Technical Customer Information

Product:

Lithium-Ion cell for Electrical Vehicles

Type:

Li-Ion cell 94Ah

SDI Part Number:

CS0940R00***

Schematic Drawing:

Comments:

Before any kind is carried out using the Li-Ion cell, the user must be familiar with the contents of this document. The instructions must be observed unreservedly.

Change history

Version	Date	Reason for change	Author	Release
2	2016-04-28	- Revision for DMC label rule and fuse type. - Update charge operating current limit.	Hyojun Kwak	

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1. INTRODUCTION

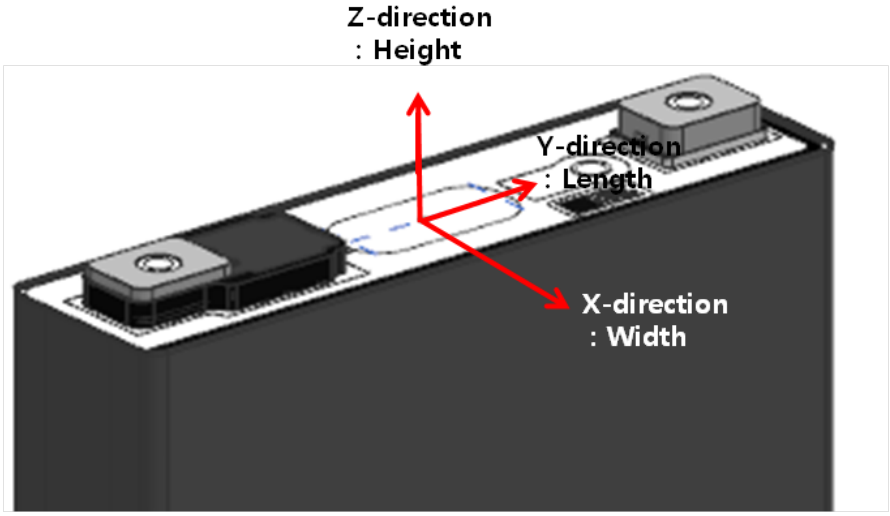
1.1. Purpose of document

This TCI document describes the characteristics and handling information of the rechargeable lithium-ion cell manufactured and supplied by Samsung SDI Co., Ltd.

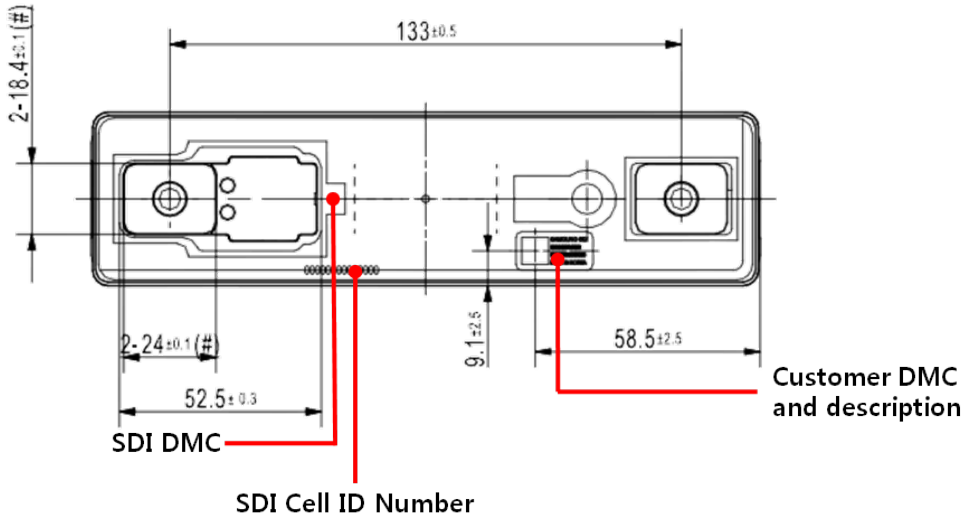
1.2. Confidentiality

The information contained in this document is intended solely for the use of the individual or entity that is authorized to receive it. It contains confidential or privileged information. Any disclosure, copying, distribution or taking an action in reliance on the contents of this document is strictly prohibited and may be unlawful.

1.3. Coordinate system



2. CELL DATA



2.1. Cell identification

2.1.1. Customer DMC and description

DMC barcode rule

Example	CS00940R00XX (1)	02031552900768 (2)	3650 (3)	15611 (4)	0486 (5)	9530 (6)

No	Contents	Digit	Information
1	Product code	12	CS00940R00XX
2	Cell ID	14	02 (A) 03 (B) 15529 (C) 00768 (D) (A) Production location : 02(Ulsan), 11(Xian) (B) Line number : 03(Line#3) (C) Production date : 15529 (2015. 5. 29) (D) Serial number
3	OCV value	4	XXXX
4	OCV measurement date	5	15611 (2015. 6. 11)
5	IR value	4	XXXX
6	Capacity	4	XXXX
		43	

Above label is attached on the top insulation film for customer

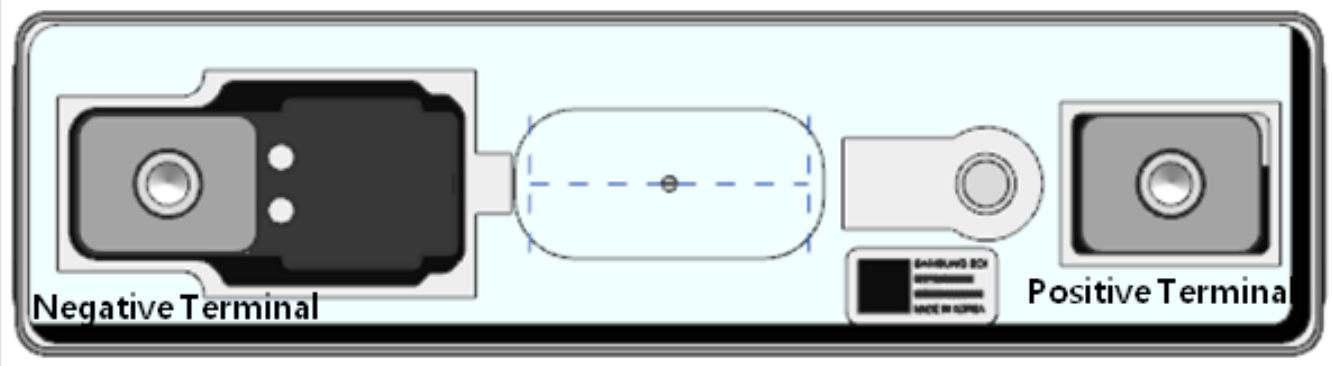
2.1.2. Samsung SDI DMC and Cell ID

The DMC code and ID numbers imply the same information. Both are inscribed on the cap plate.

Cell ID contents	Data type	Number of code (20 digits)	Example
Production location	Numerical	2	02 Ulsan
Production line	Numerical	2	01 1Line
Production Year/Month/Date	Numerical and Alphabetical	5	YYMDD (Month description) (Sep:9, Oct:A, Nov: B, Dec:C)
Serial number	Numerical	5	12345
Samsung internal contents	Numerical and Alphabetical	6	Samsung SDI internal control value

2.1.3. Identification of positive and negative terminal

Top insulator is the identifier for the negative pole.



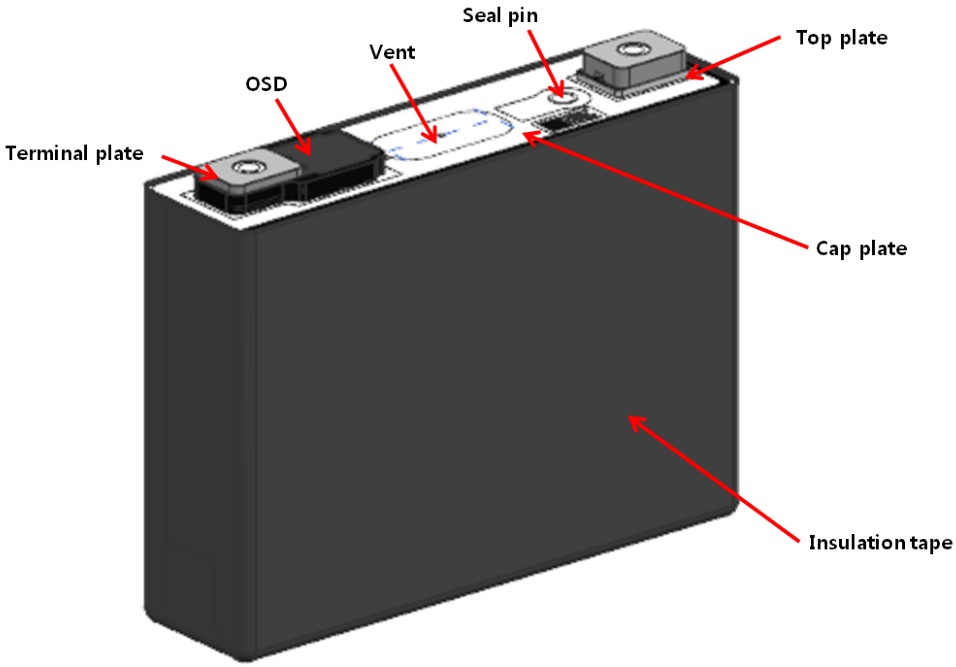
Terminal caps are not applied.

2.2. Mechanical data

2.2.1. Cell mechanical dimensions

Item	Value
Cell Dimensions [mm] Length x Height x Thickness	173.0 x 125.0 x 45.0 : without terminal, without Insulation tape 173.4 x 133.1 x 45.2 : with terminal, with Insulation tape
Cell Weight [g]	Max. 2060
Cell Volume [mL]	973, without terminal

2.2.2. Cell image



2.2.3. Technical cleanliness and cell surface condition

Cell surface side is covered with PET insulation tape (black color).

