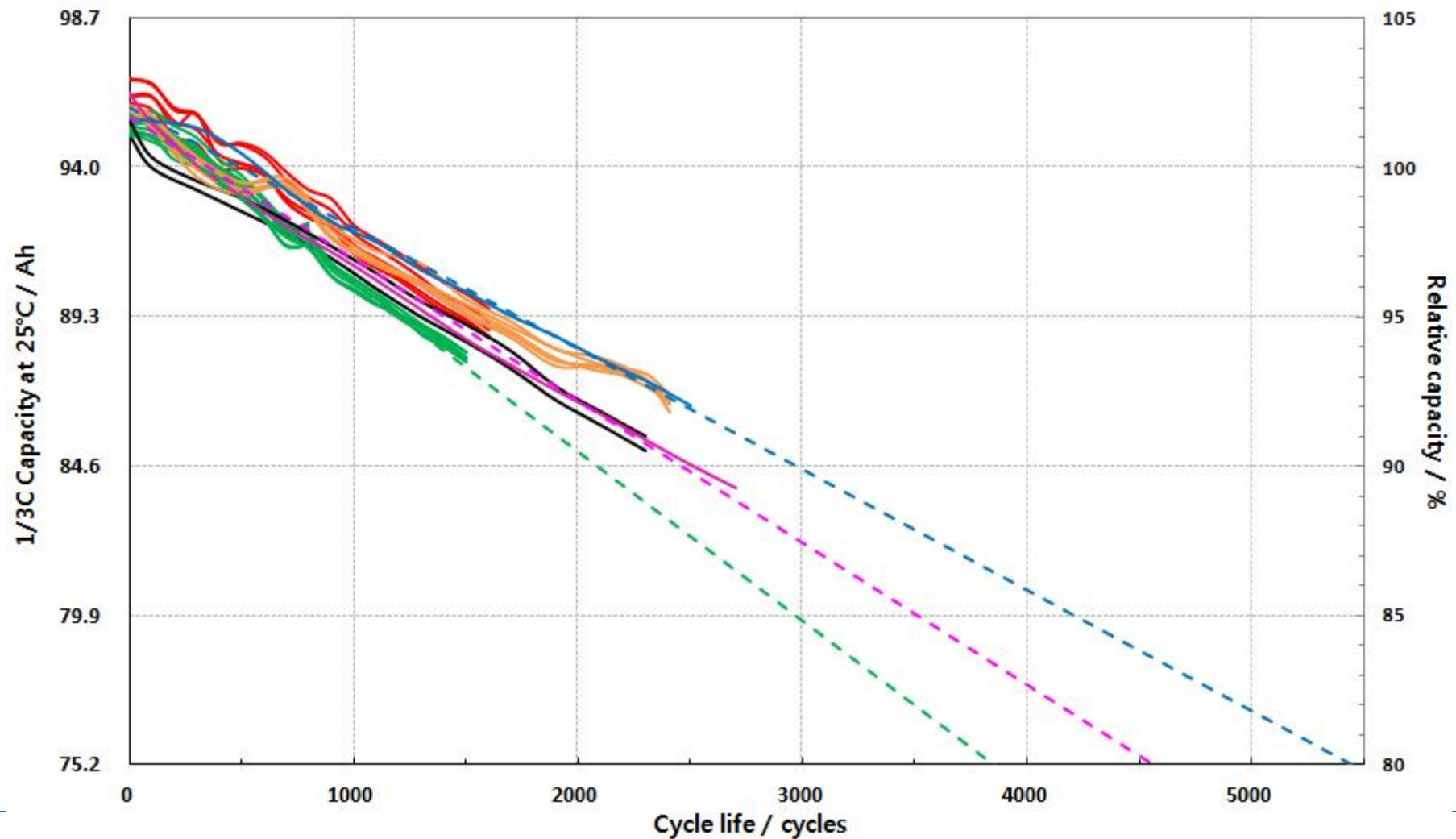
Discharge 5 sec

T\SOC	0%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	100%
40°C		-413	-413	-413	-413	-413	-413	-413	-413	-413	-413	-413	-413
25°C		-413	-413	-413	-413	-413	-413	-413	-413	-413	-413	-413	-413
5°C		-177	-266	-413	-413	-413	-413	-413	-413	-413	-413	-413	-413
-10°C		-75	-101	-202	-296	-360	-413	-413	-413	-413	-413	-413	-413
-25°C		-72	-89	-141	-207	-280	-312	-312	-312	-312	-312	-312	-312

Discharge 30 sec

T\SOC	0%	5%	10%	20%	30%	40%	50%	60%	70%	80%	90%	95%	100%
40°C		-294	-294	-294	-294	-294	-294	-294	-294	-294	-294	-294	-294
25°C		-211	-294	-294	-294	-294	-294	-294	-294	-294	-294	-294	-294
5°C		-77	-145	-277	-277	-277	-277	-277	-277	-277	-277	-277	-277
-10°C		-35	-58	-140	-172	-172	-172	-172	-172	-172	-172	-172	-172
-25°C		-29	-38	-77	-127	-127	-127	-127	-127	-127	-127	-127	-127

