

# Product Specification

TITLE: Cylindrical Lithium Ion Cell LR2170SA (EV)

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## PRODUCT SPECIFICATION

Cylindrical Lithium-ion Cell

**LR2170SA  
(EV)**

|                              | Signature               | Date |
|------------------------------|-------------------------|------|
| <b>Customer<br/>Approval</b> |                         |      |
|                              | <b>Company Name :</b> █ |      |
|                              | <b>Company Stamp :</b>  |      |

| Prepared By | Checked By | QA | Approved By |
|-------------|------------|----|-------------|
|             |            |    |             |

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## History of revision

| Revision | Date       | Originator  | Reason of Revision |
|----------|------------|-------------|--------------------|
| 0        | 11/16/2017 | Han Tengfei | Original Release   |

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## 1 SCOPE

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The product specification describes the requirements of the Cylindrical Lithium-ion Cell to be supplied to the customer by Tianjin Lishen Battery J/S Co.,Ltd.. Should there be any additional information required by the customer, customer are advised to contact Tianjin Lishen Battery J/S Co.,Ltd..

## 2 DESCRIPTION AND MODEL

|     |             |                              |
|-----|-------------|------------------------------|
| 2.1 | Description | Cylindrical Lithium Ion Cell |
| 2.2 | Model       | LR2170SA                     |

## 3 GENERAL SPECIFICATIONS

|      |   |   |
|------|---|---|
| 3.1  | Nominal Capacity  | 4000mAh (at 0.2C Discharge)               |
|      | Minimum Capacity  | 3900mAh (at 0.2C Discharge)               |
|      | Nominal capacity is measured by the discharge at 0.2C to 2.75V end voltage by standard charge method. |   |
| 3.2  | Maximum Charge Voltage  | 4.20V±0.03V                               |
| 3.3  | Average working Voltage   | 3.65V@0.2C                                |
| 3.4  | Standard Charge Method (25°C±2°C)   | Constant Current and Constant Voltage     |
|      |   | Current                      0.2C (800mA) |
|      |   | Voltage                      4.2V         |
|      |   | End Current                80mA±5mA       |
| 3.5  | Maximum Charge Current  | 0°C ≤ T ≤ 10°C      0.1C (400mA)          |
|      |   | 10°C < T ≤ 20°C     0.2C (800mA)          |
|      |   | 20°C < T ≤ 45°C     0.5C (2000mA)         |
| 3.6  | Standard Discharge  | Constant Current                          |
|      |   | Current                      0.2C (800mA) |
|      |   | End Voltage                2.75V          |
| 3.7  | Maximum Discharge Current   | -20°C ≤ T ≤ 5°C      1.0C (4000mA)        |
|      |   | 5 °C < T ≤ 45°C      3.0C (12000mA)       |
|      |   | 45 °C < T ≤ 60°C     1.5C (6000mA)        |
| 3.8  | Cycle Life  |   |
|      | 1000th cycle ≥80% of 1 <sup>st</sup> Capacity (25°C±2°C 4.2V-3.0V)                                    |   |
|      | If discharged at high rate or high temperature frequently, cell cycle life will be shorten.           |   |
| 3.9  | Weight of Bare Cell   | Avg.                      69g±2g          |
| 3.10 | Operating Enviromental Temperature  | Charge                    0°C~ 45°C       |
|      |   | Discharge                -20°C~60°C       |
| 3.11 | Storage Temperature   | 1 month                -20°C~50°C         |

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(For shipping state)

3 months

-20°C~40°C

12 months

-20°C~20°C

## 4 OUTLINE DIMENSION

Dimension: Diameter 21.7mm±0.2mm, Height 70.9mm±0.2mm. Refer to attached drawing 1.

## 5 APPEARANCE

There shall be no such defect as breakage of tube and deep scratch, flaw, crack, rust, leakage, which may adversely affect performance of the cell.

## 6 TEST CONDITION AND DEFINITIONS

### 6.1 Measuring Equipment

#### 6.1.1 Voltmeter

Inner impedance>1000Ω/V.

#### 6.1.2 Ampere-meter

Total external resistance(ammeter and wire)<0.01Ω.

