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Li-Fe battery Specification

Model : ULF18650
Capacity : 1400mAh
Voltage : 3.2V

| Prepared By/Date | Checked By/Date | Approved By/Date |
|-------------------------|------------------------|-------------------------|
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Amendment Records

| Edition | Description | Prepared by | Approved by | Date |
|---------|---------------|-------------|-------------|------|
| A/1 | First Edition | | | |
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1 Scope

This specification is applied to the reference battery in this Specification and manufactured by Unique Energy.

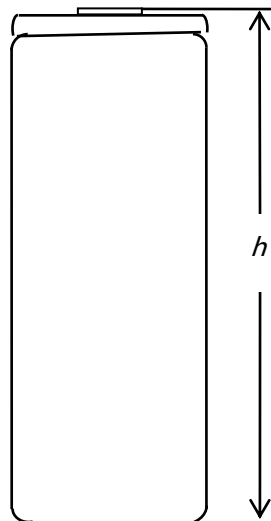
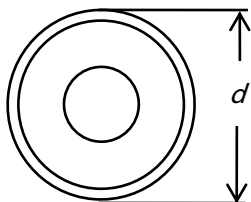
2 Product Specification

Table 1

| No. | Item | General Parameter | | Remark |
|-----|-----------------------------|--|---------|---|
| 1 | Rated Capacity | Typical | 1400mAh | Standard discharge after standard charge |
| | | Minimum | 1390mAh | |
| 2 | Nominal Voltage | 3.2V | | Mean Operation Voltage |
| 3 | Voltage at end of Dischargr | 2.0V | | Discharge Cut-off Voltage |
| 4 | Charging at end of Voltage | 3.65V | | |
| 5 | Internal Impedance | 35m Ω | | Internal resistance measured at AC 1KHz after 50% charge The measure must uses the new battreies that within one week after shipment and cycles no more that 5 times |
| 6 | Standard charge | Constant Current 0.5C Constant Voltage 3.65V 0.01C cut-off | | Charge time: Approx 4.0h |
| 7 | Standard discharge | Constant Current 0.5C end Voltage 2.0V | | |

Continuous the table 1

| No. | Item | General Parameter | Remark |
|-----|--------------------------------------|---|------------------------------------|
| 8 | Fast charge | Constant Current 1C Constant Voltage 3.65V 0.01C ₅ A cut-off | Charge time: Approx 2.5h |
| 9 | Fast discharge | Constant Current 1C end Voltage 2.0V | |
| 10 | Maximum Continuous Charge Current | 1C | |
| 11 | Maximum Continuous Discharge Current | 5C | |
| 12 | Operation Temperature Range | Charge 0~45°C | 60 ± 25%R.H. Bare Cell |
| | | Discharge -10~60°C | |
| 13 | Storage Temperature Range | Less than 1 year: -20~25°C | 60 ± 25%R.H. at the shipment state |
| | | Less then 3 months: -20~40°C | |
| 14 | Weight | Approx: 40g | FYI |
| 15 | Pack Dimension | Height: (h) 65.3mm | Initial Dimension |
| | | Width: (d) 18.2mm | |



3 Performance And Test Conditions

Standard Test Conditions

Test should be conducted with new batteries within one week after shipment from our factory and the cell shall not be cycled more than five times before the test. Unless otherwise specified, test and measurement shall be done under temperature of $20 \pm 5^\circ\text{C}$ and relative humidity of 45~48%. If it is judged that the test results are not affected by such conditions, the tests may be conducted at temperature $15 \sim 30^\circ\text{C}$ and humidity 25~85% R.H.

Measuring Instrument or Apparatus

Dimension Measuring Instrument

The dimension measurement shall be implemented by instruments with equal or more precision scale of 0.01mm.

3.2.2 Voltmeter

Standard class specified in the national standard or more sensitive class having inner impedance more than $10\text{k}\Omega/\text{V}$.

Ammeter

Standard class specified in the national standard or more sensitive class. Total external resistance including ammeter and wire is less than 0.01Ω .

Impedance Meter

Impedance shall be measured by a sinusoidal alternating current method (1kHz LCR meter)

Standard Charge/Discharge

Standard charge: Test procedure and its criteria are referred as follows:

0.5 C=

Charging shall consist of charging at a 0.5 C constant current rate until the cell reaches 3.65V. The cell shall then be charged at constant voltage of 3.65 volts while tapering the charge current. Charging shall be terminated when the charging current has tapered to 0.01 C. Charge time: Approx 4.0h, The cell shall demonstrate no permanent degradation when charged between 0°C and 45°C .

Standard Discharge

0.5 C=

Cells shall be discharged at a constant current of 0.5C to 2.0 volts @ $20^\circ\text{C} \pm 5^\circ\text{C}$.

If no otherwise specified, the rest time between Charge and Discharge amount to 30min.

