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PRODUCT SPECIFICATION

Rechargeable Lithium Ion Battery
Model : C1.5S

1

Prepared	Reviewed	Approved
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Revision History

Revision	Date	Originator	Description
0	2016-09-01	Kim, Okgeun	Original Release
1	2017-05-16	Kim, Okgeun	Revised

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Contents

Revision History 2
Contents 3
1. General Information 5
1.1 Scope
1.2 Application
1.3 Product Classification
1.4 Model Name
2. Specification 5
2.1 Nominal Specification
2.1.1 Capacity
2.1.2 Nominal Voltage
2.1.3 Voltage
2.1.4 Thickness
2.1.5 Standard Charge
2.1.6 Standard Discharge
2.1.7 Weight
2.2 Recommended Charge Specification
2.2.1 Normal Charge
2.2.2 Semi-fast Charge
2.2.3 Fast charge
2.2.4 Charge at Low Temperatures
2.3 Operating Temperature Specification
2.3.1 Continuous operation
2.3.2 Excursion
2.4 Protection limit specification
2.4.1 1st Over voltage limit
2.4.2 2nd Over voltage limit
2.4.3 Under voltage limit
3. Appearance and Dimension 7
3.1 Appearance
3.2 Dimension
4. Performance Specification 8
4.1 Standard Test Condition

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4.2 Electrical Specification
4.3 Power Limit Specification
4.4 Durability Specification
4.5 Safety Specification
5. Cautions and Prohibitions in Handling 14
6. Dimensional Drawing 16

Appendix 17

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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

1.3 Product classification: Rechargeable lithium ion battery

1.4 Model name: C1.5S

2. Specification

2.1 Nominal Specification

Item	Condition / Note	Specification
2.1.1 Capacity*	Std. charge / discharge	Minimum 25.6 Ah (C_{min})
2.1.2 Nominal Voltage		3.7 V
2.1.3 Voltage*		3.602 ~ 3.632 V
2.1.4 Thickness*	97kgf / 2sec, Shipping charge	7.51 mm (± 0.16 mm)
2.1.5 Operating Voltage	Continuous charge/discharge	2.8V ~ 4.15V
	Peak charge/discharge	2.8V ~ 4.15V @ ≥ 10°C 2.5V ~ 4.15V @ -10°C≤T<10°C 2.2V ~ 4.15V @ < -10°C
2.1.6 Standard Charge (Refer to 4.1.1)	Constant current Constant voltage End condition (Cut off) Temperature	25.9 A 4.15 V 1.295 A 25±2 ℃
2.1.7 Standard Discharge (Refer to 4.1.2)	Constant current End voltage (Cut off) Temperature	25.9 A 2.8 V 25 ± 2 ℃
2.1.8 Weight*		554 g (± 6 g)

* measured at the End-of-Line test

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2.2 Recommended Charge Specification

Item	Condition / Note	Specification
2.2.1 Normal charge	Constant current	7.8 A
	Constant voltage	4.15 V*
	End condition (Cut off)	1.2 A
	Temperature	10 ~ 45 ℃
2.2.2 Semi-fast Charge	Constant current	25.9 A
	Constant voltage	4.15 V*
	End condition (Cut off)	1.2 A
	Temperature	20 ~ 40 ℃
2.2.3 Fast charge (less than 10% usage over lifetime)	Constant current	30 A
	End condition (Cut off)	4.15 V
	Temperature	25 ~ 35 ℃
2.2.4 Charge at low temperatures	Constant current	10 A @ 0 ℃ 5 A @ -10 ℃ 2.5 A @ -20 ℃
	End condition (Cut off)	4.15 V
	Temperature	-20 ~ 0 ℃

* This cutoff voltage shall be adjusted considering power requirements and SOC accuracy (ref. 3%).

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℃

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2.4 Protection limit specification

Item	Condition / Note	Specification
2.4.2 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.	4.3V
2.4.3 2nd over voltage limit*	The battery shall not be used over this limit	4.45V
2.4.4 under voltage limit	The battery shall not be used below this limit	2.0V

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. 7.51 mm (when measured under weight of 97 kgf for 2sec)

Width : Nom. 160.3 mm

Height : Nom. 232 mm (without terminals)

Thickness increase after 20% degradation of the initial capacity : ≤ 6% of initial thickness

4. Performance Specification

4.1 Standard test condition

4.1.1 1C charge

Unless otherwise specified, "1C charge" shall consist of charging at constant current of 25.9 A. The cell shall then be charged at constant voltage of 4.15 V while the charging current is tapering to 1.295 A. For test purposes, charging shall be performed at 25 °C ± 2 °C.

