1. General Information

1.1 Scope

This product specification defines the performances of the rechargeable lithium ion battery to be supplied to the customer by LG Chem.

1.2 Application: Electric vehicle, Energy storage system

1.3 Product classification: Rechargeable lithium ion battery

1.4 Model name: E63

2. Specification

2.1 Nominal specification

Item	Condition / Note	Specification
2.1.1 Discharge Capacity*	Under 25°C, 2.50 V–4.20 V Standard charge/ 21.6 A discharge	Nominal 65.6 Ah (C_{nom}) Minimum 64.6 Ah (C_{min})
	Under 25°C, 2.50 V–4.20 V Standard charge/ 32.5 A discharge	Nominal 64.8 Ah (C_{nom}) Minimum 63.8 Ah (C_{min})
2.1.2 Nominal Voltage		3.60 V
2.1.3 Voltage		2.50 V–4.20 V
2.1.4 Thickness**		11.5 ±0.2 mm
2.1.5 Standard charge (Refer to 4.1.1)	Constant current Constant current and voltage End condition (current cut off) Temperature	21.6 A/ 4.05 V 13.0 A/ 4.20 V 3.25 A 25 ±2℃
2.1.6 Standard discharge (Refer to 4.1.2)	Constant current End voltage (Cut off) Temperature	32.5 A 2.50 V 25 ± 2℃
2.1.7 Weight*		964.9 ±8 g

* Capacity and weight of all manufactured cell is measured at activation process.
** Thickness of all activated cell is measured at end-of-line test.

2.2 Recommended charge specification in E63 charging map

Item	Condition / Note	Specification
2.2.1 Normal charge	Constant power*	6.25 W
	Termination voltage and power**	4.157 V/ 6.25 W
	Temperature	-10℃–50℃
2.2.2 22kW fast charge	Constant power*	Max 114.6 W
	Termination voltage and power**	4.157 V/ 6.25 W
	Temperature	10℃–45℃
2.2.3 43kW fast charge	Constant power*	Max. 224 W
	Termination voltage and power**	4.157 V/ 6.25 W
	Temperature	25℃–45℃
2.2.4 Charge at low temperatures	Constant power*	Max. 69.9 W at 0℃
		Max. 46.9 W at -10℃
		Max. 11.7 W at -20℃
	Termination voltage and power**	4.157 V / 13.13 W at 0℃
		4.157 V / 5.26 W at -10℃
		4.157 V / 2.60 W at -20℃
	Temperature	-20℃–0℃

* Constant power: Power for charge is defined within maximum power and may consist of several power values in series, where power diminish one after another as 4.3.2 and 4.4.2 charging map.
** Termination voltage and power: The cell voltage shall not go above the cutoff voltage and the charge ends when the power reaches the cutoff power.

2.3 Operating Temperature Specification

Item	Condition / Note	Specification
2.3.1 Continuous operation	Continuous operation is a condition where the battery will experience on a frequent basis and maintain its designed performance.	10℃–45℃
2.3.2 Excursion	Excursion is a condition where the battery may experience on an infrequent basis and be used with reduced performance.	-30℃–10℃ 45℃–55℃

2.4 Protection limit specification

Item	Condition / Note	Specification
2.4.1 1st over voltage limit	The battery may experience this voltage on an infrequent basis. When the battery's voltage reaches this limit, the charging power shall be reduced to zero.	4.40 V @ normal 4.30 V @ charge
2.4.2 2nd over voltage limit	The battery shall not be used over this limit	4.45 V
2.4.3 under voltage limit	The battery shall not be used below this limit	2.00 V

3. Appearance and Dimension

3.1 Appearance

There shall be no such defects as deep scratch, crack, rust, discoloration or leakage, which may adversely affect the commercial value of the cell.

3.2 Dimension

Thickness: Shipping thickness Nom. 11.5 mm (when measured under pressure of 90 kgf for 10 sec)

Width: Nom. 125 mm

Height: Nom. 325 mm (without terminals)

Thickness increase after 20% degradation of the initial capacity: less than 8% of initial thickness

4. Performance Specification

4.1 Standard test condition

4.1.1 Reference charge

Unless otherwise specified, "Reference charge" shall consist of charging at constant current of 21.6 A. to 4.05 V and 13.0 A to 4.20 V. The charging current is tapering after cell voltage getting 4.20 V to 3.25 A. For test purposes, charging shall be performed at 25 ±2℃.