Cycle life performance (0.5C/1C, 25°C, DOD 100%)

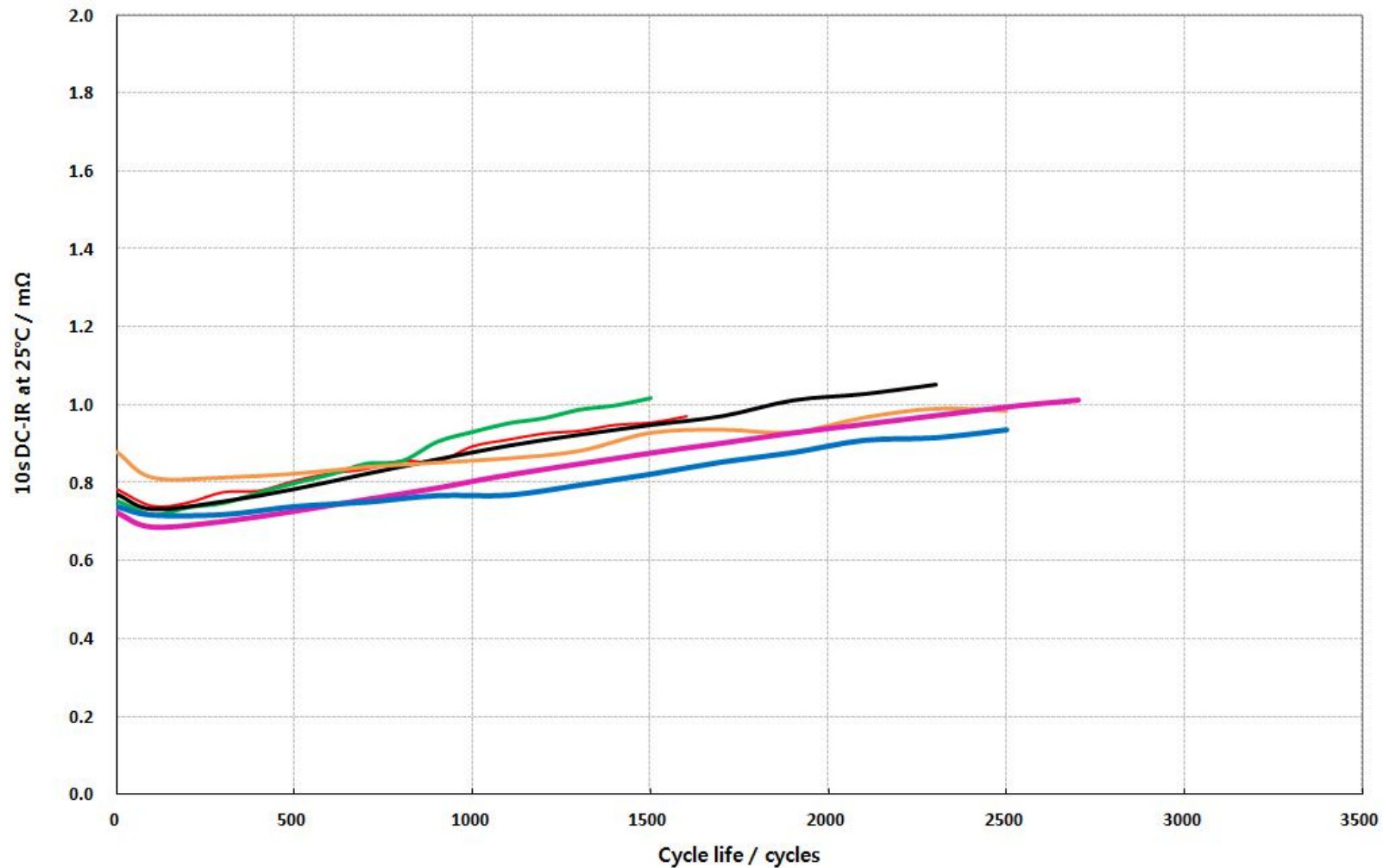


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Cycle life performance (0.5C/1C, 25°C, DOD 100%)