Cell surface top is covered with PET top insulation film (transparent) except rivet terminal and OSD.

The rest area which is not covered with the insulation tape and top insulation film is bare (aluminum metal).

2.2.3.1. Technical cleanliness of work environment

A technical cleanliness plan should be executed according to automotive industry standards (ISO/TS 16949).

2.2.3.2. Cell cleaning

Cell should be cleaned after the arrival at customer site and before module assembly in order to remove particles on the cell surface.

2.2.3.3. Fat and grease condition on (+), (-) terminal plate and insulation tape (black PET)

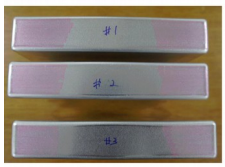
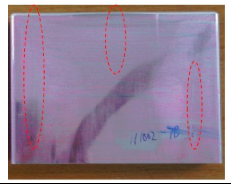
To ensure cleanliness from fat and grease, the terminal surface should meet the surface tension, min. 30mN/m tested by dyne pen as follows.

[Surface tension test]

1) Spread a standard liquid of some specific surface energy with dyne pen : 30-44mN/m (30-44dyne/cm)

2) When some specific tension liquid is applied to the surface, the liquid will either form a continuous film on the surface or pull back into small droplets

3) If the standard liquid remains as a film for 4 seconds, the surface will have a minimum surface of the respective ink value

Position	NO GOOD	GOOD
Cell Bottom		
Cell Wall		

2.2.3.4. Scratch on (+), (-) terminal plate

Rp (The distance between peak and mean line of the surface): Max. 20 ㎛

A detail description of surface conditions is in the file of “Process Mark”.

2.2.3.5. Particles

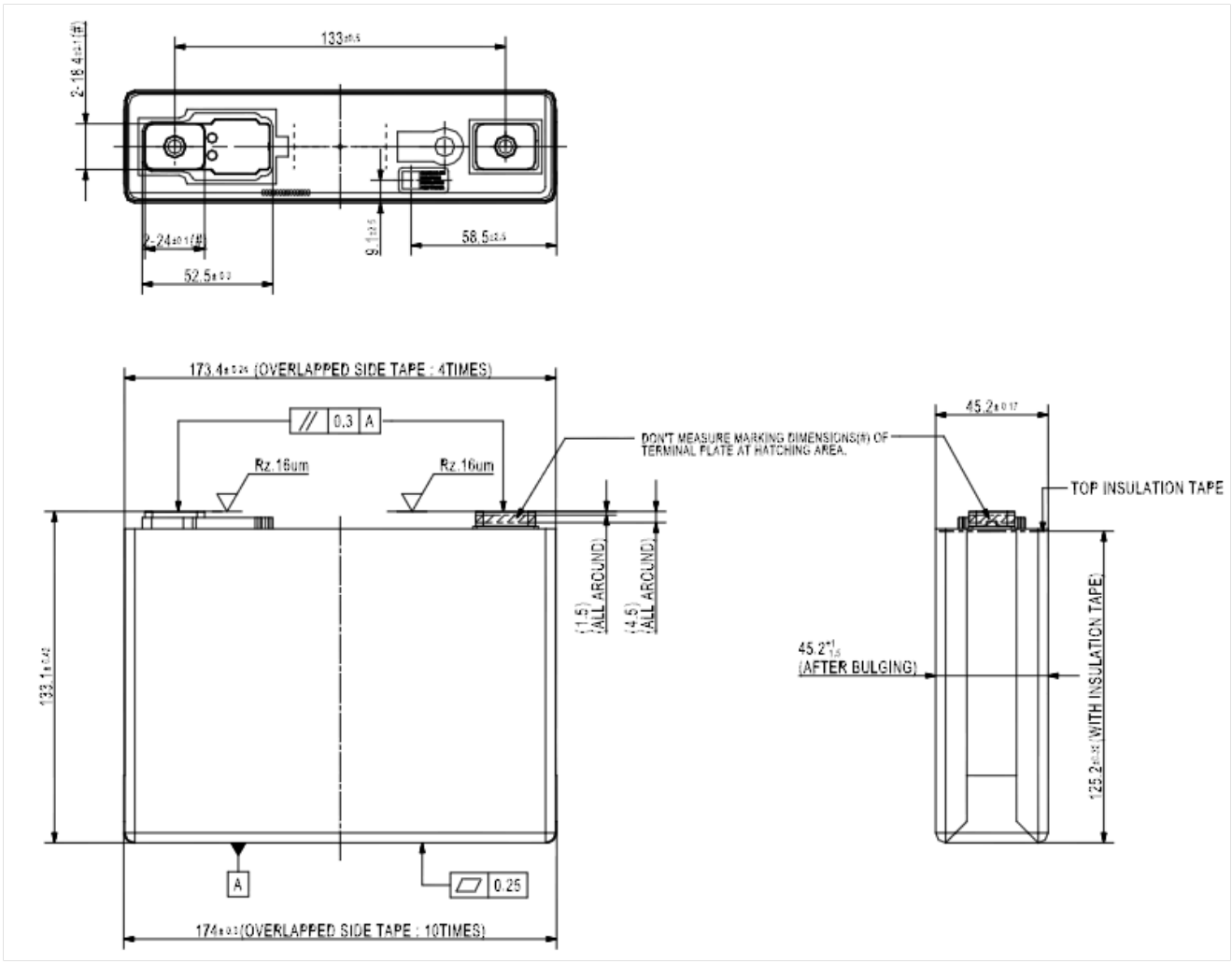
- Particle size

	Metallic	Non metallic	
	Hard	Hard	Soft
Size	Max. 200㎛	Thickness: Max 200㎛ Width/Length: Max. 1㎛	Thickness: Max 200㎛ Width/Length: unlimited

- Amounts of particle (Particle distribution by size, unit: pcs)

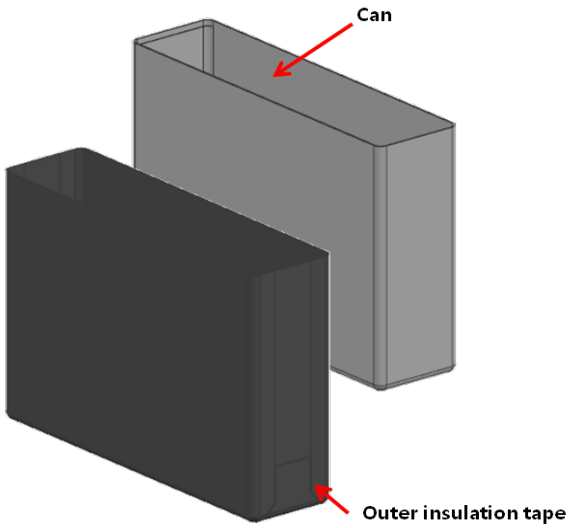
size (㎛)	50 -100	100 - 150	150 - 200	200 - 400	400 - 600	600 - 1000	> 1000
Amounts allowable (ea)	150	20	20	15	10	5	-

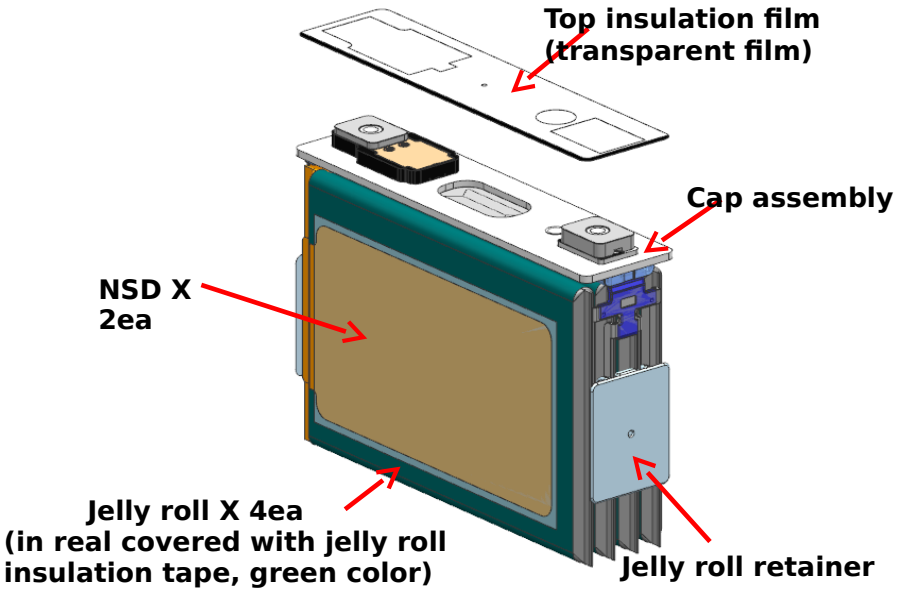
2.2.4. 2D drawing



Special characteristic dimensions	Measuring procedure	Specification [mm]	References
Length of cell	Length of cell is measured by 3D equipment.	173.4 +/- 0.24 174.0 +/-0.3(Lower side)	Chapter 7.1.1
Height of cell including terminal	Cell is located on the measuring table. The height of cell is measured by 3D equipment.	133.1 +/- 0.42	Chapter 7.1.2
Roughness of terminal plate	Cell is located on the measuring table. Roughness of top side of each terminal is measured by roughness measurement tool along specified line.	Max. Rz 16um	Chapter 7.1.3
Parallelism	(+),(-) Height between bottom of the cell and terminal plate is measured based on the reference line at the bottom of the cell. Difference of max. and min. value is described.	Max. 0.3	Chapter 7.1.4
Thickness of cell at center	Thickness of cell is measured by 3D equipment.	45.2 +1/-1.5	Chapter 7.1.5
Thickness of cell at corner	Thickness of cell at upper corner is measured by 3D equipment. Contact probe pin on the measure the thickness of point 1/2/3/4.	45.2 +/- 0.17	Chapter 7.1.6