4.1.2 Reference discharge

"Reference discharge" shall consist of discharging at a constant current of 32.5 A to 2.5 V. Discharging shall be performed at 25 ±2℃ unless otherwise noted (such as temperature dependent capacity test).

4.1.3 Reference cycle

(1) Reference performance test: Cells shall be charged by reference charge to 4.20V and discharged to 2.50 V. Cells shall be rested for 60 minutes after both charge and discharge.

(2) Reference cycle test: Cells shall be charged by reference charge to maximum voltage level and discharged to minimum voltage level. Maximum and minimum voltage level is determined by test purpose. Cells shall be rested for 60 minutes after both charging and discharging.

4.2 Electrical Specification

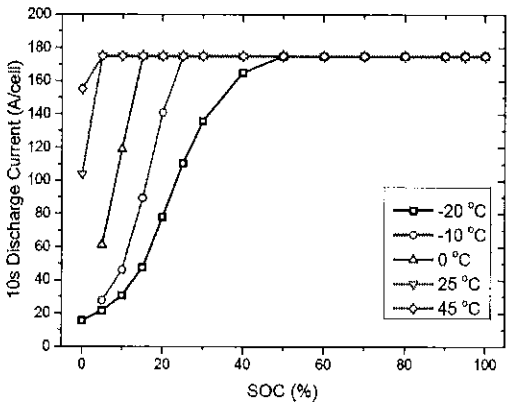
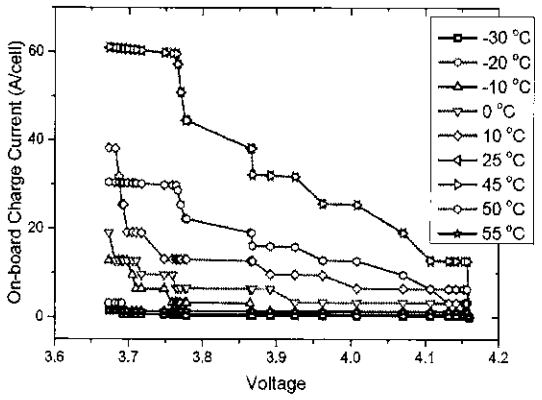
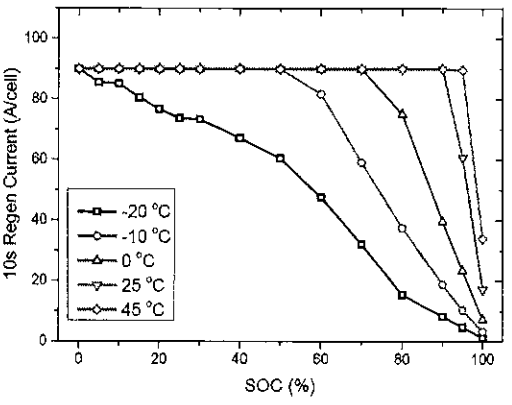
<table>
<tr><td></td><td colspan="2">Condition</td><td colspan="4">Specification</td></tr>
<tr><td>4.2.1 Initial Capacity*</td><td colspan="2">Cells shall be tested with reference performance test regulation.</td><td colspan="4">≥ 63.5 Ah (C_{min})</td></tr>
<tr><td rowspan="8">4.2.2 Temperature Dependency of Capacity*</td><td colspan="2">Cells shall be tested with reference performance test regulation.</td><td colspan="4"></td></tr>
<tr><td>Charge</td><td>Discharge</td><td colspan="4">Capacity</td></tr>
<tr><td rowspan="5">25℃</td><td>-20 ℃</td><td colspan="4">60.2% of C_{nom}</td></tr>
<tr><td>-10 ℃</td><td colspan="4">84.2% of C_{nom}</td></tr>
<tr><td>0 ℃</td><td colspan="4">90.4% of C_{nom}</td></tr>
<tr><td>25 ℃</td><td colspan="4">100.0% of C_{nom}</td></tr>
<tr><td>45 ℃</td><td colspan="4">102.1% of C_{nom}</td></tr>
<tr><td rowspan="5">4.2.3 OCV Table*</td><td colspan="2" rowspan="5">Whole test should be done under 25 ±2℃. Cells shall be charged by 21.6 A to 4.20 V. Current is tapering after cell voltage getting 4.20 V to 3.25 A. Cell shall be rested for 1 h. Cell shall be discharged by 32.5 A to 2.50 V. Cell</td><td>SOC (%)</td><td>OCV (V)</td><td>SOC (%)</td><td>OCV (V)</td></tr>
<tr><td>100</td><td>4.166</td><td>45</td><td>3.642</td></tr>
<tr><td>95</td><td>4.108</td><td>40</td><td>3.625</td></tr>
<tr><td>90</td><td>4.051</td><td>35</td><td>3.610</td></tr>
</table>