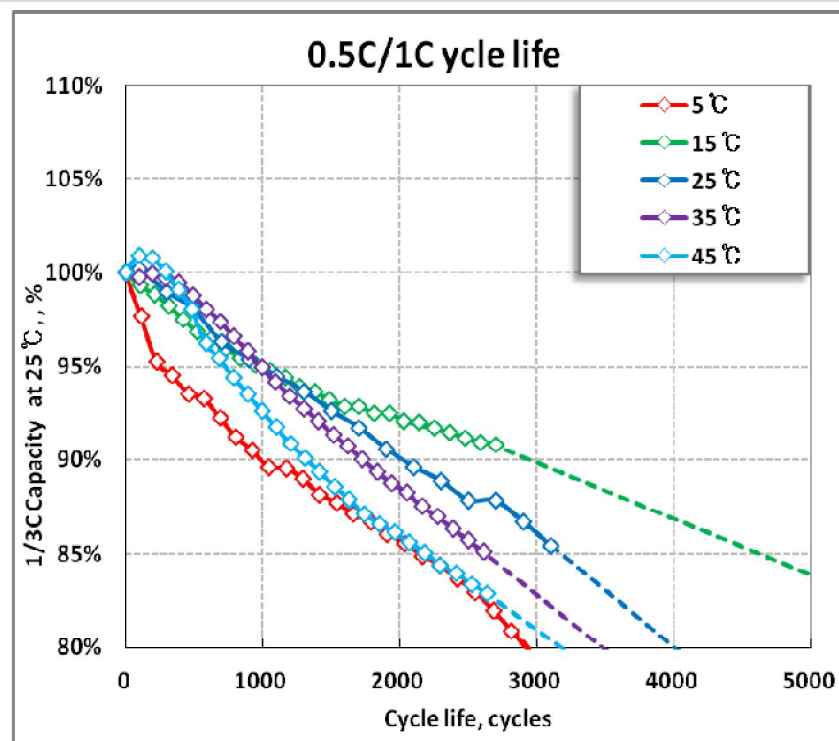
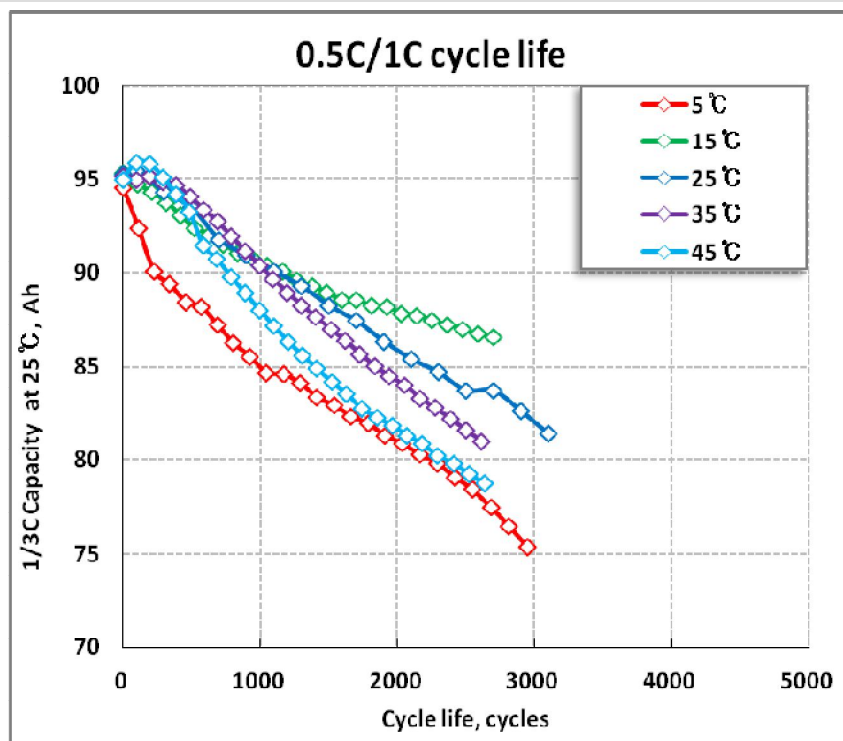
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Cycle life mapping test, B2 sample