2.2.5 Exploded diagram





2.2.6. Parts list

No.	Component	Material	Quantity per cell
1	Can	Al3005-H14	1
2	Jelly-roll	-	4
3	NSD	Cu_C1100	2
4	PFA ball	PFA	1
5	Seal pin	Al_A1050-O	1

6	Cap plate	Al_A3003-H14	1
7	(-)Rivet terminal_Friction welded	Al_A3003-H14 + Cu_C1100	1
8	(+)Rivet terminal	Al_A3003-H14	1
9	Safety vent	Al_A1050-O	1
10	OSD membrane	Al_A1050-O	1
11	(-)Current collector	Cu_C1100	1
12	(+)Current collector, Injection molded	Al_A1050-H18	1
13	Terminal plate	Al_A3003-H14	2
14	Top plate	SUS 304 with polymer coating	1
15	Seal gasket	PFA	1
16	OSD insulator	PC	1
17	OSD insulator cover	PPS	1
18	Connection plate	Al_A3003-H14	1
19	(+)Bottom insulator	PP	1
20	(-)Seal gasket insulator	PFA	1
21	Jelly roll retainer	PP	2
22	Outer top insulation film(Transparent)	PET	1
23	Outer side insulation tape(Black)	PET	1

2.2.7. Part design

2.2.7.1. Can

Parts	Material
CAN	A3005-H14

2.2.7.2. Insulation tape (Cell outer side, Low Voltage insulation tape)

Parts	Material	LV specification
Cell outer Low Voltage	PET,	Applied voltage: <100 V AC

Insulation tape	Black color, Thickness: 0.1mm	Limit Current: <10 mA

Removal force of insulation tape: Over 2 times of the cell weight on the surface with the diameter of 80mm

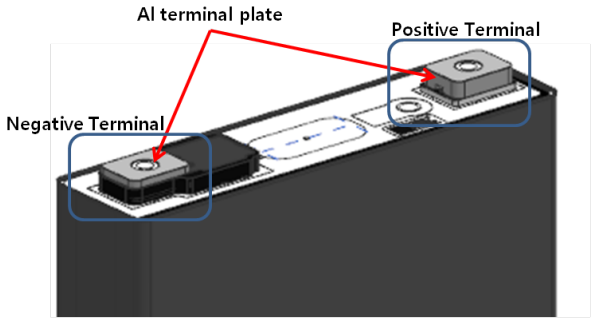
2.2.7.3. Positive and negative terminal

1) Material: Positive terminal (Al 3003 H14), Negative terminal (Friction welded: Al 3003 H14 & Cu 1100)

2) Function: In negative terminal, Al and Cu material are friction-welded.

3) Tensile strength: Over 3,000 N

4) Bending strength: No breaking in welded part at 10 degrees



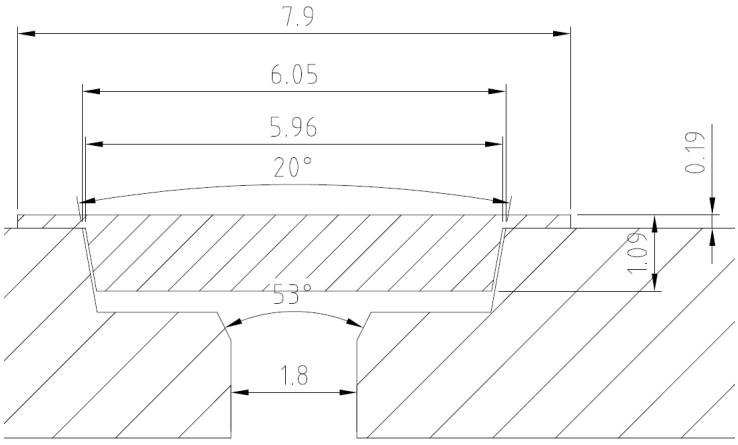
2.2.7.4. Terminal Cap

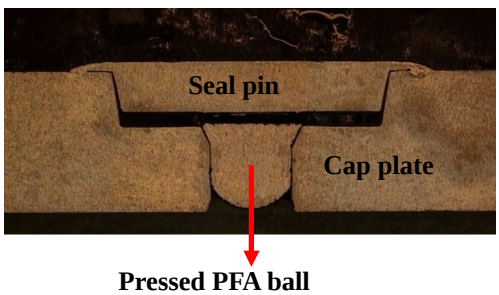
Terminal caps are not applied

2.2.7.5. Top insulation film

Parts	Description
Outer Top insulation film	Material : PET, Thickness : 0.1mm (Transparent)

2.2.7.6. Seal Pin for electrolyte Injection Hole





2.3. Electrical and other data

2.3.1 Capacity (at customer incoming)

1) Standard capacity: min.94.0 Ah (1/3C discharge, 25℃)

2)1C capacity: min. 91.6Ah (1C discharge, 25℃)

2.3.2. Performance (power)

Temperature	-	Power [W]					
		Duration time	SOC90	SOC50	SOC30	SOC20	Max current
25℃	Discharge	5sec	1549	1411	1380	1360	413A
		30sec	1104	1010	988	969	294A
	Charge	5sec	856	1633	1604	1593	413A
		30sec	609	1161	1134	1129	294A
-5℃	Discharge	5sec	1342	1180	1015	638	413A
		30sec	980	936	806	479	294A
	Charge	5sec	134	657	753	761	413A
		30sec	147	693	842	852	294A
-25℃	Discharge	5sec	1002	783	387	218	413A
		30sec	804	644	305	161	294A
	Charge	5sec	21	145	168	178	413A
		30sec	19	117	140	140	294A

2.3.3. DC-IR

Temperature	-	DC-IR [mΩ]					
		Duration time	SOC90	SOC50	SOC30	SOC20	Max current
25℃	Discharge	5sec	0.68	0.68	0.68	0.74	413A
		30sec	0.94	0.90	0.91	1.03	294A
	Charge	5sec	0.65	0.65	0.65	0.67	413A
		30sec	0.92	0.90	0.81	0.88	294A
-5℃	Discharge	5sec	1.86	2.00	2.46	3.80	413A
		30sec	2.32	2.44	3.00	5.07	294A
	Charge	5sec	4.10	2.99	2.96	3.10	413A
		30sec	3.74	2.83	2.65	2.77	294A
-25℃	Discharge	5sec	3.87	4.32	8.71	18.01	413A
		30sec	4.39	5.09	10.69	19.61	294A
	Charge	5sec	26.02	13.47	13.30	13.17	413A
		30sec	28.34	16.73	15.97	16.66	294A

2.3.4. OCV (Average value)

Temp.	OCV (V)											
	SOC%	100	90	80	70	60	50	40	30	20	10	0
25℃	Discharge	4.136	4.016	3.913	3.825	3.756	3.678	3.641	3.615	3.579	3.499	3.420
	Charge	4.133	4.022	3.921	3.833	3.765	3.690	3.653	3.627	3.598	3.517	3.433

※ Measurement accuracy (tolerance)

- Voltage: ± 2.5mV
- Current: ± 0.45A
- DC-IR: ± 0.015 mΩ

2.3.5. Safety test results

Item		Test condition		EUCAR Level	Remark
Mechanical abuse	Nail Penetration	Φ3mm,40mm/sec , SOC100%(QC/T)		**5L4**	<EUCAR safety level >
	Controlled crush	15% and 50% of cell's height or force of 1000times cell mass,	X1	**5L2**	
			X2	**5L2**	Level 0 : No effect
			+Y	**5L2, 4L4**	
			-Y	**3L2,2L4**	Level1 : Passive protection Activated
			+Z	**3L3**	
Thermal abuse	Thermal stability	150℃, heat-up rate 5℃/min Stay 30min, SOC100%		**5L4**	Level2 : Defect/Damage
		200℃, heat-up rate 5℃/min Each step temperature stay 30min		**1L6**	
Electrical abuse	Overcharge	Cell	CC/CV mode, 32A, 6V, SOC200% cutoff	X	**5L2**
				-Y	**5L2**
				+Z	**5L2**
		Module (6S)	CC/CV mode, 32A, 36V, SOC200% cutoff	+Z	**6L3**
	Forced discharge	CC discharge, 1C, 2.5hr		**5L2**	Level3 : Leakage, Δ mass < 50% Level4 : Venting, Δ mass > 50% Level5 : Fire or Flame Level6 : Rupture Level7 : Explosion
	External short circuit	Less than cell resistance(0.3mΩ total), 10min		**5L2**	
		5mΩ 10min		**5L2**	

2.3.6. Environmental test results

Environmental tests		Requirements	Test result
2.3.5.1	Drop test	≤ L2	**12L1, 3L2**
2.3.5.2	Vibration test	≤ L2,	**SOC100 : 98.9%,**

		Capacity/OCV/ AC-IR Change rate < ± 20%	**SOC0 : 101.3%**
2.3.5.3	Thermal shock test (air)		**98.2%**
2.3.5.4	Damp heat, steady-state		**95.0%**
2.3.5.5	Damp heat, cyclic		**100.9%**
2.3.5.6	Change of temperature test		**100.2%**
2.3.5.7	Thermal shock in fluids		**96.4%**
2.3.5.8	Chemical resistance with electrolytes		**100.2%**
2.3.5.9	Ozone resistance		**99.6%**
2.3.5.10	Mechanical shock		**98.6%**
2.3.5.11	Additional shock		**5L1**
2.3.5.12	Sequence test (Series A)		**4L1**
2.3.5.12	Sequence test (Series B)		**96.7**
2.3.5.12	Sequence test (Series C)		**95.5%**
2.3.5.12	Sequence test (Series E)		**98.0%**

