
 圣码特能源 ZMARTEC	Technical Specification for Sodium-Ion Battery Cell Products	version number	A/0
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## Technical Specification for Sodium-Ion Battery Cell Products

Battery Cell Model: **ZM-LNRC33140E-12A**

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## 1 scope of application

This product specification specifies the performance requirements, experimental methods, inspection rules, shipping, transportation, safety requirements, and instructions for the use of LNRC33140E-12A battery cells produced by ZMARTEC.

## 2 Battery cell parameters

Table 1 Battery Cell Parameters

project		parameter	remark
Rated capacity		12Ah discharged at 0.5C	(25±3)°C, 0.5C constant current discharge, voltage range 2.5V~4.25V
Rated voltage		3.60V	
Standard charging	Standard charging current	0.5C	Constant voltage segment cut-off current 0.05C
	Standard charging voltage	4.25V	
Standard discharge	Standard discharge current	0.5C	
	Standard discharge voltage	2.5V	
Maximum charging current		1C	The maximum charging current should not exceed 1C within the temperature range of 15-45°C
Maximum discharge current		2C	
		10C	30s
Operating Temperature	charge	-20~60°C	-20°C≤T≤-5°C, charging current ≤0.1C -5°C≤T≤15°C: Charging current ≤0.2C; 15°C≤T≤45°C: Charging current ≤1C 45°C≤T≤60°C, charging current ≤0.5C
	discharge	-40~60°C	Discharge cut-off voltage: 2.5V for 0°C<T≤60°C; Discharge cut-off voltage: 2.0V for -40°C≤T≤0°C
Storage temperature		0~45°C	
Initial AC impedance		≤2 mΩ	40~50% SOC state
Battery cell quality		290±5g	
appearance		No cracks, scratches, deformations, stains, electrolyte leakage, etc	
size		(33.2±0.2)mm*(140±0.3)mm	For details, see Appendix 10

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### 3 Electrical performance

#### 3.1 test conditions

Unless otherwise specified, the test shall be conducted in an environment with a temperature of  $25 \pm 2$  °C, a relative humidity of 15% RH~90% RH, and an atmospheric pressure of 86kPa~106kPa. The room temperature mentioned in this specification refers to  $25 \pm 2$  °C.

#### 3.2 Requirements for testing instruments and equipment

- Voltage measuring device: not less than level 0.5
- Current measuring device: not less than level 0.5
- Temperature measuring device:  $\pm 0.5$  °C
- Time measuring device:  $\pm 0.1\%$
- Dimensional measuring device:  $\pm 0.1\%$
- Quality measuring device:  $\pm 0.1\%$

#### 3.3 Electrical performance indicators and testing methods

Electrical performance indicators and testing methods

serial number	project	Technical Requirements	test method
3.3.1	Standard charging	/	At room temperature ( $25 \pm 2$ ) °C, the battery cell is charged at a constant current and voltage of 0.5C to 4.25V, with a cut-off current of 0.05C;
3.3.2	Standard discharge	/	At room temperature ( $25 \pm 2$ ) °C, the battery cell is discharged at a constant current of 0.5C to 2.5V;