Temperature effect, 0.5C/1C RPT



※ Cycle condition

Charge : 1/2C, 4.15V CCCV charge, 1/5C cut off rest 10 min

Discharge : 1C CC discharge, 2.7V cut off rest 15 min

※ Capacity condition @ 25°C

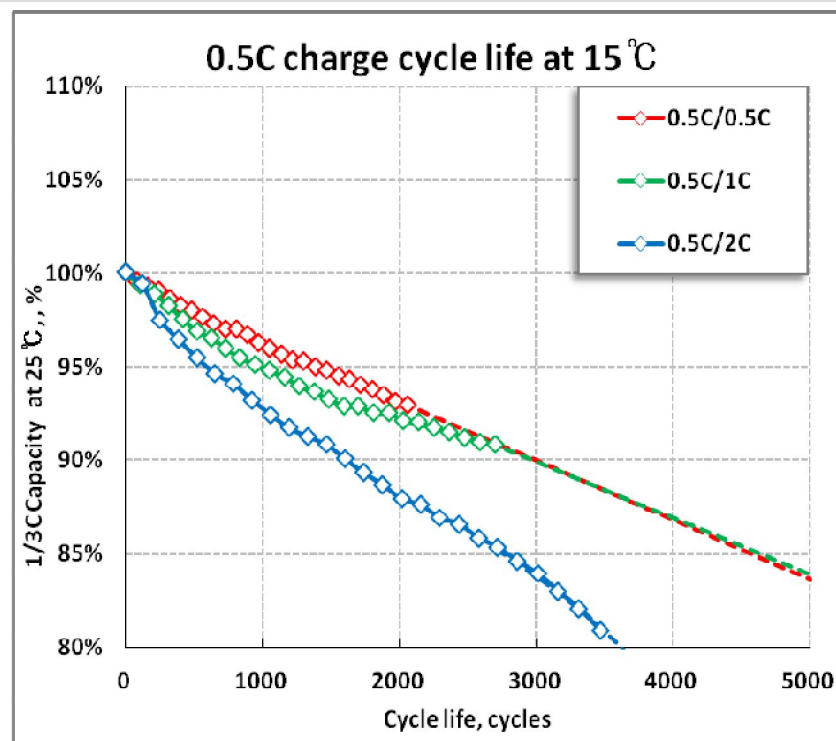
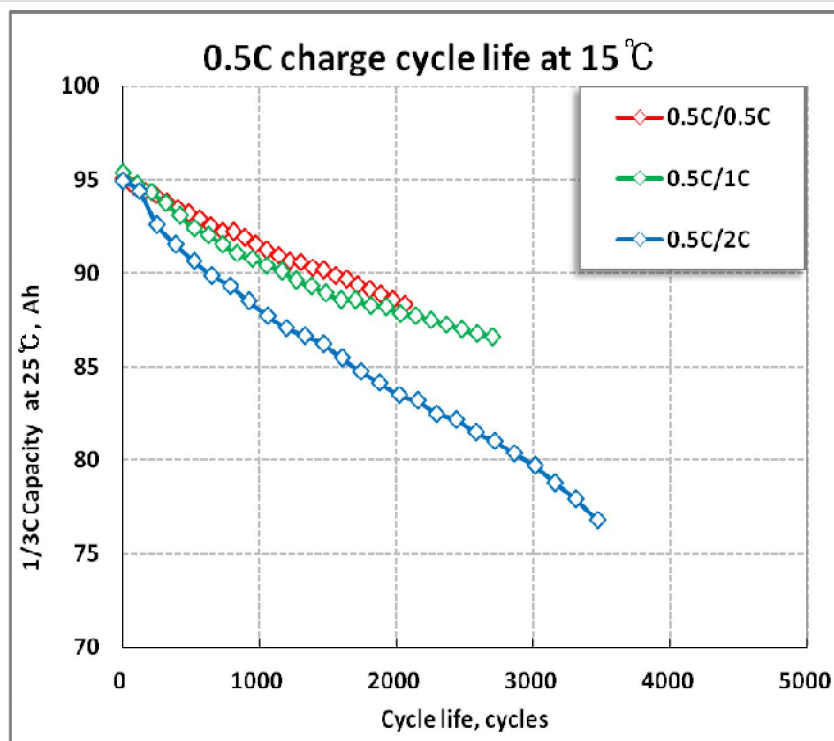
Charge : 1/3C, 4.15V CCCV charge, 1/50C cut off rest 30 min

Discharge : 1/3C CC discharge, 2.7V cut off

Temperature	Test condition	예측 수명
5 °C	0.5C/1C	2900 Days
15 °C		6500 Days
25 °C		4000 Days
35 °C		3400 Days
45 °C		3200 days