2.3.7. Life

Test condition	**0.5C/1C cycle, 25ºC (DOD 80, SoC100~20)**	**60ºC, SOC100%**
	0.5C CC, 4.15 V CV charge, 1/5C cut off 1.0C CC, 3.579 V CV charge, 1/5C cut off	Stored at SOC100% , at 60ºC,
Life at EOL80%	>3,500 cycles	>2.5 yr

<Capacity decrease during cycle>

0.5C/1C cycle at 25°C	Number of cycle, cycles							
(DOD 80, SoC100~20)	0	500	1000	1500	2000	2500	3000	3500
Capacity, %	100.0	98.7	96.0	93.4	90.7	88.1	85.5	82.9

<Capacity decrease during calendar>

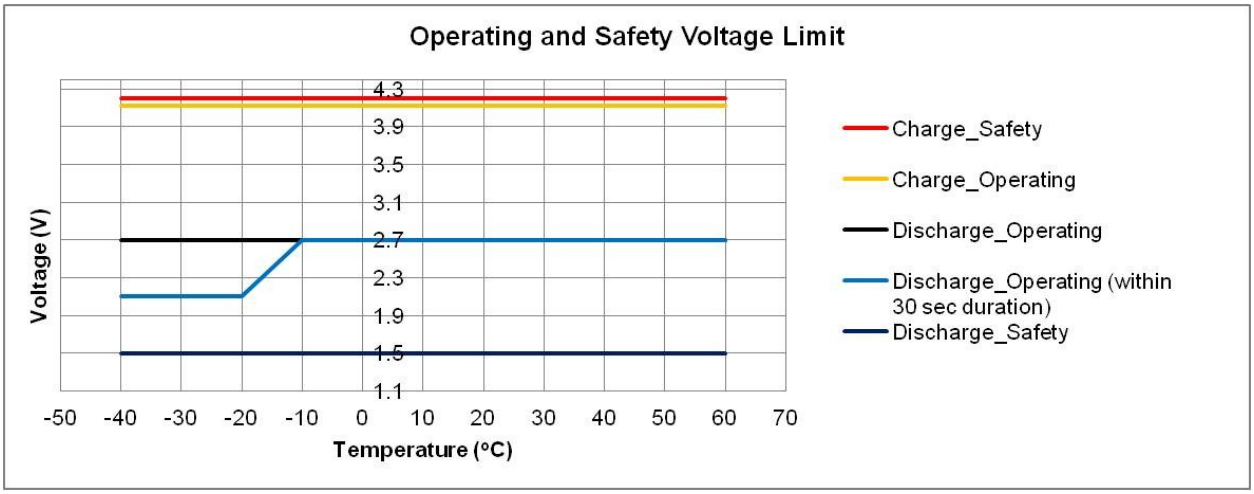
Calendar life at 60°C,	Time, days										
SOC100%	0	100	200	300	400	500	600	700	800	900	1000
Capacity, %	100.0	95.3	92.9	90.8	88.9	87.1	85.4	83.8	82.2	80.7	79.2

3. OPERATION AND SAFETY LIMIT ON CELL LEVEL

3.1. Voltage limit

Voltage limit of charge and discharge			
Limit	**Item**	**Value**	**Remark**
Safety limit	Charging voltage	4.25 V	If charge voltage violates 4.25V, SDI cannot guarantee safety of cell. Cells which violated safety voltage limit have not to be used electrically and right after violation and must be changed immediately. >=4.245 V/ Max. 2000msec

	Discharging voltage	1.50 V	If discharge voltage violates 1.5V, SDI cannot guarantee safety of cell. Cells which violated safety voltage limit have to be changed right after violation. <=1.8 V/ Max. 2200msec
Operation limit	Charging voltage	4.15 V	$X_{err, lim}$ represents the error limit for voltage limit violations 10 < T : 0.02 V^2s -25 < T ≤ -10 : Linear Interpolation T ≤ -25 : 0.05 V^2s
	Discharging voltage	2.70 V	2.1 V at below -20°C within 30 sec duration $X_{err, lim}$ represents the error limit for voltage limit violations -10 < T : 0.8 V^2s -25 < T ≤ -10 : Linear Interpolation T ≤ -25 : 0.45 V^2s



3.2. Current limit

3.2.1. Safety and operating current limit - Algorithm of current limits

Both the “moving average method” and the “low pass filter method” are equally valid to both determine and log the current limits. SDI agrees that the customer chooses the method which fits best to his function.

Operating Current Limit on Charge ➔

$$\int_{t-100}^{t} I^2 \cdot dt \le \int_{0}^{100} I_{ch\_max\_continuous}^{\ 2} \cdot dt$$

$$\begin{cases} I = 0, \text{ when } I \le 0 \text{ (discharge)} \\ I = I, \text{ when } I > 0 \text{ (charge)} \end{cases}$$

And, charging current $\le I_{ch\_max\_peak}$

Remark) $I_{ch\_max\_continuous}$ = *max continuous charge current at each temperature*

Operating Current Limit on Discharge ➔

$$\int_{t-150}^{t} I^2 \cdot dt \le \int_{0}^{150} I_{dch\_max\_continuous}^{\ 2} \cdot dt$$

$$\begin{cases} I = -I, \text{ when } I \le 0 \text{ (discharge)} \\ I = I, \text{ when } I > 0 \text{ (charge)} \end{cases}$$

And, discharging current $\le I_{dch\_max\_peak}$

Remark) $I_{dch\text{-}max\_continuous}$ = *max continuous discharge current at each temperature*

 Current limit is specified in the clause 3.2.2 and 3.2.3.

b) The current limits with low pass filter method

Basis of current data logging is

$I_{rel,\,ch}$: Relative low-pass filtered root-square value of square of charge current (only charge direction for observation of lithium plating)

$I_{rel,\,abs}$: Relative low-pass filtered root-square value of square of current (absolute current for observation of internal cell heat generation)

The values are calculated as follows:

$I_{LP,\,sq,\,ch,\,k} = a * x_{k-1} + (1 - a) * I_{LP,\,sq,\,ch,\,k-1}$ with $a = T_{sample}$ / Tau and $x = \{I^2$ if $I > 0$ else $x = 0\}$

$I_{rel,\,ch,\,k}$ = square_root $(I_{LP,\,sq,\,ch,\,k})$ / $\sqrt{(I_LP^2)}$_lim_ch

$I_{LP,\,sq,\,abs,\,k} = a * y_{k-1} + (1 - a) * I_{LP,\,sq,\,abs,\,k-1}$ with $a = T_{sample}$ / Tau and $y = I^2$

$I_{rel,\,abs,\,k}$ = square_root $(I_{LP,\,sq,\,abs,\,k})$ / $\sqrt{(I_LP^2)}$_lim_dch

 Current limit is specified in the clause 5.3.

3.2.2. Operation current limit

A cell will follow normal degradation behavior below operation current limit.

In case of undesignated temperature, values of I_{max_peak} & $I_{max\_continuous}$ can be determined by linear interpolation between two adjacent conditions on table below.

3.2.2.1. Discharge operation current limit

Temperature (°C)	Discharge Operating Current Limit			
	I_{max} (Operation)	Continuous Current Limit		
		Duration (sec)	I_{rms_limit}	
			I_{rms} (A)	Allowable usages over life
60	413	150	223	100%
50	413	150	223	100%
40	413	150	223	100%
35	413	150	210	100%
30	413	150	196	100%
25	413	150	180	100%
20	413	150	166	100%
15	413	150	153	100%
10	413	150	136	100%
5	413	150	124	100%
0	413	150	108	100%
-5	413	150	93	100%
-10	413	150	77	100%
-15	413	150	74	100%
-20	413	150	62	100%
-25	413	150	57	100%
-30	413	150	46	100%
-40	413	150	33	100%

3.2.2.2. Charge operation current limit

Temperature (°C)	Charge Operating Current Limit			
	I_{max} (Operation)	Continuous Current Limit		
		Duration (sec)	I_{rms_limit}	
			I_{rms} (A)	Allowable usages over life
60	270	100	47	100%
55	270	100	47	100%
50	270	100	47	100%
45	270	100	47	100%
40	270	100	47	100%
35	270	100	47	100%
30	270	100	47	100%
25	270	100	47	100%
20	270	100	47	100%
15	270	100	41	100%
10	270	100	32	100%
5	270	100	24	100%
0	237	100	18	100%
-5	185	100	12	100%
-10	125	100	7.2	100%
-15	62	100	4.3	100%
-20	33	100	2.7	100%
-25	22	100	1.7	100%
-30	7	100	1	100%
-40	1	100	0.4	100%

3.2.3. Safety current limit

Temperature (°C)	Safety Current Limit			
	Discharge		Charge	
	I_{max} (safety)	max. allowed duration (msec)	I_{max} (safety)	max. allowed duration (msec)
60	500	700	360	700
50	500	700	360	700
40	500	700	360	700
35	500	700	360	700
30	500	700	360	700
25	500	700	360	700
20	500	700	360	700
15	500	700	360	700
10	500	700	360	700
5	500	700	360	700
0	500	700	360	700
-5	500	700	245	700
-10	500	700	165	700
-15	500	700	83	700
-20	500	700	45	700
-25	500	700	30	700
-30	500	700	9.4	700
-40	500	700	1.8	700