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3.3.3	Nominal capacity	$\geq 12\text{Ah}$	At room temperature, the battery cell is allowed to rest for 30 minutes after standard charging, and then subjected to standard discharge. If the discharge capacity does not reach the rated capacity, it can be repeated 3 times and the average value can be taken as the nominal capacity;
3.3.4	Room temperature rate charging performance	$1\text{C}/0.5\text{C} \geq 98\%$	a) Standard discharge of battery cells from 0.5C to 2.5V; b) Let it sit for 30 minutes; c) Charge to 4.25V at 0.5C and 1C current, with a cut-off current of 0.05C; d) Calculate the ratio of 1C charging capacity to 0.5C charging capacity;
3.3.5	Room temperature rate discharge performance	$2\text{C}/0.5\text{C} \geq 97\%$	a) Charge from 0.5C to 4.25V with a cut-off current of 0.05C; b) Let it sit for 30 minutes; c) Discharge to 2.5V at 0.5C and 2C currents respectively; d) Calculate the ratio of 2C discharge capacity to 0.5C discharge capacity
3.3.6	Discharge performance at 55 °C	$55^\circ\text{C}/25^\circ\text{C} \ 0.5\text{C} \geq 95\%$	a) At $25 \pm 3^\circ\text{C}$ , the battery cell is charged from 0.5C to 4.25V with a cut-off current of 0.05C; b) The battery cell is left at $55 \pm 2^\circ\text{C}$ for 5 hours and discharged to 2.5V at 0.5C standard; c) Calculate the ratio of discharge capacity at 55 °C to discharge capacity at 25 °C 0.5C;
3.3.7	-Discharge performance at 20 °C	$-20^\circ\text{C}/25^\circ\text{C} \ 1\text{C} \geq 85\%$	a) At $25 \pm 3^\circ\text{C}$ , the battery cell is charged from 0.5C to 4.25V with a cut-off current of 0.05C; b) The battery cell is left at $-20 \pm 2^\circ\text{C}$ for 5 hours and discharged to 2.0V at 1C standard; c) Calculate the ratio of discharge capacity at -20 °C to discharge capacity at 25 °C 0.5C;
3.3.8	-40 °C discharge performance	$-40^\circ\text{C}/25^\circ\text{C} \ 1\text{C} \geq 75\%$	a) At $25 \pm 3^\circ\text{C}$ , the battery cell is charged from 0.5C to 4.25V with a cut-off current of 0.05C; b) The battery cell is left at $-40 \pm 2^\circ\text{C}$ for 5 hours and discharged to 2.0V at 1C standard; c) Calculate the ratio of discharge capacity at -40 °C to discharge capacity at 25 °C 0.5C;
3.3.9	Low temperature charging performance	$-10^\circ\text{C}/25^\circ\text{C} \geq 70\%$	a) At $25 \pm 3^\circ\text{C}$ , the battery cell is discharged to 2.5V at a standard temperature of 0.5C, then charged to 4.2V at a constant current of 0.5C with a cut-off current of 0.05C, and discharged to 2.0V at a standard temperature of 0.5C. The initial charging capacity at 25 °C is recorded; b) Place at -10 °C for 5 hours, charge to 4.2V with a constant current of 0.1C, and record the charging capacity; c) Calculate the ratio of the charging capacity at -10 °C to the initial charging capacity at 25 °C and 0.5C;
3.3.10	Room temperature charge retention and capacity recovery capability	Charge retention rate $\geq 92\%$ Capacity recovery rate $\geq 96\%$	a) Charge the battery cell at 0.5C standard to 4.25V, with a cut-off current of 0.05C, and discharge it at 0.5C standard to 2.5V as the initial capacity; b) Charge the battery cell from 0.5C standard to 4.25V, which is 100% SOC; c) Store at $25 \pm 2^\circ\text{C}$ for 28 days; d) After being left at room temperature for 5 hours, the battery cell is discharged to 2.5V at 0.5C standard, and the charge holding capacity is calculated; Standard charge and discharge 3 times, the third discharge capacity is the recovery capacity ;

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3.3.11	High temperature charge retention and capacity recovery capability	Charge retention rate $\geq 90\%$  Capacity recovery rate $\geq 95\%$	a) Charge the battery cell at 0.5C standard to 4.25V, with a cut-off current of 0.05C, and discharge it at 0.5C standard to 2.5V as the initial capacity; b) Charge the battery cell from 0.5C standard to 4.25V, which is 100% SOC; c) Store at $55 \pm 2$ °C for 7 days; d) After being left at room temperature for 5 hours, the battery cell is discharged to 2.5V at 0.5C standard, and the charge holding capacity is calculated; Standard charge and discharge 3 times, the third discharge capacity is the recovery capacity;	