<table>
<tr><td></td><td>shall be rested for 1h. Cycling shall be repeated for 2 times. SOC, or DOD, range is set as discharge capacity of 2nd measurement.
From SOC 0% to 5%, cells shall be charged by 1% of discharge capacity and rested for 2 h. This step shall be repeated for 5 times. From SOC 5% to 95%, Cells shall be charged by 1% of discharge capacity and rested for 1h. This step shall be repeated for 90 times. From SOC 95% to 100%, cells shall be charged by 1% of discharge capacity and rested for 2 h. This step shall be repeated for 5 times. OCV test shall be done through discharge direction by same procedure in SOC range. OCV at defined SOC is the average of OCV at same SOC measured by charge and discharge direction.</td><td>85
80
75
70
65
60
55
50</td><td>3.997
3.945
3.895
3.846
3.799
3.755
3.695
3.663</td><td>30
25
20
15
10
5
0</td><td>3.593
3.571
3.537
3.488
3.446
3.413
3.167</td></tr>
<tr><td>4.2.4
Discharge Resistance at room temperature*</td><td>Cells shall be set at a SOC as per 4.2.3.
Test current is set as system maximum of 175.00 A or maximum current which does reach cell voltage of 2.50 V within defined duration. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.</td><td colspan="4"><table>
<tr><th rowspan="2">SOC (%)</th><th rowspan="2">Test Current** (A)</th><th colspan="2">Resistance (mΩ)</th></tr>
<tr><th>10s</th><th>30s</th></tr>
<tr><td>100</td><td>175.00</td><td>1.38</td><td>1.75</td></tr>
<tr><td>95</td><td>175.00</td><td>1.42</td><td>1.80</td></tr>
<tr><td>90</td><td>175.00</td><td>1.43</td><td>1.82</td></tr>
<tr><td>80</td><td>175.00</td><td>1.44</td><td>1.83</td></tr>
<tr><td>70</td><td>175.00</td><td>1.44</td><td>1.84</td></tr>
<tr><td>60</td><td>175.00</td><td>1.43</td><td>1.78</td></tr>
<tr><td>50</td><td>175.00</td><td>1.35</td><td>1.64</td></tr>
<tr><td>40</td><td>175.00</td><td>1.40</td><td>1.72</td></tr>
<tr><td>30</td><td>175.00</td><td>1.46</td><td>1.84</td></tr>
<tr><td>20</td><td>175.00</td><td>1.57</td><td>2.11</td></tr>
<tr><td>10</td><td>175.00</td><td>1.97</td><td>3.96</td></tr>
<tr><td>5</td><td>175.00/
126.32</td><td>3.47</td><td>7.21</td></tr>
<tr><td>0</td><td>103.84/
54.88</td><td>6.16</td><td>11.66</td></tr>
</table></td></tr>
</table>