#### 6.1.3 Slide caliper

The slide caliper should have a scale of 0.02mm.

#### 6.1.4 Impedance meter

The impedance meter should be operated at AC 1kHz.

### 6.2 Unless otherwise specified, all tests shall be performed at 25°C±2°C and humidity of 65%RH±20%RH.

The cells used for the test mentioned should be new ones delivered a week before at most.

### 6.3 Definitions :

C Rate ("C"): The rate (milliamperes) at which a fully charged cell is discharged to its end voltage in one (1) hour.

## 7 CHARACTERISTICS

### 7.1 Charge method

#### 7.1.1 Charging shall consist of charging at 0.5C constant current rate until the cell voltage reaches 4.2V.

The cell shall then be charged at constant voltage of 4.2 volts while tapering the charge current.

Charging shall be terminated when the charging current has tapered to 0.02C.

#### 7.1.2 Charging shall consist of charging at a 0.5C constant current rate until the cell voltage reaches 4.2V.

The cell shall then be charged at constant voltage of 4.2 volts while tapering the charge current.

Charging shall be terminated when the charging current has tapered to 0.05C.

### 7.2 Discharge method :

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- 7.2.1 Cells shall be discharged at a constant current of 0.2C to 2.75 volts
- 7.2.2 Cells shall be discharged at a constant current of 0.5C to 2.75 volts
- 7.2.3 Cells shall be discharged at a constant current of 1.0C to 2.75 volts
- 7.2.4 Cells shall be discharged at a constant current of 2.0C to 2.75 volts
- 7.2.5 Cells shall be discharged at a constant current of 1.0C to 3.0 volts

### 7.3 Internal Impedance

The impedance shall be measured by 6.1.4.

Initial Internal Impedance  $\leq 20\text{m}\Omega$ .

### 7.4 Discharge Rate characteristics

Cells shall be charged per 7.1.1 (0.5C) at 25°C and discharged per 7.2.1(0.2C), 7.2.2 (0.5C), 7.2.3 (1C), 7.2.4 (2C) at 25°C. The discharge capacity of each cell at respective discharge rate shall be compared with the discharge capacity at 0.2C and the percentage shall be calculated. Each cell shall meet or exceed the requirements of Table 1.

Table 1

| 0.2C | 0.5C        | 1C          | 2C          |
|------|-------------|-------------|-------------|
| 100% | $\geq 95\%$ | $\geq 90\%$ | $\geq 85\%$ |

### 7.5 Cycle Life

Charge cells per 7.1.2. Rest 15 minutes. Discharge per 7.2.5. Rest 15 minutes before recharge. The test environmental temperature is 25°C $\pm$ 2°C. A cycle is defined as one charge and one discharge. Discharge capacity shall be measured after 1000 cycles.

Discharge capacity (1000th Cycle)  $\geq 80\%$  of 1<sup>st</sup> Cycle Capacity

### 7.6 Storage Characteristics

7.6.1 After charge as per 7.1.1, store the testing cells at 25°C $\pm$ 2°C for 28 days. Then discharge as per 7.2.1.

The recovery discharge capacity  $\geq 90\%$  of initial capacity.

7.6.2 After charge as per 7.1.1, store the testing cells at 55°C $\pm$ 2°C for 7 days. Then discharge as per 7.2.1.

The recovery discharge capacity  $\geq 90\%$  of initial capacity.

### 7.7 Temperature Characteristics

Cells shall be charged per 7.1.1 and discharged per 7.2.2. Cells, fully charged, shall be stored for 3 hours at the test temperature. The capacity of a cell at each temperature shall be compared to the capacity achieved at 25°C and the percentage shall be calculated. Each cell shall meet or exceed the requirements of Table 2.

Table 2

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| -10°C | 0°C  | 25°C | 45°C | 60°C |
|-------|------|------|------|------|
| ≥70%  | ≥80% | 100% | ≥95% | ≥95% |

## 8 SAFETY

### 8.1 External Short-circuiting Test at 25°C±2°C

Cell fully charged per 7.1.1, is to be short circuited by connecting the positive (+) and negative (-) terminals with a total external resistance of less than 50mohm. Stop the test when the cell voltage falls to below 0.1V and the cell case temperature has returned to a value within 10 °C of the original testing temperature.