Cycle life mapping test, B2 sample

Discharge C-rate effect at 15°C RPT



※ Cycle condition

Charge : 1/2C, 4.15V CCCV charge, 1/5C cut off rest 10 min

Discharge : 1C CC discharge, 2.7V cut off rest 15 min

※ Capacity condition @ 25°C

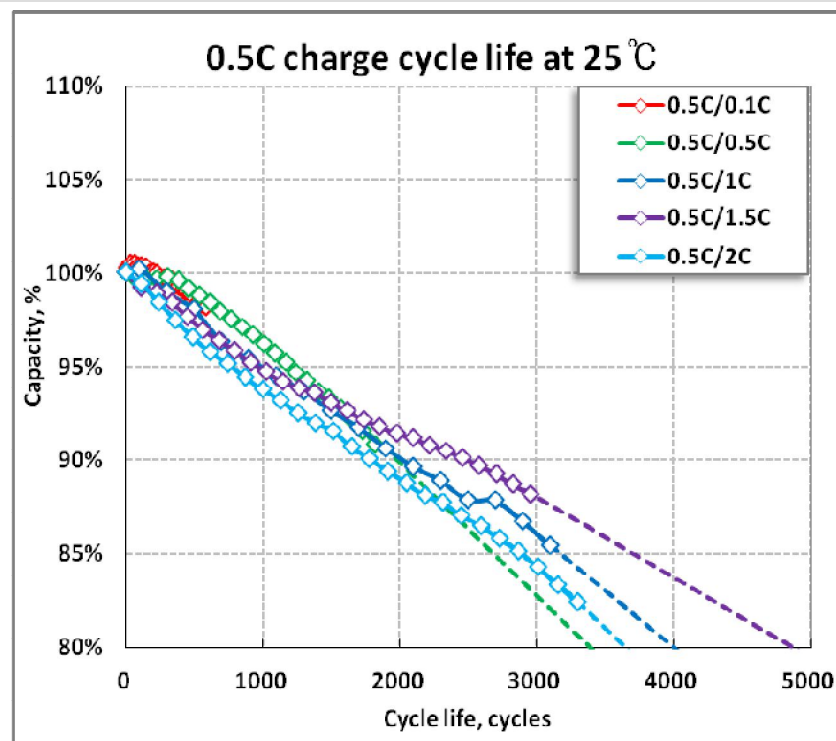
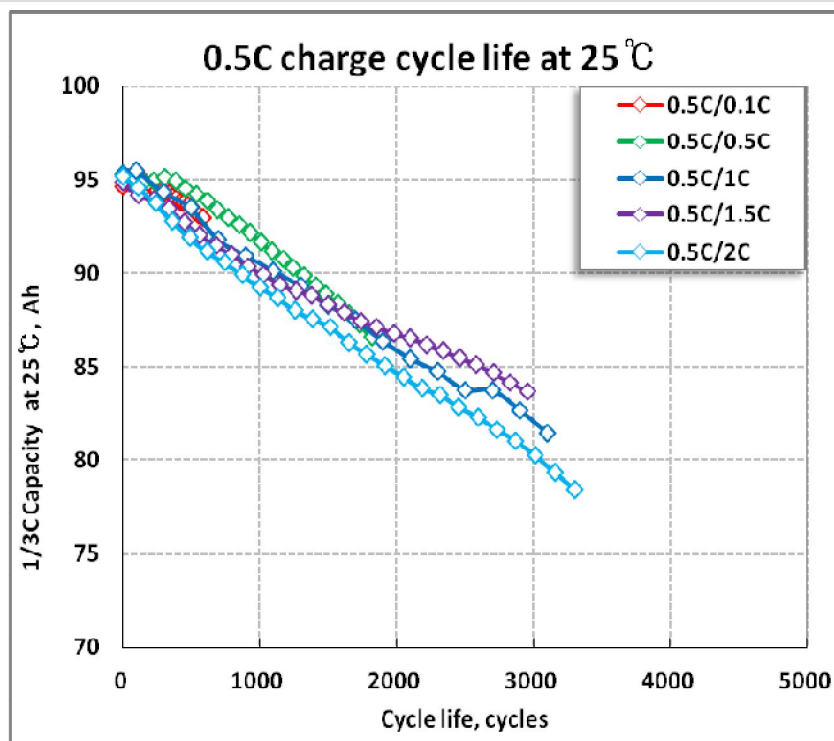
Charge : 1/3C, 4.15V CCCV charge, 1/50C cut off rest 30 min

Discharge : 1/3C CC discharge, 2.7V cut off

Temperature	Test condition	예측 수명
15 °C	0.5C/0.5C	6100 Days
	0.5C/1C	6500 Days
	0.5C/2C	3600 Days