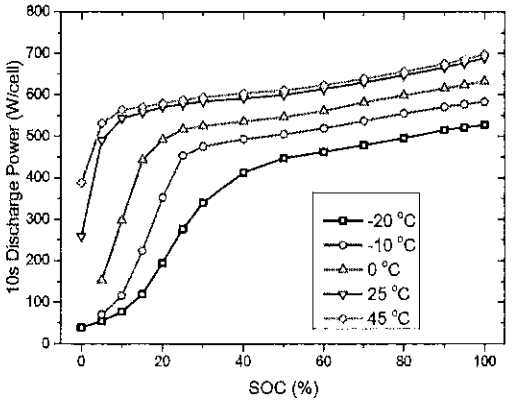
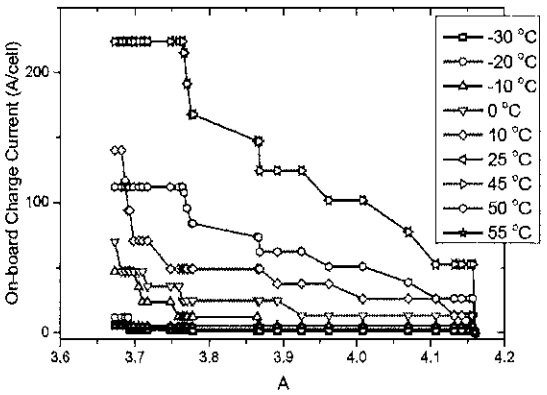
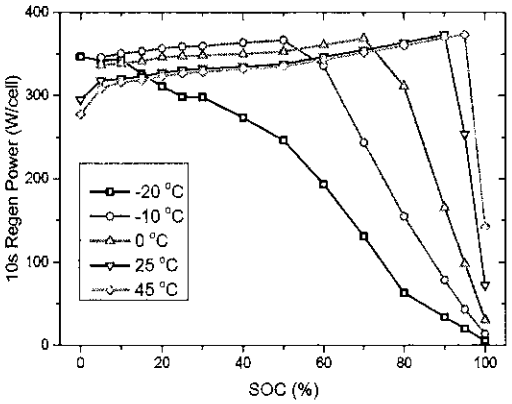
Item	Condition	Specification			
4.2.5 Charge Resistance at R.T.*	Cells shall be set at a SOC as per 4.2.3. Discharge current is set as system maximum of 90.00 A or maximum current which does reach cell voltage of 4.20 V within defined duration. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	SOC (%)	Test Current** (A)	Resistance (mΩ)	
				10s	30s
		100	17.14/ 13.46	1.46	1.86
		95	60.73/ 49.12	1.42	1.75
		90	90.00 /83.23	1.39	1.73
		80	90.00	1.38	1.72
		70	90.00	1.39	1.71
		60	90.00	1.39	1.68
		50	90.00	1.37	1.64
		40	90.00	1.37	1.60
		30	90.00	1.42	1.66
		20	90.00	1.52	1.84
		10	90.00	1.62	1.96
		5	90.00	1.82	2.12
		0	90.00	2.43	3.35

* Determined using Begin-of-Life batteries (within 3 months from the production date)
** Test current: 175 A and 90 A is taken as a system maximum of discharge and charge direction, respectively.

4.3 Current Limit Specification

Item	Condition	Specification
4.3.1 BOL Discharge Current	10s. discharge current for the voltage limits of 2.50 V.	
4.3.2 BOL Charge current (for an on-board charger)	Charge current (when charged using an on-board charger) for the voltage limit of 4.16 V	
4,3.3 BOL Regen current	10s. regen current for the voltage limit of 4.20 V.	

4.4 Power Limit Specification

Item	Condition	Specification
4.4.1 Discharge power *	10s. discharge power for the voltage limits of 2.50 V.	
4.4.2 Charge power (for an on-board charger) *	Charge power (when charged using an on-board charger) for the voltage limit of 4.15V	
4,4.3 Regen power *	10s. regen power for the voltage limit of 4.15V	

* Determined using Begin-of-Life batteries (within 3 months from the production date)

4.5 Durability specification.

Item	Condition	Specification
4.5.1 Self Discharge Rate	Cells at the shipping state shall be stored in a temperature-controlled environment at 45 °C for 1 month. After storage, cells shall be discharged per 4.1.2 and cycled per 4.1.1 and 4.1.2 for 3 cycles to obtain recovered capacity*	Capacity recovery rate ≥ 98 % of C_{min}
4.5.2 Storage at High Temperature	Cells shall be charged per 4.1.1 and stored in a temperature-controlled environment at 45 °C for 4 weeks. After storage, cells shall be discharged per 4.1.2 and cycled per 4.1.1 and 4.1.2 for 2 cycles to obtain recovered capacity.*	Capacity recovery rate ≥ 94 % of initial capacity
4.5.3 Cycle Life at R.T	Cells shall be charged and discharged per 4.1.3, 200/ 1000 cycles at 25 °C ±2 °C. After cycle, cells shall be discharged per 4.1.2 and cycled per 4.1.1 and 4.1.2 for 2 cycles to obtain recovered capacity.*	≥ 94 % of initial capacity at 200 cycles ≥ 80 % of initial capacity at 1000 cycles
4.5.4 Cycle Life at High Temperature	Cells shall be charged and discharged per 4.1.3, 200 cycles at 45 °C ±2 °C. The last discharge capacity is to be compared to the first in percentage.	≥ 91 % of 1st cycle's capacity (at 45 °C. 200 cycles)

* Recovered capacity: After storage, the cells shall be discharged with 1C discharge condition(4.1.2), 1C charge and 1C discharge cycle shall be repeated (4.1.3) three times to have the third discharge capacity as recovered capacity.