Criteria: No Fire, No Explosion

### 8.2 Overcharge Test

Cell fully charged per 7.1.1, is to be overcharged with 1.0C to 6.3V while tapering the charge current. Monitoring change of cell temperature during testing. Stop the test when cell temperature decays to room temperature.

Criteria: No Fire, No Explosion

### 8.3 Heating Test

Cell fully charged per 7.1.1, is to be placed in the hot oven. Store the testing cells connecting with thermocouple in constant temperature box, heating the cells and box (speed of ascending temperature is 5°C±2°C per min) together at room temperature simultaneity, monitor the temperature change of the box for 60minutes after the box temperature reaches to 130°C±2°C, then stop the test.

Criteria: No Fire, No Explosion

### 8.4 Overdischarge Test

Cell fully charged per 7.1.1, is discharged at constant current of 1.0C to 90min;

Criteria: No Fire, No Explosion, No Leakage

### 8.5 Crush Test

Cell, charged per 7.1.1, is to be crushed between two flat surfaces and with cell longitudinal axis parallel to the flat surfaces of the crushing apparatus. The force for the crushing is to be applied by a hydraulic ram with a 1.25 inch (32 mm) diameter piston. The crushing is to be continued until a pressure reading of 2500 psig (17.2 MPa) is reached on the hydraulic ram, applied force of 3000 pounds (13 kN). Once the maximum pressure has been obtained it is to be released.

Criteria: No Fire, No Explosion

### 8.6 Drop test

After charge as per 7.1.1, the cell is dropped from 1.5m above a concrete floor by the positive and negative terminal down. Wait for 1h.

Criteria: No Fire, No Explosion, No Leakage

## 9 GUARANTEE

Cells are guaranteed to be free from defects in workmanship and materials for a period of one year provided that the manufacturer can confirm such defects are coming from manufacturing abnormality and

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not from abusive usage, or else manufacturer will solve the quality problem. Lishen won't replace a new cell for free if the defects are not due to the failure of manufacturing process or is due to customer's abuse or misuse.

9.1. Lishen will not be responsible for trouble occurred by handling outside of the precautions in instructions.

9.2. Lishen will not be responsible for trouble occurred by matching electric circuit, cell pack and charger.

9.3. Lishen will be exempt from warrantee any defect cells during assembling after acceptance.

## 10 **PACKAGING**

Loading 64 cells per box, 2 boxes per case for a total of 128 cells. Refer to attached drawing 2.

## 11 **OTHERS**

Any matter not included in this specification shall be conferred between the both parties.

## 12 **SHIPPING**

The capacity of delivery cell is under 10%SOC. It is not specified more than 10% capacity remain at customer, because of self-discharge. During transportation, keep the cell from acutely vibration, impacting, solarization, drenching.