3.3. Temperature limit

Temperature limit of Operating and Safety			
Limit	**Item**	**Value**	**Remark**
Safety limit	Max. storage	80°C	This is to be ensured in an ambient temperature range (Electrolyte gas generation, OSD deformation vent opening, leakage, etc.)
	Min. storage	-40°C	This is to be ensured in an ambient temperature range
	Max. operation	80°C	This is to be ensured in a cell core temperature
	Min. operation	-40°C	This is to be ensured in a cell core temperature
Operation limit	Max. operation	60°C	This is to be ensured in a cell core temperature
	Min. operation	-40°C	This is to be ensured in a cell core temperature

3.4. Mechanical limits

3.4.1. Acceleration limit for mechanical shock

x direction : ±60g, y, z direction: ±35g

3.4.2. For other mechanical limit, refer to safety and environmental test result, max compression force

3.5. Active safety function - NSD, Vent, OSD, Fuse, SFL

3.5.1. NSD (Nail Safety Device)

1) Function: Pre-Internal short and voltage down through NSD during nail penetration

2) Thickness: 0.08mm

3) Quantity: 2ea (outside of J/R)

3.5.2. Safety Vent

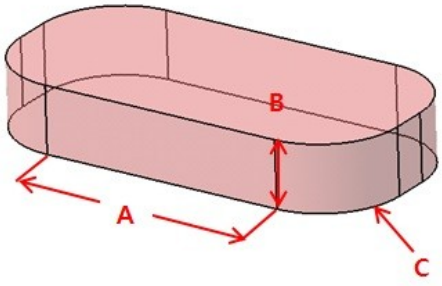
1) Function: Degassing during safety event to maintain inner pressure in a cell low.

2) Degassing area: 750mm^2

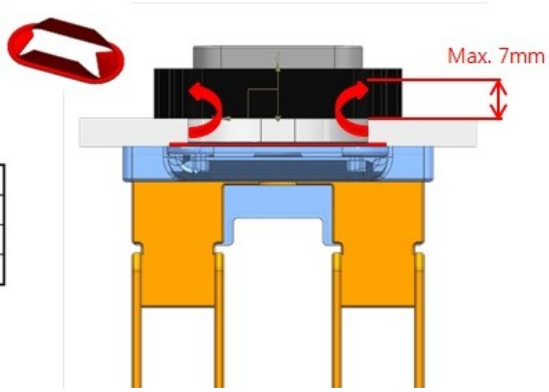
3) Operation pressure: 0.70 ± 0.1 MPa

4) Notch location: Bottom side

5) Needed space after vent activation:



mm	94Ah
A	25
B	6.85
C	R8



3.5.3. OSD (Overcharge Safety Device) and Fuse,

1) Components & material : Membrane (Al 1050 – O), Connection plate (Al 3003 H14), Fuse (Al 1050 H18)

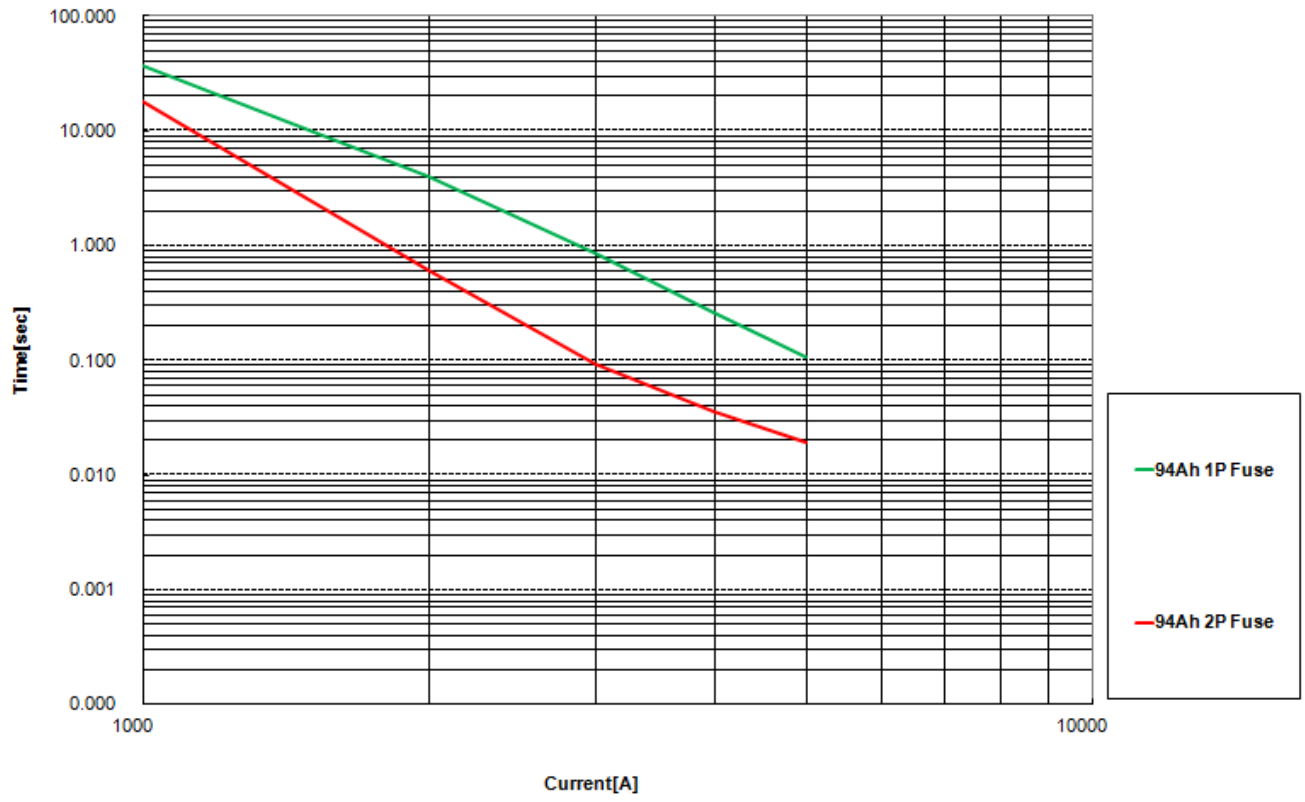
2) Function: To prevent overcharge at a specific pressure in a cell by forced external short and fuse melting.

3) OSD Operation pressure: 0.30±0.1 MPa

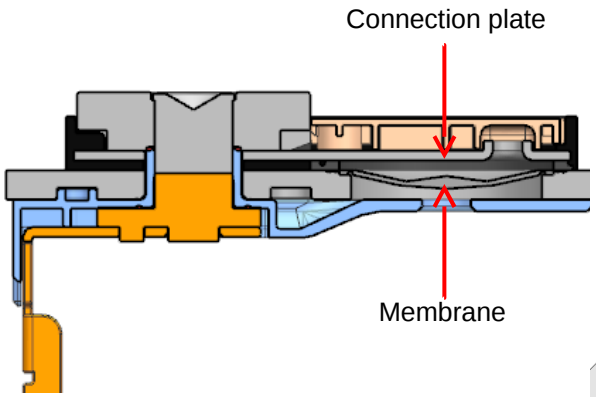
4) Module: Designed for series connection in a module.

***Caution: Once OSD is activated, discharge via terminals is not possible.**

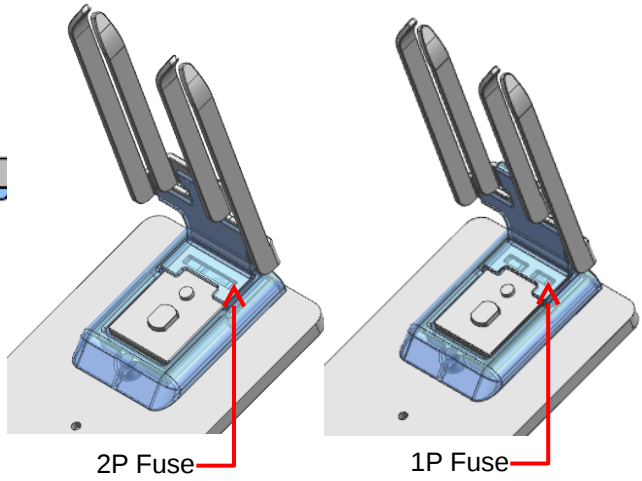
5) Cell fuse melting time vs. current characteristics



6) Image



Negative side



Positive side

3.5.4. SFL (Safety Functional Layer)

1) Material: Alumina (Al_2O_3)

2) Function: To prevent enlargement of short area when internal short event occurs.

(Joule heat enlargement and propagation from internal shortage can be cut off by Alumina SFL layer)

3) Location: On the surface of anode electrode

4) Image

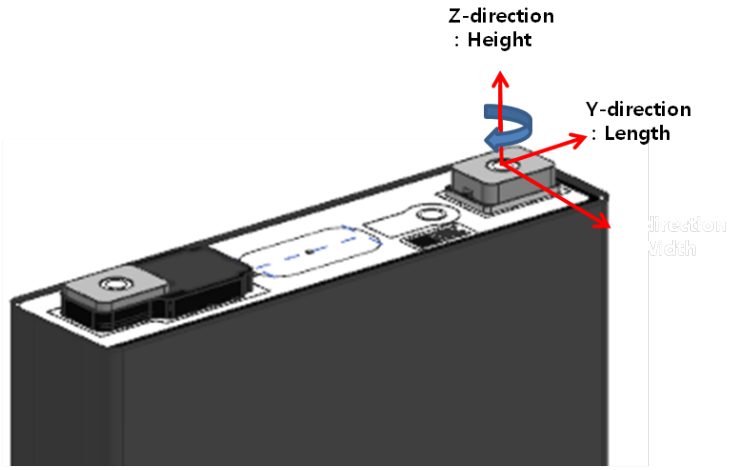
4. PARAMETER FOR MODULE DESIGN AND PROCESS

4.1. Maximum number of parallel connections

 Maximum number of parallel connections: 2 cells

4.2. Cell direction in the module or pack

Cell direction in the module or pack should be maintained the upright (Z-axis) direction. This direction only can be changed after the validation of effects on cells (safety, environmental test, cycle life).