4.6 Safety Specification

Item	Condition	Specification
4.6.1 Crush Test	Cells charged per 4.1.1 are to be crushed against the crushing apparatus (Freedom Car). At a displacement of 15 % of the cell's height which is held for 5 minutes, the cell shall be crushed again until either the displacement reaches 50 %, or the force does 1000 times the cell's mass, and held for 5 minutes. The test shall be performed with one of three axes (x, y, z) of each cell.	No explode, No fire
4.6.2 Penetration	Cells shall be charged as per 4.1.1 shall be set between two bakelite plate (290 x 180 x 10T, center hole 30 m.) and tightened by six M6 bolt and but with > 10 kgf x cm torque. Cell shall be penetrated at the center by a steel pointed rod of 3mm of diameter and 30° of angle at speed of 8 cm/sec.	No explode, No fire
4.6.3 Overcharge*	Cells charged per 4.1.1 shall be overcharged at 114.5 W-rate until SOC reaches 200% or cell voltage reaches 8.3V, whichever comes first.	No explode and venting below cell SOC 130%.
4.6.4 External Short Circuiting Test*	The positive and the negative terminal is connected with a total resistance of less than 100 mΩ for 1 hour. (UN Test)	No explode, No fire
4.6.5 Overdischarge Test*	Cells charged per 4.1.1 shall be discharged at constant current of 65.0 A for 1.5 hours.	No explode, No fire
4.5.6 Thermal Test	The cell charged as per 4.1.1 shall be set between two aluminum plates (290 x 180 x 10T) and tightened by four M6 sized bolt and nut with > 10kgf x cm torque. The cell shall be heated in a circulating air oven at a rate of 5 °C per minute. The oven temperature should be increased to 130°C and sustained for 30 min. Observation should be followed for 60 min after that cell heating process.	No explode, No fire

* The cells to be constrained in between two bakelite flat plates (290 x 180 x 10T) and tightened six M6-sized bolt and nut with > 10kgf x cm torque.

5. Caution and Prohibition in Handling

Warning for using the lithium ion rechargeable battery. Mishandling of the battery may cause heat, fire and deterioration in performance. Be sure to observe the following.

Caution

- When using the application equipped with the battery, refer to the user's manual before usage.
- Please read the specific charger manual before charging.
- When the cell is not charged after long exposure to the charger, discontinue charging
- Please check the positive(+) and negative(-) direction before packing.
- When a lead plate or wire is connected to the cell for packing, check out insulation not to short-circuit.
- Battery must be stored under insulated status, such as insulation treatment of positive or negative end, storing on insulation polymer tray in paper-based box.
- Battery must be stored in a dry area with controlled temperature (25 ±3°C) for long-term storage.
- Do not place the battery in direct sunlight or heat.
- Do not use the battery in high static energy environment where the protection device can be damaged.
- When rust or smell is detected on first use, please return the product to the seller immediately.
- The battery must be away from children or pets
- When cell life span shortens after long usage, please exchange to new cells.
- Do not wear metallic objects (ex. ring, watch, accessory, etc.) while handling battery cells.
- When use cells for an assembly of module or pack, the "first-in, first-out" (FIFO) principle should be applied.
- Charge time should not be longer than specified in the manual.
- Do not expose the battery to the outside of the operating temperature range specified in this document.