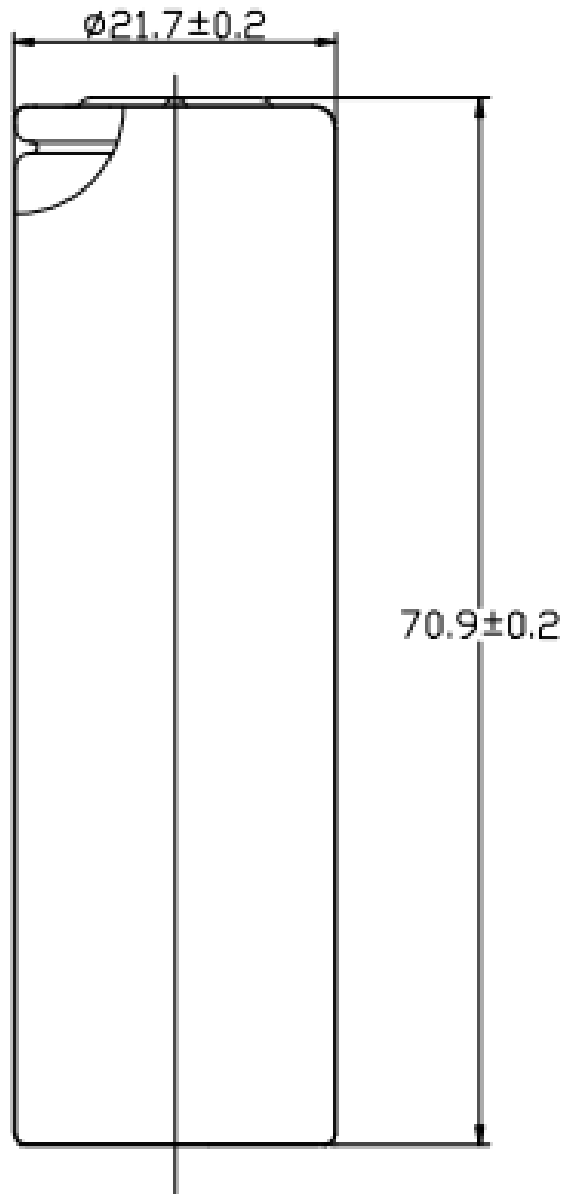


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Attached drawing 1

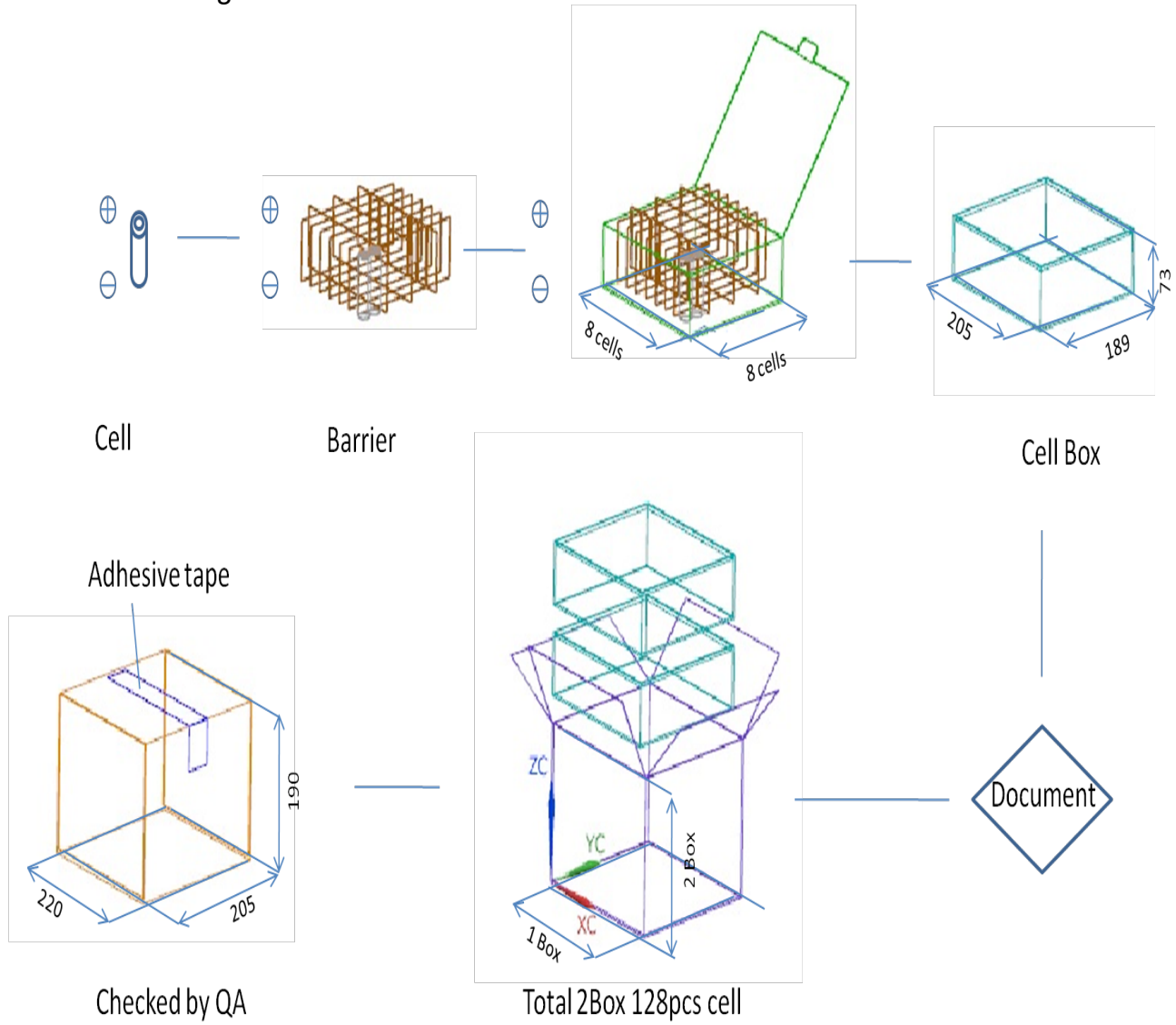


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Attached drawing 2



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The following caution and warning should appear in manuals and/or instructions for users, especially at the point of use.

## HANDLING INSTRUCTIONS FOR LITHIUM ION RECHARGEABLE CELL

### 1 ELECTRIC CAR, CHARGER AND BATTERY PACK DESIGN CONSIDERATIONS

#### 1.1 Charging

1.1.1 Cell must be charged with constant current-constant voltage method. Charging voltage must be below 4.20V/cell and the charging cut-off current is greater than or equal to 1/20C. Even if the charge could be out of order, charge voltage of charger should not be above 4.23V/cell to avoid over-charging. Cell life will be shorten by charging voltage above 4.20V.

1.1.2 Charger should be equipped with a pre-charging system, and the function should be used to prevent

the abnormal large multiplier charging after the deep discharge. In case of cell voltage is below 2.75V(0%SOC), cell should be charged with pre-charge that current is below 0.4A (0.1C). Then cell voltage reach over 2.75V, standard charge starts. And if cell voltage never reaches to 2.75V in 30 minutes, charger will stop charging.

1.1.3 Charger should be equipped with a complete charging detection device. It can pass the timer inspection or open circuit voltage, current, detect the current state of charge, after a full battery charge detection device is detected, should be completely cut off the charging circuit, avoid to produce turbulence.

1.1.4 Charger should start charging at temperature range 0°C~ +45°C. When the cell temperature exceeds this range, it should be placed in the battery temperature to teach the above range before recharging.