Appearance

There shall be no such defect as flaw, crack, rust, leakage, which may adversely affect commercial value of battery.

Initial Performance Test

Table 2

| Item | Test Method Condition | Requirements |
|----------------------------|---|--------------------|
| (1) Open-circuit Voltage | The open-circuit voltage shall be measured within 24 hours after standard charge. | |
| (2) Internal impedance | Internal resistance measured at AC 1KHz after 50% charge. | |
| (3) Minimal Rated Capacity | The capacity on 0.5C discharge till the voltage tapered to 2.0V shall be measured after rested for 30min then finish standard charge. | Discharge Capacity |

Temperature Dependence of discharge capacity

Cells shall be charged per 3.3.1 and discharged @0.5C to 2.0 volts. Except to be discharged at temperatures per Table 3. Cells shall be stored for 3 hours at the test temperature prior to discharging and then shall be discharged at the test temperature. The capacity of a cell at each temperature shall be compared to the capacity achieved at 23°C and the percentage shall be calculated. Each cell shall meet or exceed the requirements of Table 3.

Table 3

| Discharge Temperature | -10°C | 0°C | 23°C | 60°C |
|--------------------------|-------|-----|------|------|
| Discharge Capacity(0.5C) | 50% | 80% | 100% | 95% |

Cycle Life and Leakage-Proof

Table 4

| No. | Item | Criteria | Test Conditions |
|-----|-----------------------|--|--|
| 1 | Cycle Life (0.5 C) | Higher than 70% of the Initial Capacities of the Cells | Carry out 1000 cycle Charging/Discharging in the below condition. <ul style="list-style-type: none"> ◆ Charge:Standard Charge,per 3.3.1 ◆ Discharge:0.5 C to 2.0V ◆ Rest Time between charge/discharge:30min. ◆ Temperature:20±5°C |
| 2 | Leakage-Proof | No leakage (visual inspection) | After full charge with standard charge,store at 60 ± 3°C,60 ± 10%RH for 1 month. |

4. Mechanical characteristics and Safety Test

Table5 (Mechanical characteristics)

| No. | Item | Test Method and Condition | Criteria |
|-----|----------------|--|-----------------------------------|
| 1 | Vibration Test | After standard charging,fix the cell to vibration table and subjection cycling that the frequency is to be varied at the rate of 1Hz per minute between 10Hz and 55Hz,the excursion of the vibration is 1.6mm.The cell shall be vibrated for 30minutes per axis of XYZ axes. | No leakage No fire |
| 2 | Drop Test | The cell is to be dropped from a height of 1 meter twice onto concrete ground. | No explosion, No fire,no leakage. |

Table 6

(Safety Test)

| Item | Battery Condition | Test Method | Requirements |
|-----------------------|---------------------|--|---|
| Crush | Fresh,Fully charged | Crush between two flat plates.Applied force is about 13kN(1.72Mpa) for 30min. | No explosion,No fire |
| Short Circuit 20°C | Fresh,Fully charged | Each test sample battery,in turn,is to be short-circuited by conneting the (+)and (−) terminals of the battery with a Cu wire having a maximum resistance load of 0.1Ω. Test are to be conducted at room temperature (20°C±2°C). | No explosion,No fire.The Temperature of the surface of the Cells are lower than 150°C |
| Short Circuit 60°C | Fresh,Fully charged | Each test sample battery,in turn,is to be short-circuited by connecting the (+)and (−) terminals of the battery with a Cu wire having a maximum resistance load of 0.1Ω. Test are to be conducted at temperature (60°C±2°C). | No explosion,No fire.The Temperature of the surface of the Cells are lower than 150°C |
| Impact | Fresh,Fully charged | A 56mm diameter bar is inlayed into the bottom of a 10Kg weight.And the weight is to be dropped from a height of 1m onto a sample battery and then the bar will be across the center of the sample. | No explosion,No fire |
| Forced Discharge | Fresh,Fully charged | Discharge at a current of 1 C for 2.5h. | No explosion,No fire |
| Nail Pricking 3mm | Fresh,Fully charged | Prick through the sample battery with a nail having a diameter of 3mm and remain 2h. | No explosion,No fire |

5. Protection circuit

5.1 PCM Specification

| Item | Test Condition |
|----------------------------|--|
| Over charge Protection | The battery should be charged under 4.0V/1C.The charging should be shut off when the internal cell voltage becomes more than the specified protection voltage. |
| Overs discharge Protection | The battery should be discharged with 1C,The discharging should be shut off when the internal cell voltage becomes less than the specified protection voltage. |
| Short protection | After rated charge,(+) and (-) terminals are connected with 10m Ω mental resistor or equivalence. |

5.2 PCM Standard

| Symbol | Name | MIN. | TYP. | MAX. | Unit |
|-----------------|---|------|------|------|------------|
| Vdet 1 | Over-Charge detect voltage | | | | V |
| Vdet 2 | Over-discharge detect voltage | | | | V |
| Vdet 3 | Over-current detect voltage | | | | V |
| I _{BC} | Excess Current threshold | | | | A |
| R _D | Internal resistance in normal operation | | | | m Ω |

6. Handling of Cells

Prohibition short circuit

Never make short circuit cell. It generates very high current which causes heating of the cells and may cause electrolyte leakage are very dangerous.