## 4 cycle life

### Cycle life test

serial numbe	project	Technical Requirements	test method
4.1	Normal temperature cycle ( $25 \pm 3$ °C)	Capacity retention rate after 2000 cycles $>70\%$	a) Charge the battery cell at a constant current and voltage of 0.5C to 4.25V, with a cut-off current of 0.05C; b) Let it sit at room temperature for 30 minutes; c) Discharge the battery cell at a constant current of 0.5C to 2.5V; d) Let it sit at room temperature for 30 minutes; e) Repeat steps a) to d) 2000 times;
4.2	High temperature cycle ( $45 \pm 3$ °C)	Cycle 800 times with capacity Quantity retention rate $>70\%$	a) Charge the battery cell at a constant current and voltage of 0.2C to 4.25V, with a cut-off current of 0.05C; b) Let it sit for 30 minutes; c) Discharge the battery cell at a constant current of 0.5C to 2.5V; d) Let it sit for 30 minutes; e) Repeat steps a) to d) 800 times;
4.3	Low temperature cycle ( $-10 \pm 3$ °C)	Cycle 500 times capacity Quantity retention rate $>70\%$	a) Charge the battery cell at a constant current of 0.1C to 4.2V, with a cut-off current of 0.05C; b) Let it sit for 10 minutes; c) Discharge the battery cell at a constant current of 0.5C to 2.0V; d) Let it sit for 10 minutes; e) Repeat steps a) to d) 500 times;


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## 5 Safety Performance

### safety performance

serial number	Testing items	Testing conditions and methods	performance standard
5.1	impact test	After completing standard charging at an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ , let it sit for 30 minutes; Fix fully charged individual batteries onto the fixture, and each battery must withstand maximum acceleration A half sine wave impulse with a pulse duration of 6 milliseconds and 150gn. Each battery must withstand three impacts in the positive direction of three mutually perpendicular battery or battery pack installation orientations, followed by three impacts in the opposite direction, for a total of 18 impacts.	The battery does not ignite or explode
5.2	extrude	After completing standard charging at an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ , let it sit for 30 minutes; Place the battery in two planes (parallel to the longitudinal axis of the battery and the two plates), apply pressure perpendicular to the direction of the plates, and apply a pressure of $13.0\text{ kN} \pm 1\text{ kN}$ between the two plates. Once the pressure reaches its maximum value, the compression test can be stopped, and the battery must not experience external short circuits during the test process;	The battery does not ignite or explode
5.3	thermal abuse	The battery is heated in a natural convection or flowing air oven, and the oven temperature is raised to $130 \pm 2\text{ }^{\circ}\text{C}$ ( $282 \pm 3.6\text{ }^{\circ}\text{F}$ ) at a rate of $5 \pm 2\text{ }^{\circ}\text{C}$ ( $9 \pm 3.6\text{ }^{\circ}\text{F}$ )/min for 30 minutes before stopping;	The battery does not ignite or explode
5.4	Forced discharge	At an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ , discharge the battery at 6A to the termination voltage, and then reverse charge the battery with a current of 12A for no less than 90 minutes;	The battery does not ignite or explode
5.5	short circuit	After completing standard charging at an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ , let it sit for 30 minutes; Place the battery in an environment of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ . When the surface temperature of the battery reaches $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ , let it sit for another 30 minutes. Then connect the positive and negative terminals of the battery with wires and ensure that the total external resistance is $80\text{ m}\Omega \pm 20\text{ m}\Omega$ . During the test, monitor the temperature changes of the battery. When either of the following two situations occur, the test is terminated: a) The battery is completely discharged until the voltage is below 0.2V; b) The shell temperature drops to the ambient temperature $\pm 10\text{ }^{\circ}\text{C}$ ;	The battery does not ignite or explode;  Battery surface temperature $\leq 150\text{ }^{\circ}\text{C}$