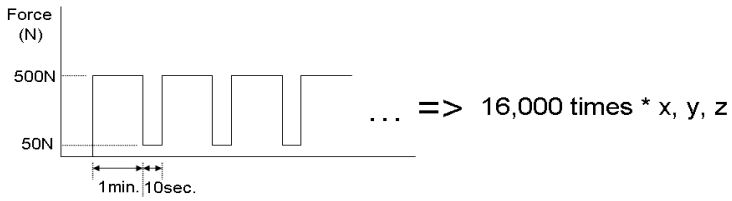


4.3. Max. torque which can be applied to terminal

- Torque strength : Max. 4 Nm in x, y, z direction

4.4. Max. Force which can be applied to terminal

- Static force at terminal: Max. 500 N in x, y, z axis.
- Dynamic force at terminal: Max. 500 N in x, y, z axis (detailed evaluation condition is as follows)



4.5. Compression parameter during module assembly

4.5.1. Compression parameters during module assembly (It will be updated.)

[Condition]

- Compression area: 173 mm X 125 mm
- Compression speed: 0.02 mm/sec (for cell) / 1mm/s (for module)
- Target thickness : 45 mm without insulation tape (for cell) / 45.19 mm * 6 cells = 271.14 mm with insulation tape (for module)
- Duration: 5 min
- Cell SOC: 60%

Items		Unit	Requirement / specification	Current status (@SOC 60%)
Compression force @ BOL	Cell	N	-	Avg. 167
	Module (6 cells in series)			Avg.1236
Relaxation Force	Cell		-	Avg.160

@ BOL	Module (6 cells in series)			Avg. 725

4.5.2. Safety compression force limit during module assembly (TBD)

[Condition]

- Compression area: 173 mm X 125 mm
- Compression speed: 0.02 mm/sec
- Cell SOC: 100%

Phenomena at cell	1 cell	6 cells module
Deformation	31.2kN	31.0kN
Leakage	394kN	48.4kN
Gas emission	862kN	313kN
Ignition	-	457kN

Therefore, the cell or module must not be compressed by more than 31kN. Otherwise cell deformation will occur.

4.6. Swelling force for module strength design

4.6.1. Test condition

1) Cell compress to 45 mm (without insulation film)

2) Charge/discharge condition

- Charge: 0.5C, CC, 4.15 V, 1/5C cut off, rest 10 min
- Discharge: 1C, CC, 2.7 V cut off, rest 15 min

4.6.2. Estimated EOL under 0.5C/1C cycle conditions: 1,200 cycles

4.6.3. Test result after 1,200 cycles

Swelling force	BOL	< 4,000 N
	EOL	< 25,000 N

4.7. Max. allowable storage date before module assembly(TBD)

Logistics scenario	Allowable Nuremberg Warehouse Storage Days as logistics scenarios			
	Sea		Air	
	Normal	Special	Normal	Special
Detail condition	Standard	Boat delay 3 week	Standard	Delay(incl.Trucking) i.e.public holiday, Customs clearance

Capacity	TBD	TBD	TBD	TBD
SOC	TBD	TBD	TBD	TBD

- The number in the table indicates the possible storage day excluding logistics.
- Warehouse temperature should be controlled (Average. 25℃, TBD)
- To satisfy both capacity and SOC specification, capacity(short period) should be standard
- Storage days were calculated for capacity degradation and self-discharge.

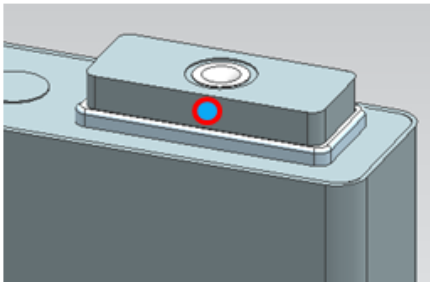
4.8. Thermal parameters

	Thermal conductivity (W/mK)	
	Cross plane	In plane
Applied force on JR	3840 N	356 N
Average Thermal conductivity	0.855 W/mK	17.97 W/mK
	Heat capacity (kJ/kgK)	
Mass of JR	424.6 g	
Average heat capacity	0.875 kJ/kgK	

4.9. Effect of heat on cell for module welding

Welding profile is confirmed by SDI if the welding condition is not changed from 'A' to 'B' except location of temperature measurement during welding. When welding condition is changed additionally, temperature profile should be confirmed by SDI.

For the practical measuring point, center point at the side wall of the positive terminal plate is recommended.



Measuring point A

5. DATA LOGGING REQUIREMENT

Usage data for battery packs and modules shall be recorded for comparison of real-life usage against cell specifications. This data shall contain information about

- Temperature
- Voltage
- Current
- Capacity Throughput

The data generally shall be stored in histograms to provide a compromise between memory consumption and information depth. Because of exchangeability of cell modules certain data has to be stored separately for each module.

(94Ah cell) Data logging summary

6. CELL SHIPPING

6.1. Packaging description and definition

TBD

6.2. Cell lot definition

Lot definition SDI internally

Items	Standards
Lot standards	Formation Batch according to one day anode coating
Limit Condition for sampling	If below conditions would be changed, Lot number has to be changed Anode coating condition change Active material lot change Apply process change items
Estimated lot size	approximately 10,000 cells

6.3. Storage condition at customer

To guarantee required cell performance in specification, incoming inspection of cell should be done within 3 days after transportation to customer side. And cell has to be stored under 30°C condition.

It needs to keep battery cells with packaging (unpacking) for 24 haours at least after unloading from RF(Refrigeration) container if cells are delivered by RF container for temperature equilibrium.

7. CELL CONDITION AT DELIVERY

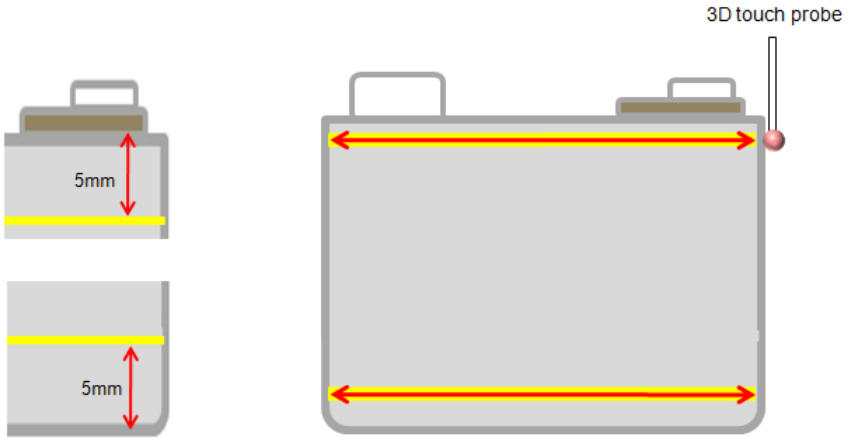
7.1. Measurement methods for all specified inspection items at delivery

7.1.1. Length of Cell

Measuring gauge: 3D equipment (touch probe)

Measuring method

- Cell is on the measuring table.
- Measure the upper point on the Top area of Cell. Lower point on the Bottom area of Cell

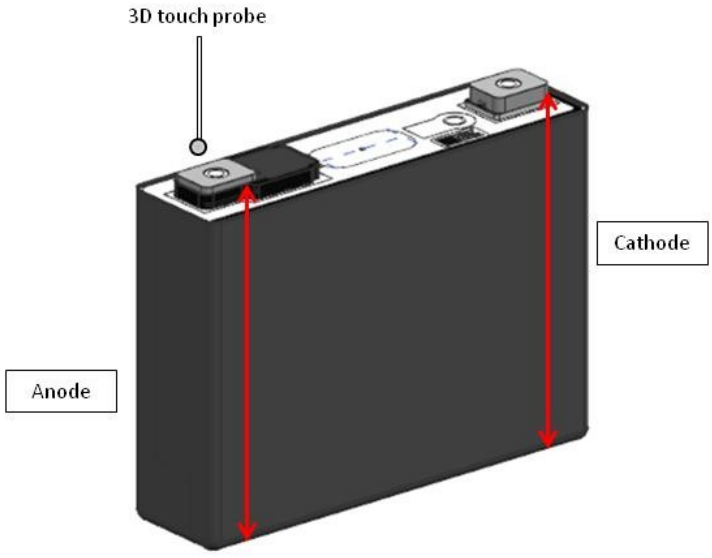


7.1.2. Height of Cell including terminal (or CMM)

Measuring gauge: 3D equipment (touch probe)

Measuring method:

- Cell is on the measuring table
- Measure the Cathode side.
- Measure the Anode side.



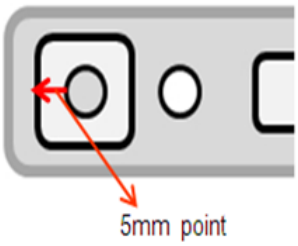
7.1.3. Roughness of Terminal Plate

Measuring gauge: Surface roughness tester

Measuring method :

Set the Surface roughness tester to Zero.