#### 1.2 Discharging

1.2.1 Discharge current must be below 3C (12000mA) /cell.

1.2.2 Discharge end voltage must be over 2.75V.

1.2.3 Discharge temperature range should be -20°C~ +60°C. If surface temperature exceeds 70 degrees, the discharge must be stopped.

#### 1.3 Overdischarge

If the voltage of a single battery is less than 2.75V, the battery is considered to be overdischarge and cannot continue to be used.

#### 1.4 Storage

Any storage, cell should be in low humidity (less than 70%RH) , no corrosive gas atmosphere area.

And there is no press and condensation on the cell. Best temperature range -20°C~20°C

When stored within 1 month : -20°C~ 50°C

When stored within 3 months : -20°C~ 40°C

When stored within 12 months : -20°C~ 20°C

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## 1.5 Precautions on battery pack design

### 1.5.1 Battery pack Shape, Mechanism and Material

The battery pack should be designed to ensure that it can not be charged by an unauthorized charger. The battery pack should be designed to ensure that it can not be connected to unauthorized equipment and equipment; both ends of the battery pack should be designed to avoid short circuits or positive and negative. The battery pack design should have anti-static function and can prevent the dust. The battery should be designed so that even if the battery leakage occurs, the electrolyte can not reach the protection circuit board; battery design should ensure that the battery is fixed in the battery pack, can not move; battery pack in the structure should ensure that The use of materials such as double-sided tape and rubber should verify its flammability; welding mold should be sealed with glue; if the welding die in the sealed when the welding of the mold can not be used, The use of ultrasonic welding method, for the emergence of any defects, God does not bear anything Either.