Cycle life mapping test, B2 sample

Discharge C-rate effect at 25°C RPT



※ Cycle condition

Charge : 1/2C, 4.15V CCCV charge, 1/5C cut off rest 10 min

Discharge : 1C CC discharge, 2.7V cut off rest 15 min

※ Capacity condition @ 25°C

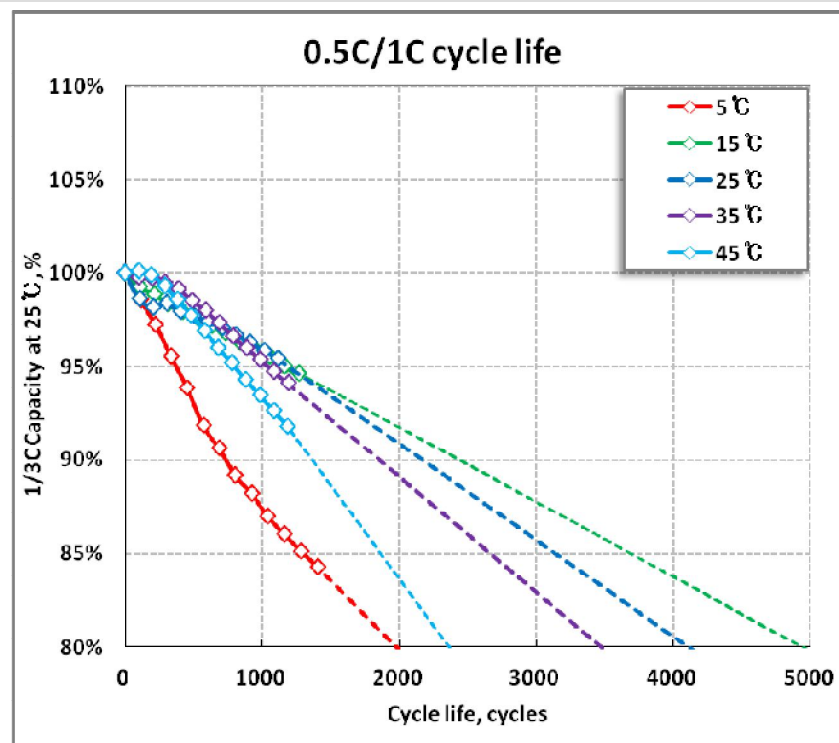
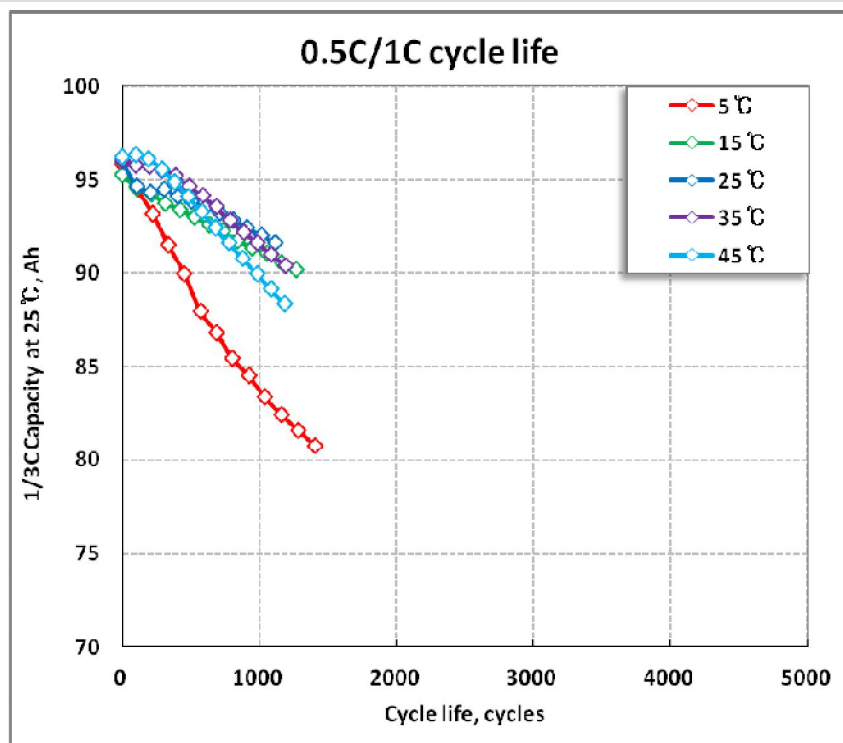
Charge : 1/3C, 4.15V CCCV charge, 1/50C cut off rest 30 min

Discharge : 1/3C CC discharge, 2.7V cut off

Temperature	Test condition	예측 수명
25°C	0.5C/0.1C	3800 Days
	0.5C/0.5C	3400 Days
	0.5C/1C	4000 Days
	0.5C/1.5C	4900 Days
	0.5C/2C	3600 Days

Cycle life mapping test, C sample

Temperature effect, 0.5C/1C RPT



※ Cycle condition

Charge : 1/2C, 4.15V CCCV charge, 1/5C cut off rest 10 min

Discharge : 1C CC discharge, 2.7V cut off rest 15 min

※ Capacity condition @ 25°C

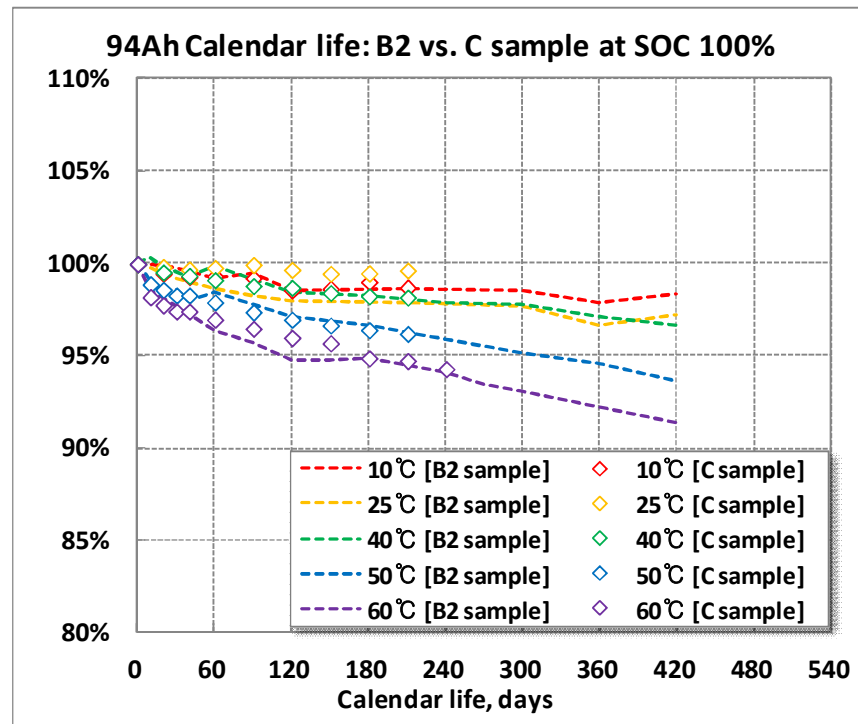
Charge : 1/3C, 4.15V CCCV charge, 1/50C cut off rest 30 min