4.1.2 1C discharge

"1C Discharge" shall consist of discharging at a constant current of 25.9 A to 2.8 V. Discharging shall be performed at 25 °C ± 2 °C unless otherwise noted (such as capacity versus temperature).

4.1.3 1C charge / 1C discharge cycle

Cells shall be charged at constant current of 25.9 A to 4.15 V with end current of 1.295 A. Cells shall be discharged at constant current of 25.9 A to 2.8 V. Cells shall be left for 10 minutes after both charge and discharge.

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4.1.4 1C charge / 2C discharge cycle

Cells shall be charged at constant current of 25.9 A to 4.15 V with end current of 1.295 A. Cells shall be discharged at constant current of 51.8 A to 2.8 V. Cells shall be left for 10 minutes after both charge and discharge.

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 charged per 4.1.1 and discharged per 4.1.2 within 1h after full charge.</td><td colspan="4">≥ 25.6 Ah (C_{min})</td></tr>
<tr><td rowspan="3">4.2.2
Temperature Dependency of Capacity*</td><td colspan="2">Cells shall be charged per 4.1.1 at 25 ± 2 ℃ and discharged per 4.1.2 at the following temperatures.</td><td colspan="4"></td></tr>
<tr><td>Charge</td><td>Discharge</td><td colspan="4">Capacity</td></tr>
<tr><td>25℃</td><td>-20 ℃
0 ℃
25 ℃
45 ℃</td><td colspan="4">80 % of C_{min}
90 % of C_{min}
100 % of C_{min}
100 % of C_{min}</td></tr>
<tr><td rowspan="13">4.2.3
OCV Table*</td><td colspan="2" rowspan="13">Cells shall be charged per 4.1.1, and discharged 5 % of the capacity measured as per 4.2.2 at constant current of 12.95 Ah. The discharge repeats 20 times. Cells take a pause for 60 minutes after every discharge. OCV shall be recorded after every pause.</td><td>SOC (%)</td><td>OCV (V)</td><td>SOC (%)</td><td>OCV (V)</td></tr>
<tr><td>100</td><td>4.128</td><td>45</td><td>3.718</td></tr>
<tr><td>95</td><td>4.080</td><td>40</td><td>3.686</td></tr>
<tr><td>90</td><td>4.051</td><td>35</td><td>3.660</td></tr>
<tr><td>85</td><td>4.024</td><td>30</td><td>3.632</td></tr>
<tr><td>80</td><td>3.989</td><td>25</td><td>3.598</td></tr>
<tr><td>75</td><td>3.954</td><td>20</td><td>3.555</td></tr>
<tr><td>70</td><td>3.923</td><td>15</td><td>3.511</td></tr>
<tr><td>65</td><td>3.894</td><td>10</td><td>3.486</td></tr>
<tr><td>60</td><td>3.848</td><td>5</td><td>3.361</td></tr>
<tr><td>55</td><td>3.797</td><td>0</td><td>3.046</td></tr>
<tr><td>50</td><td>3.756</td><td></td><td></td></tr>
<tr><td rowspan="2">4.2.4
Discharge Resistance at R.T.*</td><td colspan="2" rowspan="2">Cells shall be set at a SOC as per 4.2.4 and discharged at as 4-points DCPR as 2.8 V is not reached within 10 seconds.</td><td rowspan="2">SOC (%)</td><td colspan="3">Resistance (mΩ)</td></tr>
<tr><td colspan="2">2s</td><td>10s</td></tr>
</table>