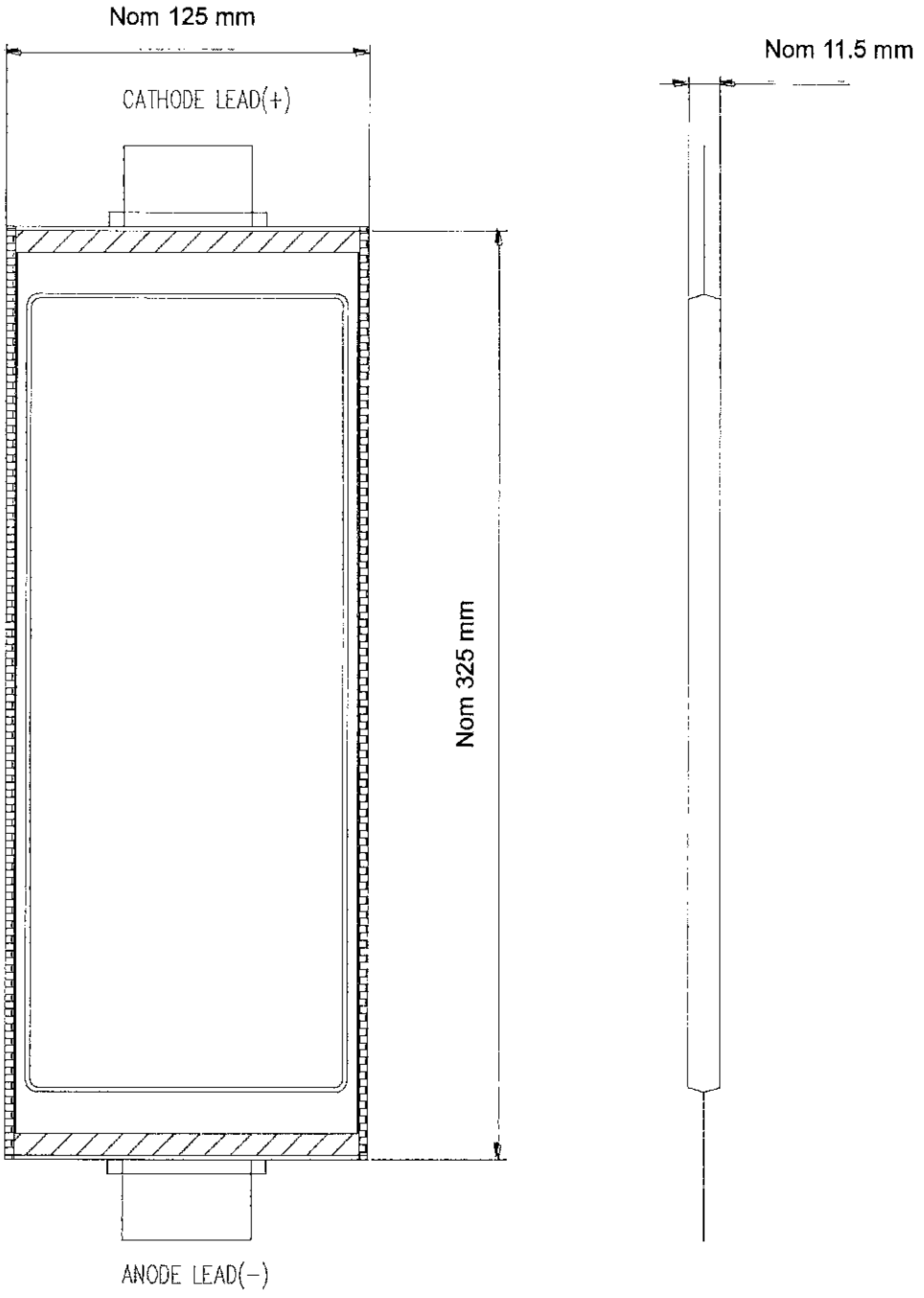
Prohibitions

- Do not use different charger.
- Do not charge with more than maximum charge rate.
- Do not disassemble or reconstruct the battery.
- Do not throw or cause impact.
- Do not pierce a hole in the battery with sharp things. (such as nail, knife, pencil, drill)
- Do not use with other batteries or cells.
- Do not solder on battery directly.
- Do not press the battery with overload in manufacturing process.
- Do not use old and new cells together for packing.

- Do not expose the battery to high heat. (such as fire)
- Do not put the battery into a microwave or high pressure container.
- Do not use the battery reversed.
- Do not connect positive(+) and negative(-) with conductive materials (such as metal, wire)
- Do not allow the battery to be immerged in or wetted with water or sea-water.
- Do not deform the battery cell (e.g. bending the terrace area or the pouch sealing area) without written agreement with the battery manufacturer.