5.6	temperature cycling	<p>After completing standard charging at an ambient temperature of <math>20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}</math>, let it sit for 30 minutes; Place the battery in a temperature controlled box with a temperature of <math>20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}</math> and perform the following steps:</p> <p>a) Place the battery sample in an experimental chamber with a temperature of <math>75\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}</math> and maintain it for 6 hours;</p> <p>b) Reduce the temperature of the experimental chamber to <math>-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}</math> and maintain it for 6 hours;</p> <p>c) The temperature replacement time shall not exceed 30 minutes;</p> <p>After 10 cycles, place the battery at <math>20 \pm 5\text{ }^{\circ}\text{C}</math> for 24 hours for testing.</p>	The battery does not leak, ignite, or explode
5.7	over-discharge	<p>After completing standard charging at an ambient temperature of <math>20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}</math>, let it sit for 30 minutes; The battery cell was discharged at a constant current of 1C for 1.5 hours.</p>	The battery does not ignite or explode
5.8	vibration	<p>The battery cell must undergo three vibrations of equal magnitude. Vibration testing should be conducted in three mutually perpendicular directions. If there are only two axes of symmetry, testing should be conducted in both directions. The direction of each vibration is the front of the battery cell. The way each battery vibrates is as follows: for the first 3 milliseconds, the minimum average acceleration is 75g (g is the local acceleration). The peak acceleration must be between 125 and 175g. The test temperature is <math>20 \pm 5\text{ }^{\circ}\text{C}</math>.</p>	The battery does not ignite or explode
5.9	low pressure	<p>After completing standard charging at an ambient temperature of <math>20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}</math>, let it sit for 30 minutes;</p> <p>Low pressure test: The battery cell is left at room temperature for 6 hours under an absolute pressure of 11.6kPa.</p>	The battery does not leak, smoke, ignite, or explode
5.10	drop test	<p>After completing standard charging at an ambient temperature of <math>20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}</math>, let it sit for 30 minutes;</p> <p>Drop test: The positive and negative terminals of the battery cell fall freely from a height of 1.5m onto a cement floor.</p>	The battery does not leak, smoke, ignite, or explode
5.11	Pin prick test	<p>a) Standard charging of battery cells;</p> <p>b) After the battery charging is completed, use a high-temperature resistant steel needle with a diameter of 5 to 8 mm (the cone angle of the needle tip is <math>45^{\circ}</math> - <math>60^{\circ}</math>, the surface of the needle is smooth, free of rust, oxidation layer, and oil stains) to penetrate from the direction perpendicular to the battery plate at a speed of <math>(25 \pm 5)\text{ mm/s}</math>, and the penetration position should be close to the geometric center of the pierced surface. The steel needle should stay in the battery and observe for 1 hour.</p>	The battery does not ignite or explode
5.12	Overcharge test	<p>Charging: Charge the battery cell at a constant current of 0.5C to 5.4V or 115% SOC, and then let it sit for 1 hour.</p>	The battery does not ignite or explode

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## 6 Shipment, transportation, and quality assurance

### 6.1 shipment

Individual battery cells with 30% to 40% SOC or customer requirements for shipment, the remaining capacity after shipment and before charging depends on storage time and conditions.

### 6.2 transportation

6.2.1 The product is packaged in boxes before transportation, and the state of charge during transportation meets the specified requirements.

6.2.2 Violent loading and unloading should be strictly prohibited during transportation, to prevent severe vibration, impact or compression, to prevent exposure to sunlight and rain, and not to invert.

6.2.3 During the loading and unloading process, handle with care and strictly prevent throwing, rolling, and heavy pressure.

### 6.3 quality assurance

6.3.1 The shelf life of the battery cells shall be determined according to the contract from the date of shipment. However, during this period, ZMARTEC does not promise to replace the battery cells free of charge if the quality problems are caused by customer misuse or exceeding the usage conditions, rather than due to the process reasons of Saint Mark Company;

6.3.2 ZMARTEC company shall not be held responsible for any issues arising from violations of safety regulations;

6.3.3 ZMARTEC company shall not be held responsible for any issues arising from the use of circuits, battery packs, or chargers;

6.3.4 Defective battery cells generated by customers during the assembly process after shipment are not within the scope of ZMARTEC's quality assurance.