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	Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	100	1.44	1.83
		90	1.41	1.78
		80	1.41	1.77
		70	1.41	1.76
		60	1.42	1.77
		50	1.42	1.78
		40	1.44	1.79
		30	1.47	1.87
		20	1.57	2.02
		10	1.66	2.75
4.2.5 Charge Resistance at R.T.*	Cells shall be set at a SOC as per 4.2.4 and charged at as 4-points DCPR as 4.15 V is not reached within 10 seconds. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	SOC (%)	Resistance (mΩ)	
			2s	10s
		100	1.77	2.28
		90	1.52	1.90
		80	1.51	1.90
		70	1.50	1.85
		60	1.50	1.91
		50	1.47	1.82
		40	1.47	1.80
		30	1.47	1.80
		20	1.51	1.89
		10	1.54	1.83
4.2.6 Discharge Resistance at 0℃.*	Cells shall be set at a SOC as per 4.2.4 and charged at as 4-points DCPR as 2.5 V is not reached within 10 seconds. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	SOC (%)	Resistance (mΩ)	
			2s	10s
		100	2.86	3.20
		90	2.85	3.18
		80	2.86	3.21
		70	2.89	3.24
		60	2.97	3.34
		50	3.10	3.51
		40	3.27	3.72
		30	3.52	4.22

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		20	3.83	4.94
		10	5.72	9.50
4.2.7 Charge Resistance at 0℃.*	Cells shall be set at a SOC as per 4.2.4 and charged at as 4-points DCPR as 4.15 V is not breached within 10 seconds. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	SOC (%)	Resistance (mΩ)	
			2s	10s
		100	4.47	5.29
		90	4.24	4.88
		80	4.07	4.70
		70	3.96	4.54
		60	3.92	4.49
		50	3.87	4.36
		40	3.91	4.32
		30	4.00	4.41
		20	3.99	4.39
		10	4.03	4.29
4.2.8 Discharge Resistance at -20℃.*	Cells shall be set at a SOC as per 4.2.4 and charged at as 4-points DCPR as 2.2 V is not breached within 10 seconds. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	SOC (%)	Resistance (mΩ)	
			2s	10s
		100	7.96	8.39
		90	7.94	8.35
		80	8.16	8.57
		70	8.15	8.61
		60	8.58	9.15
		50	9.27	10.09
		40	10.07	11.39
		30	11.21	14.64
		20	14.36	21.83
		10	18.13	37.61
4.2.9 Charge Resistance at -20℃.*	Cells shall be set at a SOC as per 4.2.4 and charged at as 4-points DCPR as 4.15 V is not breached within 10 seconds. Resistance is calculated by dividing the difference between OCV and the voltage at the end of discharge by the test current.	SOC (%)	Resistance (mΩ)	
			2s	10s
		100	22.64	26.32
		90	21.70	23.54
		80	19.97	22.00

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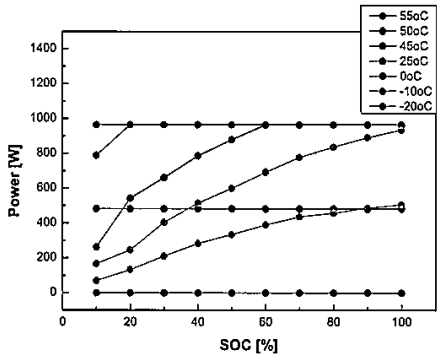
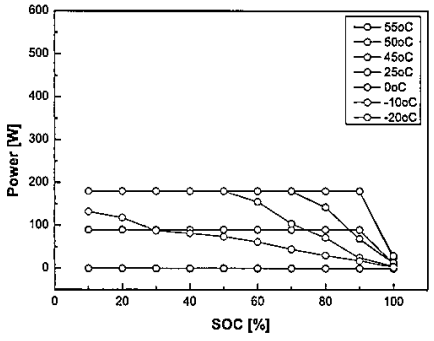
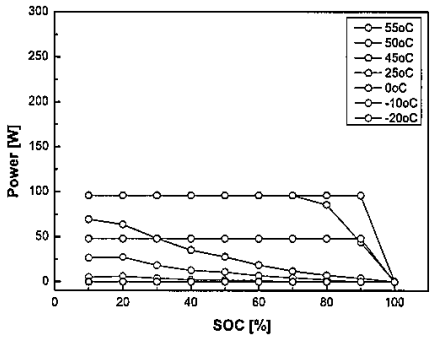
		70	19.32	20.80
		60	19.32	20.65
		50	19.32	20.65
		40	19.32	20.65
		30	19.31	20.65
		20	19.31	20.65
		10	19.67	20.98

* Determined using Begin-of-Life batteries (within 3 months from the production date) / This value is a nominal value.