- Cell is measured on the measuring table.
- Roughness of top side of each terminal plate is measured.
- Along the specified line as below picture.
  - → Measure 5 mm line on the Top plate.
  - → Data is saved 5 values during the measurement of 5mm.
  - → And then calculation of Average value.

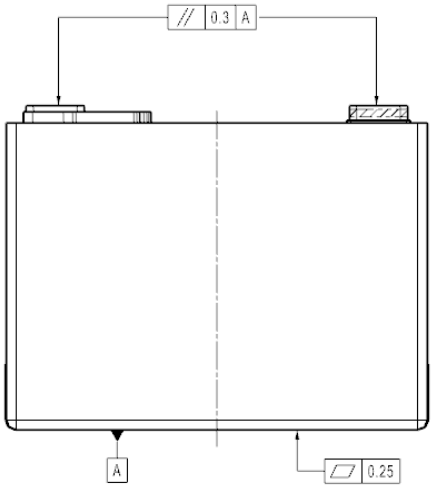


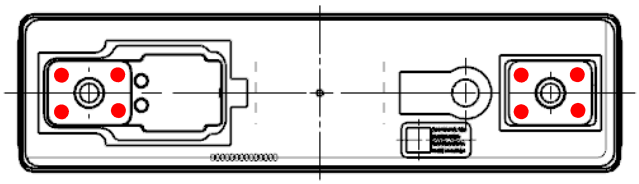
7.1.4. Terminal parallelism

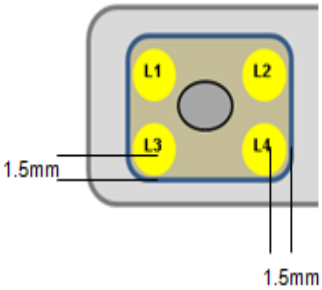
Measuring gauge : 3D equipment (Vision)

Measuring method :

- Put the cell upright on the measuring table
- Measure height of cathode and anode terminal respectively
- Calculate[ABS(A-B)] the difference of each terminal height





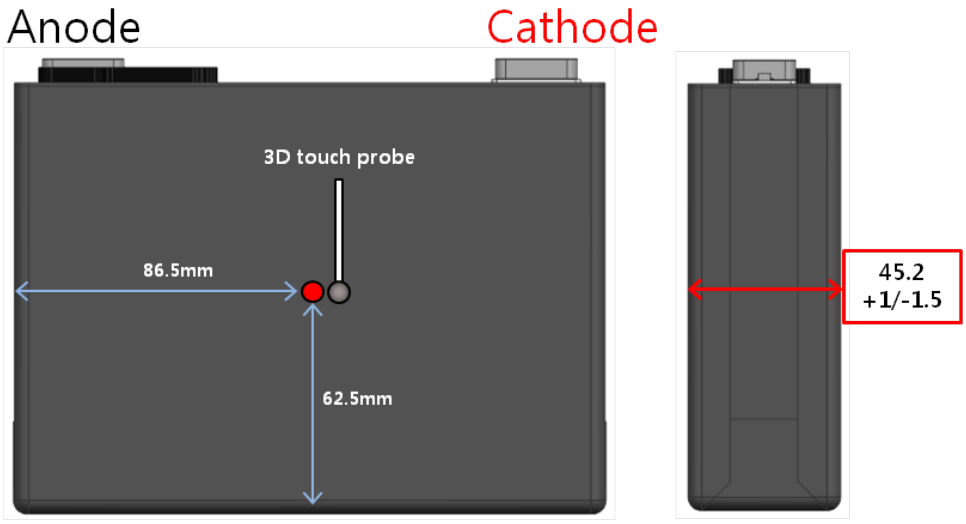


7.1.5. Cell Thickness at center

Measuring gauge: 3D equipment (touch probe)

Measuring method :

- Cell is on the measuring table.
- Contact probe pin on the center of cell and calculate the thickness of cell.

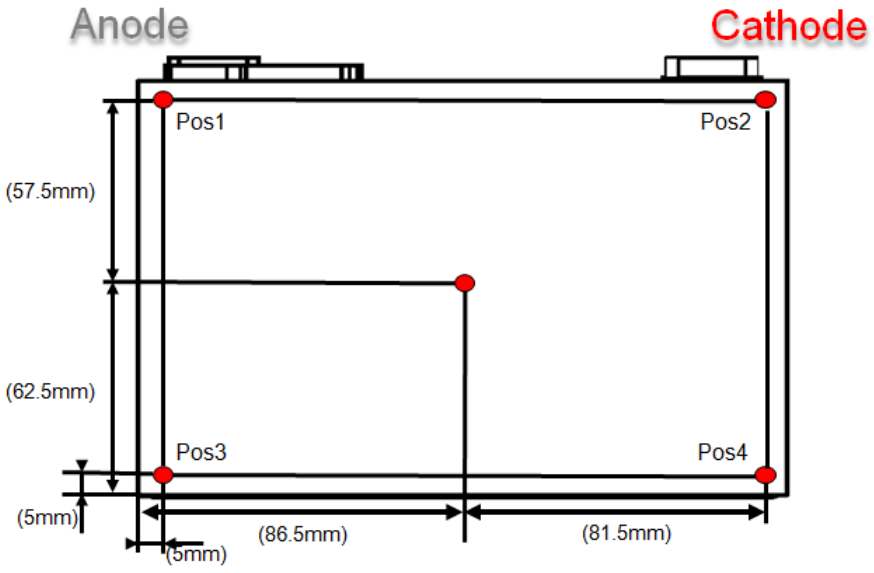


7.1.6. Cell Thickness at corner

Measuring gauge : 3D equipment (touch probe)

Measuring method:

- Cell is on the measuring table.
- Contact probe pin on the measure the thickness of point 1/2/3/4.



7.2. Incoming inspection parameter over time (AC-IR, OCV)

7.2.1. AC-IR : 0.30~0.60 mOhm (at 1kHz, 15~35°C)

7.2.2. OCV(TBD)

- Customer shall check every cell voltage (incoming OCV at customer) before module assembly and sort out if the cell shows higher self-discharge than that of “OCV lookup table” as attached based on Delta OCV calculation.

: Delta OCV = [OCV coded in DMC (outgoing OCV at SDI)] - [Incoming OCV at customer before module assembly]

- Customer shall provide incoming OCV data to SDI in any case of 0-km/field claims.

8. ISSUING DEFECT CELLS TO SDI

Form_Product Return Order

8.1. Contact Information for Cell Defect Claims and Regional pick-up service

: If the cell is defective, do not return and disuse the cell directly. Please contact SDI as following:

: When you return the cells to SDI, please fill in the form “Product Return Order & Problem Findings ".

Overall :

Dr. Andreas Maier

689-701 Samsung SDI, SamNam, UlJu, Ulsan City, Korea (RoK)

TEL. Kiheung Office: +82-31-210-8380 TEL. Ulsan Plant: +82-70-7142-7100

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Mr. heungtaek Shim

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Mr. Kwanhyeong Kim
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Mr. Ricky CHOI
Samsung SDI, 7F-1, No.399, Ruiguang Rd., Neihu Dist., Taipei Taiwan (ROC)
Tel : + 886-2-8178-5901 Mobile : + 886-988-958-239
Email: hoon@samsung.com

9. HAZARD WARNINGS, POTENTIAL FAULTS

Danger to life and health caused by an electric arc if active live parts are touched.
Danger to life and health (burns, ventricular fibrillation or heart stopping) caused by body currents if active live parts are touched.
Danger to health caused by organic substances and acids that might be emitted in case of failure conditions.
Danger of explosion and fire when operating with overvoltage, after under-voltage, at too high temperature or with too high charge or discharge power.
Environmental hazard from released substances, e.g. electrolyte.
Hazard by mechanical impact: the housing can have sharp edges due to manufacturing process, thus special care must be taken.

A characteristic feature of lithium-ion cell is a high energy content with a low weight. In the event of a fault, the thermal energy released is a multiple of the electrically usable energy. Unlike normal lead starter batteries, the electrolyte is not aqueous but organic. The cells are gas-tightened.
In other words: No gases, vapours or liquids escape during normal operation.
Unlike normal starter batteries, the chemical hazard is not from acids and the generation of hydrogen, but from organic solvents and the used conducting salt and their secondary chemical reactions when released in the event of a fault. Under faulty conditions, toxic and corrosive agents might be set free.
If the cell bursts into flames, the scope for extinguishing the fire is limited, as the battery cell contains both oxidants and reductive. Only cold water in large quantities should be used to extinguish the fire. This will also cool cells.
In case of a short circuit, cells will be damaged due to high energy content, stable electrical arcs and welding effects. This can cause smoke and the release of toxic and corrosive agents (gases and liquids).
If live parts (under faulty conditions, the metal housing of the cell) are touched, a current hazardous to life and health can flow through the body and may cause burns, ventricular fibrillation or even result in the heart stopping.

Care should be taken during work with, at or inside the cells. Pay attention to the risk of electric shock and the hazard by chemicals in the event of an accident.
At least two people should be present in the room when working on cells. Eye contact must be kept through a glass panel so help can be given in the event of an accident. Cells may only be stored and operated in appropriate rooms.
There is no special degassing system inside the cell for releasing gas and electrolyte in case of cell opening. Thus special care must be taken after cell opening.
Cells that have clearly overheated, experienced mechanical shocks (fallen down or fallen over) or are visibly damaged cannot be used anymore but must be returned to SDI immediately.

Possible fault scenarios, causes and consequences are described in above statements.. Each operator must be familiar with the risk potential, the protective measures and behavioural rules and observe them accordingly.