### 1.5.2 Battery pack structure (battery pack limits the number of batteries used)

The number of parallel connections is unlimited, but the battery pack must pass the overcharge test (the charging current of the overcharge test is the maximum charge current of the charger and the product of the parallel quantity); the number of series is unlimited and the fuse is required; the battery should be away from the heat Device to avoid deterioration of battery performance; PCBA circuit board and battery pack should be insulated between the insulation material (such as plastic barrier to provide air isolation or non-conducting thermal insulation material).

### 1.5.3 Protection Circuit insure safety of battery

The following protection circuit should be installed in the battery pack:

Overcharge protection. For safety reasons and in order not to shorten the cycle life, the maximum overcharge protection voltage for the individual cells within each module should be less than 4.23V (including tolerances);

Over discharge protection. If the single cell voltage reaches 2.75V, we recommend that the discharge protection should cut off the discharge current, the circuit current consumption should be as small as possible;

Overcurrent protection. If the discharge current of the single cell exceeds about 12A, the overcurrent protection should cut off the discharge current circuit. In order to avoid long-term storage over discharge mode, battery pack protection circuit current consumption should be set as small as possible. Long-term use, to regularly check the remaining state of electricity, to ensure that the battery within the single cell can not achieve over-discharge state.

### 1.5.4 Cell connection

Do not solder onto a cell in order to avoid a damage on the cell. Weld spot welding lead plate onto cell, and solder lead wire or lead plate. the battery pack in the discharge, the internal cell temperature difference should be less than or equal to 5 °C.

## 1.6 Cell usage

- 1.6.1 When using batteries for serial and use, use the same gear, the same batch and the same state of charge batteries, you can get this information from the inside and outside the box label. Batteries need to be used before the detection of voltage resistance, and in accordance with

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its use for the combination, God recommended at least to ensure that the use of batteries within 10mV voltage within the internal resistance within 6mohm.

- 1.6.2 Battery pack before shipment Check the voltage, internal resistance, protection line function, thermistor, thermal fuse.
- 1.6.3 Transfer the batteries to the assembly process to pay special attention to prohibit the transportprocess caused by external damage, the transport process is recommended to use the same transport packaging, even if there is a process of opening the package.
- 1.6.4 Do not use damaged or leaked batteries due to transport damage, drop, short circuit or other reasons.

## 1.7 Warranty Exemption

Lishen is not liable for any loss caused by breach of notice in the specification;

Lishen is not responsible for any problems caused by design defects in battery packs, electric cars and chargers;

Lishen does not accept abnormal batteries caused by improper assembly.

## 2 SAFETY INSTRUCTIONS

Batteries containing organic solvents and other flammable substances, such as improper use may cause the core heat or fire, resulting in damage to the battery or personal injury. Please pay attention to the use of prohibited items, while the protection device should be added to avoid the use of equipment caused by abnormal batteries accident. Before using lithium-ion rechargeable batteries, please read the following safety guidelines carefully. In addition, God strongly recommends adding these instructions to the user manual.

### 2.1 Dangerous matter

- 2.1.1 Don't use or place batteries in high temperature (above 70 ° C) environment. Do not put it into fire, wate or make it moisture. Do not repair or disassemble batteries, there is a risk of causing the batteries to ignite, overheat, leak or explode.
- 2.1.2 Don't place the batteries in a chaotic manner, away from metal and other conductive materials to avoid positive (+) negative (-) short circuit, do not reverse the positive (+) negative (-) pole
- 2.1.3 Don't use non-specified charging equipment and violate charging requirements. Non-specified conditions charge will cause the battery to overcharge or abnormal chemical reactions, heat generation, smoke, rupture or fire.
- 2.1.4 Don't connect the battery to the AC plug (outlet) or the car plug. The battery needs to have a specific charger. If the battery is connected directly to the plug, the battery may catch fire, smoke, explode, or cause heat.
- 2.1.5 Don't overcharge, over-discharge, drive nail into the cell, strike it by hammer or tread it.
- 2.1.6 Don't hit or throw batteries. If the batteries appear to fall, please treat the waste, can not continue to use.
- 2.1.7 Don't dissect the battery. If the protection line is damaged, the battery will no longer be protected. Then, the battery may fire, smoke, explode or cause heat.
- 2.1.8 Don't charge near high temperatures. If the battery is charged near the high temperature, the battery can not be recharged due to the protection line. In this case, the protection circuit may be interrupted, the battery may fire, smoke, explode or cause heat.