4.3 Power and Current Limit Specification

Item	Condition	Specification
4.3.1 Discharge power at BOL	10s. discharge power for the voltage limits defined below 2.8 V @ ≥ 10°C 2.5 V @ -10°C≤T<10°C 2.2 V @ < -10°C	
4.3.2 Regen power at BOL	10s. regen power for the voltage limit of 4.15V	

4.3.3 Charge power (for an on-board charger)	Plug-in charge power (when charged using an on-board charger) for the voltage limit of 4.15V	

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4.4 Durability specification.

Item	Condition	Specification
4.4.1 Self Discharge Rate	Cells at the shipping state shall be stored in a temperature-controlled environment at 25 °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}
4.4.2 Storage at High Temperature (SOC80%)	Cells shall be charged per 4.1.1 and stored in a temperature-controlled environment at 60 °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 3 cycles to obtain recovered capacity.*	Capacity recovery rate ≥ 84 % of C_{min}
4.4.3 Cycle Life at R.T	Cells shall be 1C charged and 1C discharged per 4.1.3, 1000 cycles at 25 ± 2 °C. The last discharge capacity is to be compared to the first in percentage.	≥ 89 % of 1st cycle's capacity (at 25 °C. 1000 cycles)
4.4.4 Cycle Life at High Temperature	Cells shall be 1C charged and 2C discharged per 4.1.4, 200 cycles at 45 ± 2 °C. The last discharge capacity is to be compared to the first in percentage.	≥ 93 % 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.

4.5 Safety Specification

Item	Condition	Specification
4.5.1 External Short Circuiting Test*	Cells shall be charged as per 4.1.1, and the positive and the negative terminal is connected with a total resistance of less than 5mΩ for 10 min. (QC/T 743 Test)	No explode, No fire
4.5.2 Crush Test	Cells charged per 4.1.1 are to be crushed against the crushing regulation(compression area≥20cm^2). The test shall be performed with Z axes of cell and held until case is cracked or cell voltage reaches 0V.	No explode, No fire
4.5.3 Over-discharge Test*	Cells charged per 4.1.1 shall be discharged at constant current of 25 A until cell voltage reaches 0V. (QC/T 743 Test)	No explode, No fire
4.5.4 Heating Test*	The cell charged as per 4.1.1 shall be set between two aluminum plates (240 x 240 x 10 mm), the distance of which is 7.5 mm from each other. The cell shall be stored in a temperature-controlled oven at 130 °C for 60min. (QC/T 743 Test)	No explode, No fire
4.5.5 Penetration	Cells charged per 4.1.1 shall be penetrated at the center by a steel pointed rod of 3mm diameter at speed of 40mm/sec. (QC/T 743 Test)	No explode, No fire
4.5.6 Overcharge*	Cells charged per 4.1.1 shall be overcharged at 1C-rate until cell voltage reaches 6.5V or duration time reaches 90min, whichever comes first. (QC/T 743 Test)	No explode, No fire

* The cells to be constrained in between two solid flat plates (e.g. 10mm thick Al plate) for the test.

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 separately.
- Battery must be stored in a dry area with low temperature (≤25°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.