6. Dimensional Drawing

ACEN1063I-A1, A2 Dimension



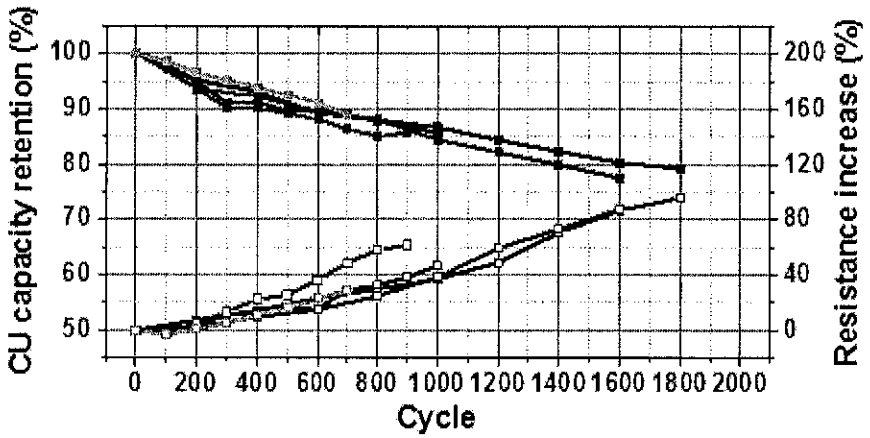
Appendix

A.1 Cycle life at selected conditions

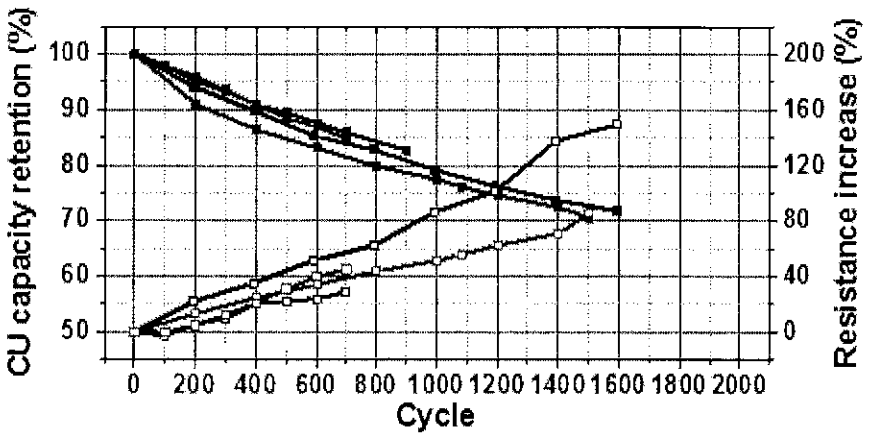
A.1.1 Cycle Life (Reference cycle)

- Test condition
  - Charge: 21.6 A CC, V_{max} 4.05 V → 13.0 A CC and CV, V_{max} 4.16V I_{min} = 3.2A
  - Discharge: 32.5 A, V_{min} = 2.50 V
  - SOC range: SOC 0%–SOC 97%
  - Rest time: 60 min after charge / discharge

25°C cycling



45°C cycling

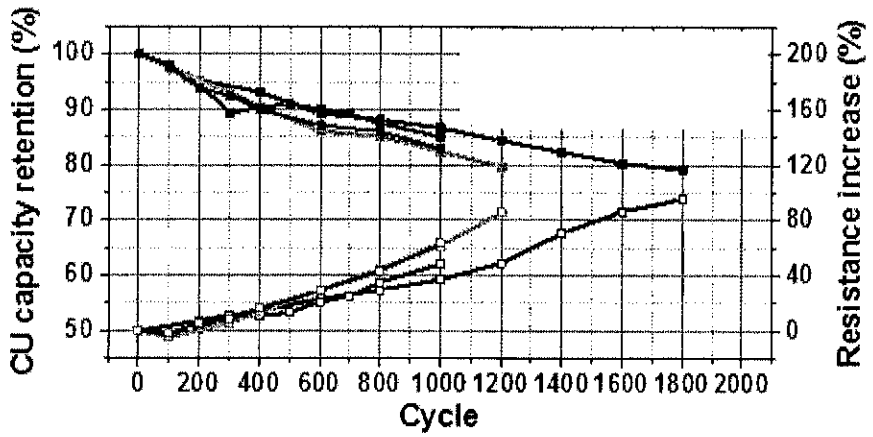


A.1.2 Cycle Life (charging protocol)