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- 2.1.9 Don't use batteries that are clearly damaged or deformed. May cause fever, smoke, rupture or burning.
  - 2.1.10 Don't direct soldering of batteries, overheating will lead to insulation gaskets and other parts of the deformation, causing cell deformation, leakage, explosion or fire.
  - 2.1.11 Don't reverse polarity charge. In the case of charging, the battery is reverse charging will be abnormal chemical reaction. In addition, there is an unpredictable high current through the discharge. These may cause heat, smoke, rupture or burning.

## 2.2 Warning

- 2.2.1 Batteries should be kept away from infants and young children. In case of swallowing the battery, please seek medical attention immediately.
- 2.2.2 Don't place the battery in a microwave oven or other cooking utensils. Due to the heating and electrical shock of the microwave oven, the battery may ignite, smoke, explode or cause heat.
- 2.2.3 Don't mix with other batteries. The battery can not be mixed with other different capacities, chemical systems, or manufacturers' batteries. Do not connect other batteries or mix other batteries. The battery may catch fire, smoke, explode or cause heat.
- 2.2.4 Don't use an abnormal battery. If there are obvious abnormalities, such as odor, fever, deformity or discoloration, stop using the battery. Such batteries may be defective and, if used, may cause fire, smoke, heat or explosion.
- 2.2.5 If the charging process does not end, stop charging. If the battery can not complete the charging process for a specified period of time, stop the charging step. The battery may catch fire, smoke, explode or cause heat.
- 2.2.6 Don't use a leaky battery near a flame. If the battery or liquid out of the battery produces a pungent odor, the battery should remain away from the flame. The battery may be ignited or exploded.
- 2.2.7 Don't touch the leaky battery. If the liquid leaking from the battery into the eyes, will cause serious damage. If you come from your leaked liquid into your eyes, rinse your eyes with water immediately. Please consult a doctor immediately. If the liquid is left in the eyes, it will cause serious damage.
- 2.2.8 In order to avoid short circuit or damage, please tightly put the battery into a box or carton.

## 2.3 Precautions

- 2.3.1 Don't use or place batteries in high temperature environments, such as in direct sunlight. The battery may catch fire, smoke, explode or cause heat. At the same time, may cause battery performance and life degradation.
- 2.3.2 Battery pack has a protective line. Do not use batteries in places where static electricity (over 100V) is generated, which may damage the protection circuit. If the protective line of the battery is damaged, the battery may catch fire, smoke, explode or cause heat.2.7 Do not use Lithium ion cell with the primary batteries or secondary batteries whose capacity or kinds or maker is different. If do that, the cell will be discharged or charged excessively in use. And it may cause the generating heat, smoke, rupture or flame because of the abnormal chemical reaction in cells.
- 2.3.3 Charging temperature range specified in the 0 °C-45 °Cbetween. Do not charge the battery outside the specified temperature range. Failure to do so may result in heat, leakage, or serious damage. In addition, battery performance and life degradation may occur.

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- 2.3.4 Please read the manual before use. Please keep this manual for future reference.
- 2.3.5 Please read the charging method of the charger manual.
- 2.3.6 In the first use, if the battery has an abnormal smell, heat or rust, please contact the supplier.
- 2.3.7 Keep away from flammable materials during charging and discharging. May cause fire, smoke, explode or cause heat.
- 2.3.8 If the electrolyte leaks from the battery, gets on the clothes or on the skin, rinse it immediately with water. Otherwise it may irritate the skin.
- 2.3.9 If wires or metal objects come out of the battery, completely seal and insulate them. Otherwise, the battery may cause a short circuit, fire, smoke, explosion, or cause heat.
- 2.3.10 After use, please carry out battery recycling according to local laws and regulations.