Discharge : 1/3C CC discharge, 2.7V cut off

Temperature	Test condition	예측 수명
5 °C	0.5C/1C	1900 Days
15 °C		4900 Days
25 °C		4100 Days
35 °C		3400 Days
45 °C		2400 days

Calendar life mapping test result, B2 vs. C sample

Temperature effect at SOC100%



Condition	BOL [Ah]	@150D [Ah]	Recovery [%]
10℃ [B2 sample]	94.9	-	-
10℃ [C sample]	94.4	93.7	98.7
25℃ [B2 sample]	94.9	92.7	97.7
25℃ [C sample]	94.0	93.5	99.5
40℃ [B2 sample]	94.3	-	-
40℃ [C sample]	94.3	92.8	98.4
50℃ [B2 sample]	95.4	-	-
50℃ [C sample]	95.7	92.5	96.7
60℃ [B2 sample]	95.5	90.5	94.8
60℃ [C sample]	95.9	91.8	95.7

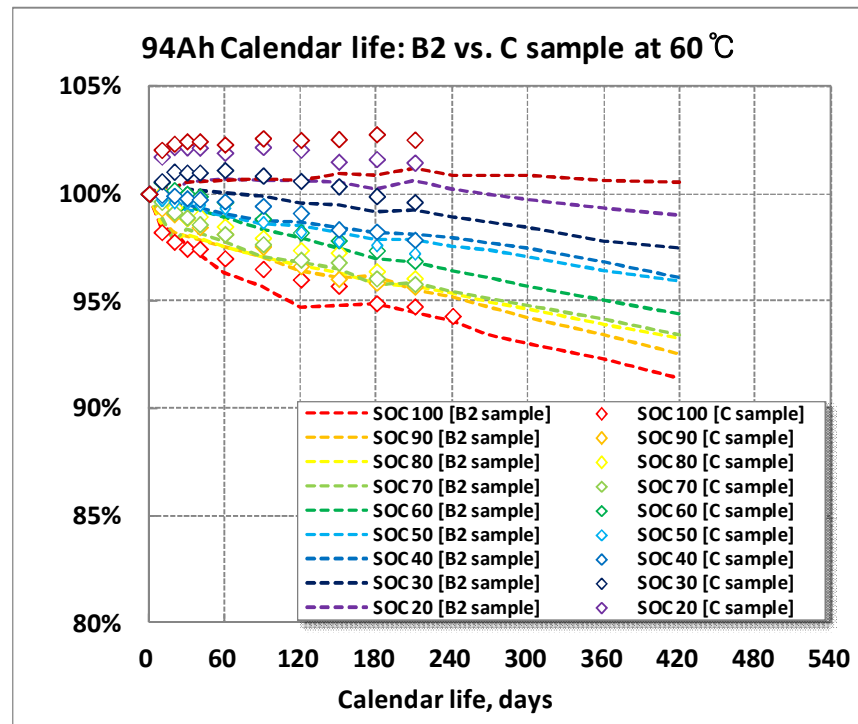
※ RPT condition

Charge : 1/3C Vmax CCCV charge, 1/50C cut off rest 30 min

Discharge : 1/3C CC discharge Vmin cut off rest 60 min at 25℃

Calendar life mapping test result, B2 vs. C sample

SOC effect at 60 °C



Condition	BOL [Ah]	@150D [Ah]	Recovery [%]
SOC100	92.0 / 95.9	90.5 / 91.8	94.8 / 95.7
SOC 90	92.9 / 94.5	91.6 / 90.8	96.1 / 96.0
SOC 80	92.6 / 94.0	91.4 / 91.5	96.3 / 97.3
SOC 70	92.8 / 93.5	91.6 / 91.2	96.5 / 96.8
SOC 60	93.5 / 94.5	92.2 / 92.5	97.5 / 97.8
SOC 50	94.0 / 95.7	93.2 / 93.6	98.2 / 97.8
SOC 40	94.1 / 95.7	93.4 / 94.1	98.4 / 98.3
SOC 30	95.1 / 94.6	94.5 / 94.9	99.4 / 100.4
SOC 20	95.8 / 93.9	95.7 / 95.3	100.5 / 101.5
SOC 10	95.5 / 93.7	95.8 / 96.1	100.9 / 102.6