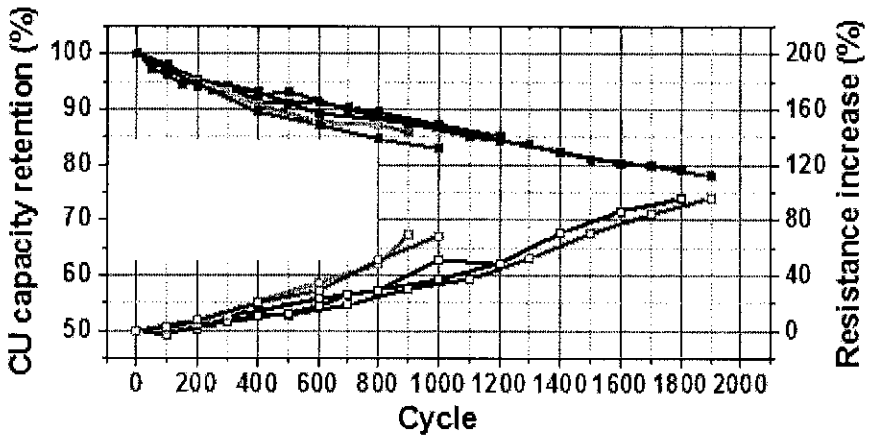
- Test condition

- Charge: Fast charging 43 kW and 22 kW protocol
- Discharge: 32.5 A, V_{min} = 2.50 V
- SOC range: SOC 0%–SOC 97%
- Rest time: 60 min after charge / discharge

43 kW charging protocol (at 25°C)

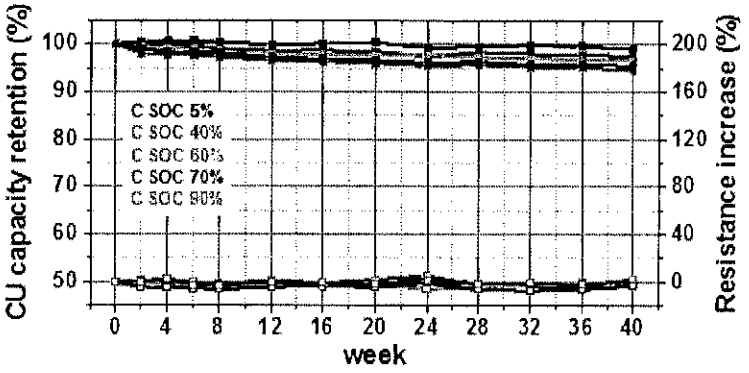


22 kW charging protocol (at 25°C)

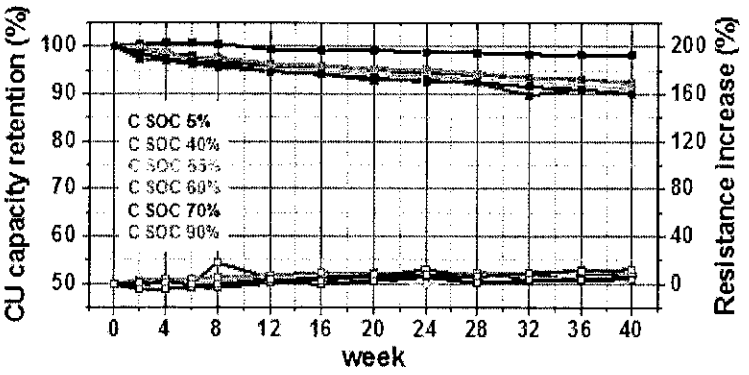


A.2 Storage life at selected conditions

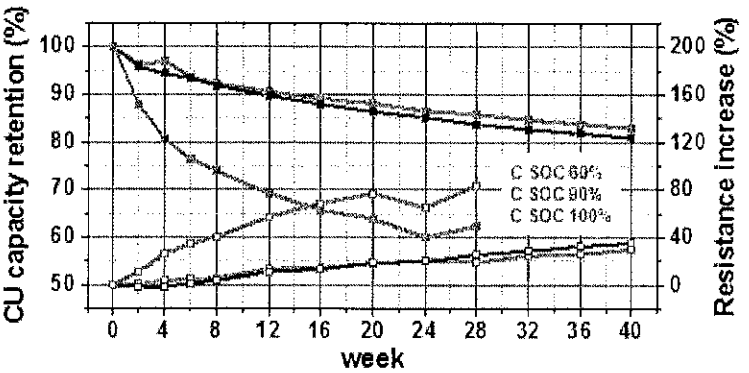
25°C storage



45°C storage



60°C storage



A.3 Protocol for the capacity measurement at each check point

- Put the battery in a chamber of 25°C and wait for an hour.
- Discharge the cell with 4.1.2 reference discharge condition.
- Then repeat the 4.1.1 charging and 4.1.2 discharging for two times.
- Get the second discharge capacity as the capacity for each check point.