The Li-Fe tabs may be easily short-circuited by putting them on conductive surface.

Such outer short circuit may lead to heat generation and damage of the cell.

An appropriate circuitry with PCM shall be employed to protect accidental short circuit of the battery pack.

7. Notice for Designing Battery Pack

7.1 Pack toughness

Battery pack should have sufficient strength and the Li-Fe cell inside should be protected from mechanical shocks.

7.2 Cell fixing

The Li-Fe cell should be fixed to the battery pack by its large surface area.

No cell movement in the battery pack should be allowed.

7.3 Inside design

No sharp edge components should be inside the pack containing the Li-Fe cell.

7.4 Tab connection

Spot welding is recommended for Li-Fe tab connection method.

Battery pack should be designed that shear force are not applied to the Li-Fe tabs.

If apply manual solder method to connect tab with PCM, below notice is very important to ensure battery

- ◆ • performance:
- ◆ • The solder iron should be temperature controlled and ESD safe;
- ◆ • Soldering temperature should not exceed 350°C;
- ◆ • Soldering time should not be longer than 3s;
- ◆ • Soldering times should not exceed 5 times, Keep battery tab cold down before next time soldering;
- ◆ • Directly heat cell body is strictly prohibited, Battery may be damaged by heat above approx. 100°C.

7.5 For mishaps

Battery pack should be designed not to generate heat even when leakage occurs due to mishaps.

- 1) Isolate PCM (Protection Circuit Module) from leaked electrolyte as perfectly as possible.

- 2) Avoid narrow spacing between bare circuit patterns with different voltage.(Including around connector)
- 3) Li-Fe battery should not have liquid from electrolyte,but in case if leaked electrolyte as possible touch bare circuit patterns,higher potential terminal material may dissolve and precipitate at the lower potential terminal,and may cause short circuit,The design of the PCM must have this covered.

8. Notice for Assembling Battery Pack

Shocks,high temperature,or contacts of sharp edge components should not be allowed in battery pack assembling process.

9. Others

9.1 Cell connection

- 1) Direct soldering of wire leads or devices to the cell is strictly prohibited.
- 2) Lead tabs with pre-soldering may cause damage of components,such as separator and insulator.by heat generation.

9.2 Prevention of short circuit within a battery pack

Enough insulation layers between wiring and the cells shall be used to maintain extra safety protection.

The battery pack shall be structured with no short circuit within the battery pack ,which may cause generation of smoke or firing.

9.3 Prohibition of disassembly

1) Never disassemble the cells

The disassembling may generate internal short circuit in the cell,which may cause gassing,firing,explosion,or other problems.

2) Electrolyte is harmful

Li-Fe battery should not have liquid from electrolyte flowing,but in case the electrolyte come into contace with the skin,or eyes,physicians shall slush the electrolyte immediately with fresh water and medical advice is to be sought.

9.4 Prohibition of dumping of cells into fire

Never incinerate nor dispose the cells in fire.These may cause explosion of the cells,which is very dangerous and is prohibition.

9.6 Battery cells replacement

The battery replacement shall be done only by either cells supplier or device supplier and never be done by the user.

9.7 Prohibition of use of damaged cells

The cells might be damaged during shipping by shock. If any abnormal features of the cells are found such as damages in a plastic envelop of the cell, deformation of the cell package, smelling of an electrolyte, an electrolyte leakage and others, the cells shall never be used any more.

The cells with a smell of the electrolyte or a leakage shall be placed away from fire to avoid firing or explosion.

10. Period of Warranty

The period of warranty is half a year from the date of shipment. Sanchuan guarantees to give a replacement in case of cells with defects proven due to manufacturing process instead of the customer abuse and misuse.

11. Storing the Batteries

The batteries should be stored at room temperature, charged to about 30% to 50% of capacity.

We recommend that batteries be charged about once per half a year to prevent over discharge.

12. Other The Chemical Reaction

Because batteries utilize a chemical reaction, battery performance over time even if stored for a long period of time without being used. In addition, if the various usage conditions such as charge, ambient temperature, etc. are not maintained within the specified ranges the life expectancy of the battery may be shortened or the device in which the battery is used may be damaged by electrolyte leakage. If the batteries cannot maintain a charge for long periods of time, even when they are charged correctly, this may indicate it is time to change the battery.

13. Note

Any other items which are not covered in this specification shall be agreed by both parties.