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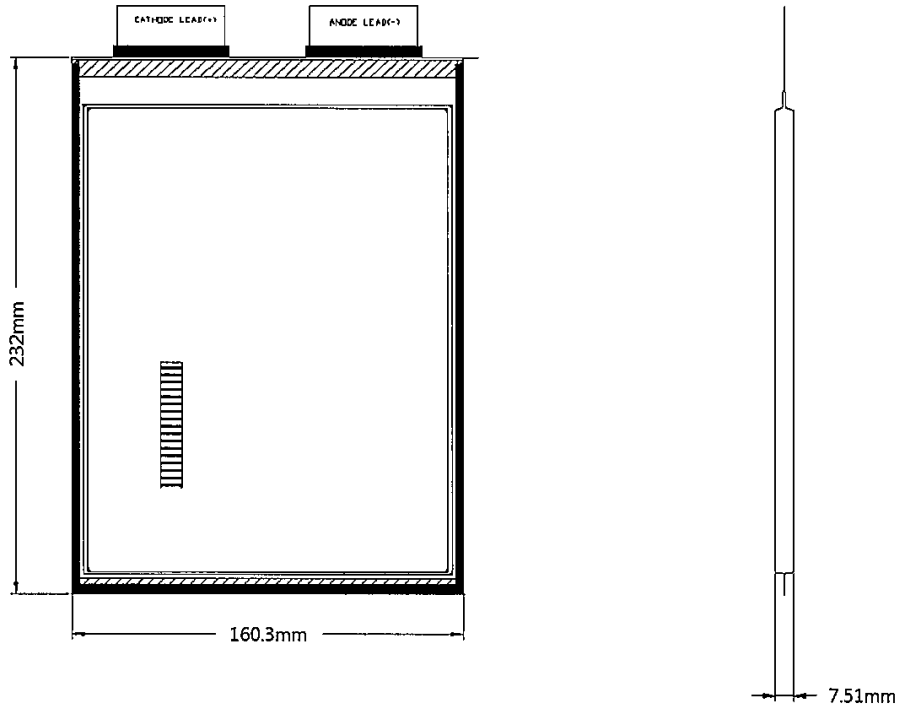
6. Dimensional Drawing

C1.5S Dimension



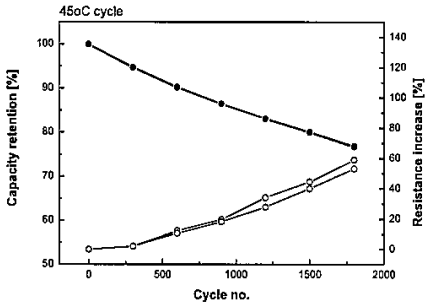
Appendix

A.1 Cycle life at selected conditions

A.1.1 Cycle Life (DOD100%)

- Test condition

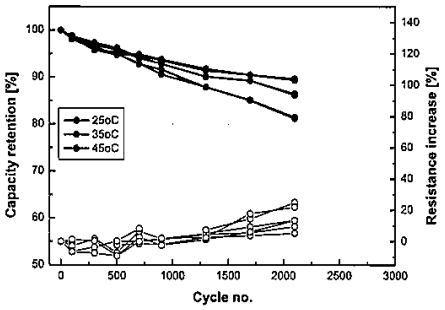
- Charge : 1C CCCV, Vmax=4.15V, Imin=1.25
- Discharge : 2C, Vmin=2.8V
- SOC range : SOC 0~100%
- Temperature : 45℃
- Rest time : 10 min after charge / discharge



A.1.2 Cycle Life (DOD77%)

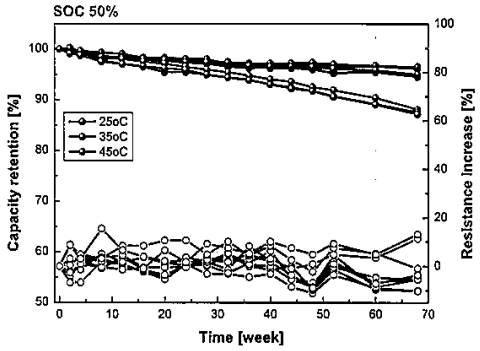
- Test condition

- Charge : 1C CCCV, Vmax=4.07V, Imin=1.25A
- Discharge : 2C, reset the Vmin after 200 or 400cycles unit at test temperature.(3.4~3.2V)
- SOC range : SOC 15~92%
- Temperature : 25, 35, 45℃
- Rest time : 10 min after charge / discharge



A.2 Storage life at selected conditions

A.2.1 Storage Life at SOC 50%



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 1C discharge condition (4.1.2)
- Then repeat the 1C charge and 1C discharge cycle (4.1.3) for three times.
- Get the third discharge capacity as the capacity for each check point.