## 7 Safety and Warning

7.1 Before use, it is necessary to carefully read the specification sheet.

7.2 Do not immerse the battery cells in water or other conductive liquids.

7.3 Do not put the battery cells into fire or expose them to temperatures outside their working range for a long time.

7.4 Strictly connect the positive and negative terminals of the battery cell according to the markings and instructions, and reverse charging is prohibited.


7.5 When the electrolyte leaks, avoid skin and eye contact with the electrolyte. If there is contact, rinse the area with plenty of water and seek help from a doctor. No person or animal is allowed to ingest any component or substance contained in the battery cell.

7.6 Make every effort to protect the battery cell from mechanical vibration, collision, and pressure impact, otherwise there may be a short circuit inside the battery cell, resulting in high temperature or fire.

7.7 It is strictly prohibited to subject the battery cells to excessive mechanical impact.

7.8 It is strictly prohibited to use batteries that have been squeezed, dropped, short circuited, leaked, or have other abnormal problems during use.

7.9 During use, it is strictly prohibited for the shells of each battery cell to come into direct contact or be connected together through conductors to form a path.

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7.10 Battery cells should be stored and used in a place away from static electricity.

7.11 If the battery cell suddenly heats up, emits odor, changes color, deforms or reacts during charging, discharging, storage or use, it should be immediately stopped from use and corresponding measures should be taken.

## 8 Instructions for using battery cells

### 8.1 charge

8. 1. The charging temperature range for battery cells is  $-20\text{ }^{\circ}\text{C}\sim 60\text{ }^{\circ}\text{C}$ ;

8. 1.2 Charge with a constant current and voltage of 1C to 4.25V. It is recommended not to use a current exceeding 1C;

8. 1.3 -When charging at  $20\text{ }^{\circ}\text{C}\sim 5\text{ }^{\circ}\text{C}$ , the current should not exceed 0.1C;

8. 1.4 Do not continue charging beyond the standard time;

8. 1.5 Correctly connect the positive and negative terminals of the battery, and reverse charging is strictly prohibited. If the positive and negative terminals of the battery are reversed, the battery cell cannot be charged. At the same time, reverse charging will reduce the charging and discharging performance and safety of the battery cell, and may cause heating and leakage.

### 8.2 discharge

8.2.1 The discharge temperature range of the battery cell is  $-40\text{ }^{\circ}\text{C}$  to  $60\text{ }^{\circ}\text{C}$ ;

8.2.2 The discharge termination voltage is 2.5V, and the discharge termination voltage is 2.0V in an environment with a temperature below  $0\text{ }^{\circ}\text{C}$ . The maximum constant current discharge current is 2C;

8.2.3 It should be noted that during the long-term unused period of the battery cell, it may be in a certain over discharge state due to other self discharge characteristics. To prevent over discharge, the battery cell should be charged regularly to maintain its charge at around 50% SOC.

### 8.3 Connection of battery cells


It is recommended to use ultrasonic welding or spot welding techniques to connect the battery cell to the protective circuit module or other parts.

### 8.4 Storage suggestions

8.4.1 The battery cells should be stored at a temperature range of  $-20\sim 45\text{ }^{\circ}\text{C}$ ; In an environment with relative humidity  $<65\%$  RH and without corrosive gases.

8.4.2 It is best to store battery cells in a  $40\sim 50\%$  SOC state.

8.4.3 Long term storage: If the battery cell needs to be stored for a long time (more than 3 months), it should be stored in an environment with a temperature range of  $0\sim 25\text{ }^{\circ}\text{C}$ , relative humidity  $<65\%$  RH, and no corrosive gases.

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## 9 End of Product Life Management

In order to ensure the safe application of battery cells, customers need to establish an effective tracking system to monitor and record the internal resistance of each cell. The measurement and calculation methods of internal resistance need to be jointly discussed and agreed upon by the customer and Saint Mark. When the internal resistance of the battery cell exceeds 200% of its initial resistance, or when the capacity decays to 70% of its initial capacity, the use of the battery cell should be stopped. Violation of this requirement will exempt ZMARTEC from its product quality assurance responsibilities under the product sales agreement and this specification.

## 10 Cell size