Protective Measures and Rules of Conduct

	Work on this battery that has dangerous voltages (more than 4.25V DC for each cell), particularly when it is live, must only be done by qualified electricians with basic knowledge of traction batteries or under the management and supervision of a qualified electricians qualified for such tasks. Autonomous charging or discharging by electricians qualified for such tasks is only permissible in the exceptional case as described below. The cell must not be freely accessible. Access to laboratory/test bed and cell storage room should only be subject to approval and instruction from the responsible laboratory manager.
	Personal protective equipment must be worn when working on batteries (protective goggles, insulating gloves, work clothing, safety shoes and insulating tools).
	Fire, sparks, open flame, smouldering objects and smoking are prohibited near batteries. Electrostatic discharge must be avoided. Adequate ventilation must be ensured. When charging the cell, always maintain a safe distance of 2.5 m from flammable materials, as a risk of explosion and fire must generally be assumed. Highly flammable materials must not be stored in the cell room or test laboratory.
	The electrolyte and the conducting salt from lithium-ion batteries can be toxic. Reaction products in the event of a fault may also be caustic. Avoid damage to battery housing. Clean up discharged electrolyte immediately with acid fleece and dispose in waste disposal container provided. Inform SDI immediately to clarify how to proceed further.
	Only use suitable and approved lifting and transport equipment, e.g. lifting gear compliant with VDI 3616. The lifting gear must not cause any damage to the battery housing or any connecting cables.

Generally lithium-ion batteries have a risk of explosion and fire. Warning! The metal housing of the cells may be live in the event of a fault (even in the discharged state). Danger from electric arc or body-borne current. Avoid short circuits! Do not place any objects or tools on the battery. Rings, wrist watches or any other metal parts on clothing must be taken off / removed when near to batteries.

In order to preclude any further potential hazards from leaking liquids etc., no drinks or food should be consumed while working on the cells or on the test bench.

9.1. Conduct in the event of accidents

Self-preservation / raising the alarm
Protection of other people / rescue / recovery
Fire fighting / limiting spread of fire

Protecting assets

Press emergency stop button on the test bench. And observe your own personal safety!
Pull exposed and energized cables with a non-conducting material (broomstick from wood) away from any injured person. Warn others that no energized parts are touched (install a barrier).
Get any injured person out of the danger zone and lay them down.

Provide first aid assistance (immediate measures):
Get a survey of the kinds of injuries
Place emergency call
Where did it happen?
What happened?
e.g. electrical accident, contamination, fire, explosion …
How many casualties?
Which kind of injuries
e.g. electric shock, contamination, burn injury
Wait for questions

If the injured person(s) is(are) unconscious, the function of heart and respiration is essential. If necessary start with cardiopulmonary resuscitation immediately. If available use a layman heart defibrillator.
Cool burn injuries immediately with plenty of water (at least ten minutes).

Do not leave the patient unattended until a damage of the heart is checked by a medic (ECG).
Electrolyte on the skin: remove contaminated clothing. Rinse affected area with water for at least 15 min as an initial precaution. If action is taken swiftly, calcium gluconate compressions or calcium gluconate gel can be applied. Inform your doctor. (Establish if and in what quantities HF and CO can be created as a result of reacting with moisture in the air. Establish which organic electrolyte is involved and what countermeasures are required).
Electrolyte in the eyes: rinse immediately with lukewarm tap water for at least five minutes. Consult an ophthalmologist who will flush with local anaesthetic and also rinse with plenty of calcium gluconate. Inform your doctor.
Stomach, bowel: in the case of clear chemical burns do not induce vomiting, no carbon, no neutralization. Administer fluoride-binding fluids as quickly as possible, e.g.: calcium gluconate or dissolved calcium tablets. Inform your doctor.
Protect the injured from heat loss.
Support and take care about the injured
Check and observe the vital functions continuous (respiration and heartbeat)
Take the injured person to an emergency room or doctor/ wait for the paramedic and inform them of the situation.
If there is no fire, allow plenty of fresh air into the site of the accident. Otherwise, close doors and windows once everyone has left the room.
Do not change the scene of the accident.

9.2. Storing the Cells

The storage area must be dry, as free of dust as possible and well ventilated.
Storage for prolonged period should be at a SOC of 20–25%.
The cells may only be stored in a designated cell room:
Room must only be accessible to authorized persons.
Room must be dry and ventilated.
Store the cells on surfaces that provide electrical insulation.
Electrostatic discharge must be avoided.
Permissible temperature range: 10°C–30°C; temperatures below 20°C are recommended.

9.3. General notes on operating Cells

Autonomous operation of cells by an electrician qualified for certain tasks instructed in the operation of cells is only permissible subject to consultation with and approval by a qualified electrician! The structural features — cabling, state of the battery pack system, connection of the same to the battery test bench — must be checked by the qualified electrician in advance.

If several employees are working on one test bench, a work manager must be designated.

The work manager marks the laboratory for the duration of the work.

The work manager is responsible for ensuring that the work is carried out in conformity with the five safety rules:

Disconnect
Provide a safeguard to unintentional restart/reclosing
Assure zero-potential
Ground and short-circuit
Cover or shield neighbouring live parts
As a rule, activation of the cells and/or the test bench is only permitted once the cabling and connections and the settings of all systems have been checked! Connections and cabling must be securely routed and protected against contact.

Only a suitable battery test bench may be used to charge or discharge cells.

Cells may only be charged in rooms with adequate ventilation — see also protective measures and rules of conduct. When charging in freely accessible areas, the cells must be blocked off and a clearly visible warning sign should be put up where appropriate. The test station must be cordoned off with a safety chain to prevent persons not involved with the work on the test bench inadvertently approaching live parts of the assembly. The pedestals of the chain must be positioned so that the minimum distances from the live parts of the test assembly are met. Notices W08 (yellow sign with flash) and where necessary P06 (red round sign) must be visibly fixed to the safety chain.

W08 Warnung vor gefährlicher elektrischer Spannung

P06 Zutritt für Unbefugte verboten

During tests where the low voltage supply is switched on, only those persons directly involved with the tests may stay within the demarcated area of the test station. Other persons must leave the test area.

Endurance tests where the test bench remains unsupervised during operation are only permitted on specially designed cell test benches with automatic switch-off, an extinguisher system and ventilation. The cell status must be monitored constantly during charging.
Commissioning the Cells
Commissioning and the tests required for this are to be specified by SDI.
Disposing of the Cells
The cell must be disposed considering local regulations.
Caution and Prohibition

Before using and handling cells, please read "Handling Precaution and Prohibitions of Lithium Ion cell" document as follows

Handling Precaution and Prohibitions of Lithium Ion Cell

Before using the cells, be sure to read the cell handling user manual and precautions.

Improper handling of lithium ion cell may cause leakage, heat, smoke, an explosion, or fire. This could cause deterioration of performance or failure.

Please be sure to follow instructions carefully.

Storage

Store the battery at room-temperature conditions

(10 – 30°C; below 20°C is recommended).

Safety precautions and prohibitions

To assure product safety, please list the following precautions in the application's instruction manual.

Electrical misusage

- Use dedicated charger
- Use or charge the battery only in the dedicated application
- Reverse charging is prohibited
- Charge current must be controlled by the specified value in the cell specifications
- Cut-off voltage for charging must be 4.12 V
- Charger must stop charging battery by detecting cut-off current specified in the cell's specifications
- Discharge current must be controlled by the specified value in the product specifications
- Cut-off voltage of discharging must be over 2.1 V when the temperature is below -20°C

and 2.7 V when the temperature is over -20°C

- No parallel connection of cells is allowed

Environmental misusage

Don't leave a cell near a fire or a heat source

Don't throw a cell into a fire

Don't immerse, throw, and wet cell in water / seawater

Others

Don't store metallic objects (such as keys or screwdriver) near the cell.

Don't short circuit (+) and (-) terminals with metallic object intentionally.

Don't pierce cells with a sharp object such as a needle, or screwdrivers.

Don't heat a part of cells with heating objects such as a soldering iron.

Don't hit cells with heavy objects such as a hammer, or heavy weights.
Don't step on cells, or throw or drop a cell on the hard floor.
Don't disassemble a cell or modify the a cell design including electric circuit.
Don't solder anything on cells directly.
Don't use seriously scratch or deform cells.
Don't put the a cell into a microwave oven, dryer, or a high-pressure container
Don’t disassemble cells.
Don’t expose to water splashing condition.
Don’t expose to heavy humidity condition.
Don’t use after drop accident.
Before using charger, be sure to read the charger’s user manual.
Before installing and removing cells from application, be sure to read the application’s user manual
If cell needs to be stored for a long period, cells should be removed from the application and stored in a proper place under room temperature conditions and consider the described available leaving period (12 months at SOC20%).
While the cell is charged, used and stored, keep it away from object materials with static charge

Warning

Stop charging cells if charging isn't completed within the specified time
Stop using cells if the battery becomes abnormally hot, develops an odor, becomes discolored, becomes deformed, or develops any other abnormal conditions during use, charge, discharge, or storage
Keep away from fire or hot heat sources immediately when a leakage or foul odors are detected. If liquid leaks onto your skin or cloths, wash it out with plenty of fresh water immediately
If liquid leaks from cells and gets into your eyes, don't rub your eyes.
Wash your eyes out with plenty of clean water and seek medical attention immediately.
If the terminals of cells become dirty, wipe them with a dry cloth before using the cells.
Cells can be used within the following temperature ranges. Don't exceed these ranges (Operating temperature range: -40°C ~ 60°C)
Cover terminals with proper insulating tape before disposal
Don’t leave cells over 6 months after discharging cut-off (2.7 V)
After long storage and leaving period, if charging and operating is not available, stop the charging and operating, contact the service center.