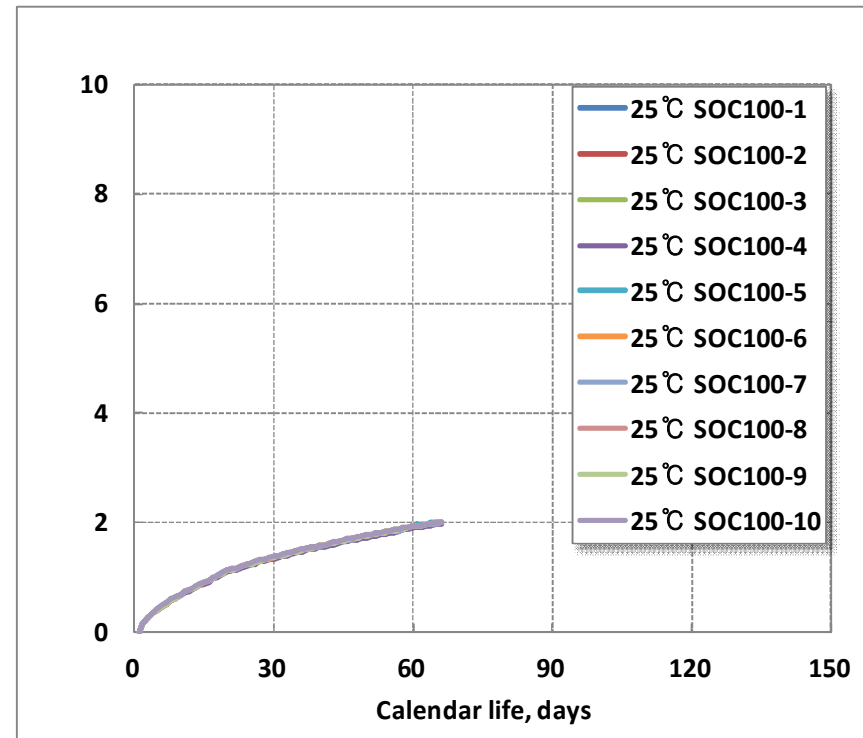
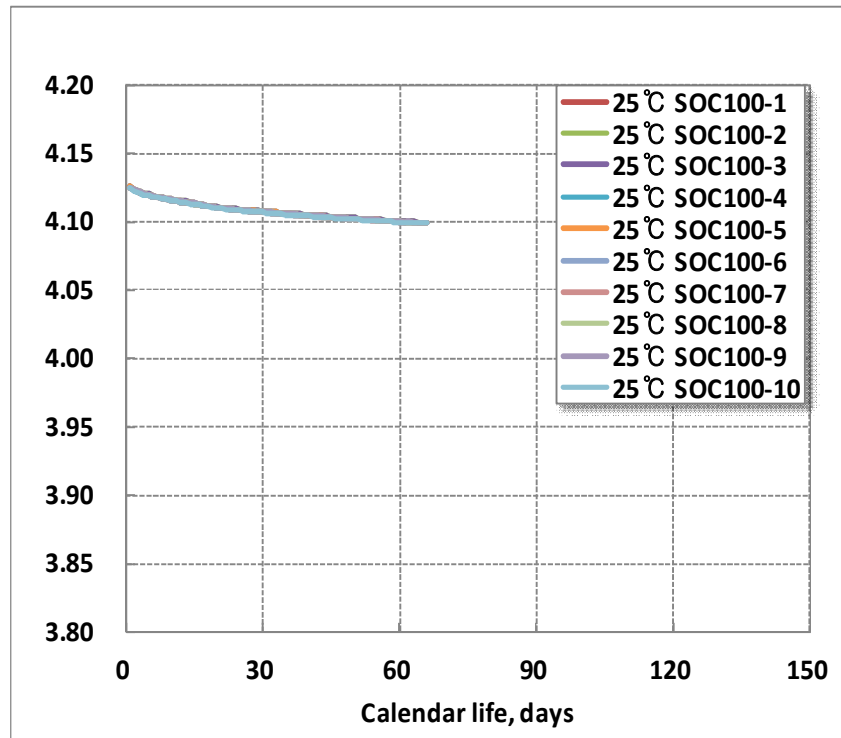
※ B2 sample / C sample

※ RPT condition

Charge : 1/3C Vmax CCCV charge, 1/50C cut off rest 30 min

Discharge : 1/3C CC discharge Vmin cut off rest 60 min at 25 °C

Self discharge: at 25°C, SOC 100%



Method	Specification	Remark
25 °C, SOC 100%, 30 days	Capacity retention ≤ 2.5%	Capacity retention ≤ 2%

Self discharge: at 25°C, SOC 20%