A.4 Cell information for BMS & Pack design guide

A.4.1 Cell information for BMS design guide

Cell type : L3	Symbol	Value	comment	Refer to
2nd over voltage	OV2	4.45 V	If the voltage of cell is over than OV2, the cell can be permanent damaged and not reversible. User never used cell over OV2.	"2.4.2 2nd over voltage limit"
1st over voltage ~ 2nd over voltage			The margin to safety use cell.	
1st over voltage	OV1	4.3 V	The threshold of OV1	
Max. operating voltage for regen. Pulse ~ 1st over voltage		4.15 – 4.3 V	The power derating is applied in this range.	"2.4.1 1st over voltage limit"
Max. operating voltage for regen. Pulse	Vmax_P	4.15 V	If the voltage of cell is over Vmax_P, the power derating should be started.	= Max. operating V + X [X = 0 for C1.5S]
Max. operating voltage	Vmax_O	4.15 V	The threshold of Vmax_O	2.1.5 Standard Charge : Constant Voltage
Max. operating voltage ~ Min. operating voltage		4.15 – 2.8 V	The range of cell voltage to safety use.	
Min. operating voltage	Vmin_O	2.8 V	The threshold of Vmin_O	
Min. operating voltage ~ Under voltage limit		2 ~ 2.8V	The margin to safety use cell.	
Under voltage limit	UV	2.0 V	If the voltage of cell is under UV, the cell can be permanent damaged and not reversible. User never used cell under UV.	2.4.3 under voltage limit
Max Safety temp. ℃	Tmax	55 ℃	If the temperature of cell is over Tmax, the cell can be permanent damaged and not reversible. User never used cell over Tmax.	2.3.2 ; Max temperature
Max Safety temp. ℃ ~ Max operating temp. ℃		55 - 45	The margin to safety use cell. The power derating should be applied.	
Max operating temp. ℃	Tmax_O	45 ℃	If the temperature of cell is over Tmax_O, the power derating should be started.	

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Max operating temp. ℃ ~ Min operating temp. ℃		45 - 10	the range of cell temperature to safety use.(when charging)	
Min operating temp. ℃	Tmin_O	10 ℃	If the temperature of cell is under Tmin_O, the charging power derating should be started.	
Min operating temp. ℃ ~ Min Safety temp. ℃		10 - -30	The margin to safety use cell. The charging power derating should be applied.	
Min Safety temp. ℃	Tmin	-30 ℃	If cell is used under Tmin, the cell can be permanent damaged and not reversible. User never used cell under Tmin.	
Max. operating current	Imax		It is decided by the required power and the structure of Pack. (ex. Busbar, current sensor, heat and so on) User never used cell over Imax.	
Max. operating current ~ Min. operating current		-	The range of cell current to safety use.	
Min. operating current	Imin		It is decided by the required power and the structure of Pack. (ex. Busbar, current sensor, heat and so on) User never used cell under Imin.	

A.4.2 Cell information for Pack design guide

Cell type : C1.5S	Symbol	Value	comment	Refer to
Max. allowed pressure	Pmax	350 kPa		
Min. required pressure	Pmin	30 kPa		

A.4.3 Abbreviation

Acronym / Term	Full Form / Definition
SOC	State of charge
SOH	State of health
BMS	Battery Management System
CAN	Controller Area Network
DV	Design Validation

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Acronym / Term	Full Form / Definition
HV	High Voltage
V	Voltage
I	Current
MSD	Manual service disconnect
IATA – DGR	International Air Transport Association – Dangerous Goods Regulations
IMDG code	International Maritime Code for Dangerous Goods
ADR	The European Agreement concerning the International Carriage of Dangerous Goods by Road
TBD	To Be Determined
TBC	To Be Confirmed
USOC	User State-Of-Charge
SCCR	Short Circuit Current Rating
APQP	Advanced Product Quality Planning
ASIC	Application Specification Integrated Circuit
ASIL	Automotive Safety Integration Level
ASPICE	Automotive Software Process Improvement & Capability Determination
BDU	Battery Disconnect Unit
BMS	Battery Management System
CAN	Controller Area Network
DIA	Development Interface Agreement
DPR	Design Prerequisites
DTC	Diagnostic Trouble Code
DV	Design Validation

Acronym / Term	Full Form / Definition
EMC	Electro-Magnetic Compatibility
FTA	Fault Tree Analysis
HV	High Voltage
HW	Hardware
PHEV	Plug-in Hybrid Electric Vehicle
PV	Product Validation
SOH	State-Of-Health
SW	Software
TBD	To Be Determined
TBC	To Be Confirmed
USOC	Usable State-Of-Charge
V	Voltage

LG Chem
LGCNA/wangwenjun

附件2： 产品型号(Cell ID)

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