



-EVE Power CO., LTD Confidential Proprietary-

Model	MB56	Specification No.	PBRI-MB56-D06-01	Version	A
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Sample Specification

Prismatic LFP Cell

Model: MB56

Drafted by	Product Design Checked by	Quality Checked by	Sales Checked by	Approved by

Customer Recipient
Company Name
Approved by
Date

Nov. 2023
EVE Power Co., Ltd.



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Customer Requirements

Customers shall communicate and reach an agreement with EVE Power Co., Ltd. regarding special requirements beyond the product specifications. If certain applications and operation conditions are out of the description of this specification, EVE may design and manufacture products according to customer's inputs.

No.	Special Requirements	Standards
1		
2		
3		
4		
5		

Customer Code : _____ **Signature** : _____ **Date** : _____



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Revision History

Version	Date	Contents	Checked By
A	2023.11.23	First issue, sample delivery	Zhao Yuan

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Term Definition

Product

Refers to the MB56 rechargeable lithium-ion cell with prismatic aluminum shell manufactured by EVE Power Co., Ltd. (hereinafter referred to as EVE) in this specification.

Customer

Refers to the buyer in the product sales contract signed with EVE.

Environment temperature

The ambient temperature where the cell is located.

Cell temperature

The temperature measured by temperature sensor installed at the center of cell surface. The selection of temperature sensor and measuring line shall be jointly agreed by EVE and the customer.

Fresh cell

Refers to the cell within 7 days from the customer's receipt date (for domestic transportation only)

Power

The ratio of the charge/discharge power to the cell energy value measured multiple times by the battery system, denoted by P. For example, when the cell energy is 2009.6 Wh and the charge/discharge power is 1004.8 W, the charge/discharge power is 0.5P; When the cell energy decays to 1607.68 Wh and the charge/discharge power is 803.84 W, the charge/discharge ratio is 0.5P.

State of charge

Under unloaded conditions, the ratio of the cell capacity state to the nominal capacity measured in ampere-hour or watt- hour. The abbreviation is expressed by SOC. For example, if the capacity at 628 Ah is 100% SOC, the capacity at 0 Ah is 0% SOC.

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State of health

The ratio of actual cell capacity to nominal capacity, abbreviated as SOH. For example, if the cell capacity of 628 Ah is 100% SOH, when the cell capacity decays to 502.4 Ah, it's at 80% SOH.

Cycle :

A cycle means the cell being charged and discharged once according to the charging and discharging standards. The cell shall be charged and discharged once according to the specified charging and discharging standards as a cycle. The cycle includes short-term normal charging or a combination of regenerative charging and discharging processes. In the charging process, sometimes there is only normal charging and no regenerative charging. The discharge can be formed by combining some partial discharges.

Open circuit voltage

The voltage of the cell measured when unloaded or circuit is disconnected. The abbreviation is expressed by OCV.

AC resistance

Apply 1kHz sine wave current between the positive and negative poles of the cell, and the internal resistance obtained is AC resistance, which is abbreviated as ACR. The test method is described in appendix 1.6 of this specification.

DC resistance

The ratio of the voltage changes to the corresponding current change under working conditions, and the abbreviation is DCR. The test method is as described in appendix 1.6 of this specification.

Module

The intermediate product between single cell and pack, which is formed by lithium-ion cells in series and parallel after installing cell monitors and management devices.

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The currents that appear periodically are called pulse currents. The pulse currents appear either in the same direction or in alternating positive and negative directions.

Compression force

When the module is assembled, the cell can withstand the force perpendicular to the cell stacking direction.

Swelling force

The force on the clamp due to cell expansion during use, which may be caused by inherent characteristic changes, such as the rebound of electrode thickness.

Units of measurement: Refer to following table

Table 1 Units of Measurement

No.	Units	Abbreviation	Type of units
1	Volt	V	Voltage
2	Ampere	A	Current
3	Ampere-Hour	Ah	Capacity
4	Watt-Hour	Wh	Energy
5	Ohm	Ω	Resistance
6	Milliohm	m Ω	Resistance
7	Degree Celsius	$^{\circ}\text{C}$	Temperature
8	Millimeter	mm	Length
9	Second	s	Time
10	Hertz	Hz	Frequency
11	Newton	N	Force
12	Kilogram-Force	kgf	Force

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1 Scope of Application

This document describes the specification of the MB56 lithium-ion cell manufactured by EVE Power Co., Ltd.

2 Cell Specifications

2.1 Product Specifications

Table 2 Product Specifications

Items	Specifications	Remarks
Nominal Capacity 标称容量	628 Ah	0.5P / 0.5P, 25°C ± 2°C, 2.5 V ~ 3.65 V Fresh cell
Nominal Energy		
Nominal Voltage	3.2 V	/
End-of-charge Voltage (U _{max})	3.65 V	/
End-of-discharge Voltage (U _{min})	2.5 V (T > 0°C) 2.0 V (T ≤ 0°C)	/
Standard Charging Power	0.5P	25°C ± 2°C
Max. Continuous Charging Power	0.5P	25°C ± 2°C
Standard Discharging Power	0.5P	25°C ± 2°C
Max. Continuous Discharging Power	0.5P	25°C ± 2°C
Initial Internal Resistance	0.10 mΩ ± 0.05 mΩ	AC, 1 kHz, Delivery SOC,
Weight	11500 g ± 300 g	/
Dimensions (With	Height1 207.2 mm ± 0.5 mm	With Terminal

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insulation film)	Height2	205.1 mm ± 0.5 mm	Without Terminal		
	Length	352.3 mm ± 0.5 mm	/		
	Thickness	71.7 mm ± 0.5 mm	(300 kgf ± 20 kgf compression force, Delivery SOC)		
	Center distance between the poles	180.0 mm ± 0.3 mm	/		
Operation Temperature	Charging Temperature	0°C ~ 60°C	/		
	Discharging Temperature	-30°C ~ 60°C	/		
Storage Temperature	1 year	0°C ~ 35°C	Delivery SOC status		
	1 month	-20°C ~ 45°C			
Self-discharge	First Month	≤ 3.5% / M	Delivery SOC status, 25°C ± 2°C storage		
	After First Month	≤ 3.0% / M			

2.2 Electrical Performance

Table 3 Electrical Performance Parameters

Items	Specifications			Testing Methods
Rate Charge and Discharge Performance	Items	Discharging energy	Energy efficiency	Appendix 1.11
	Rate			
	0.5P	E_1^*	$E_1^*/E_1 \geq 94\%$	
	1P	$E_2^* \geq 95\% * E_1^*$	$E_3^*/E_3 \geq 90\%$	
High/Low Temperature Charge/Discharge Performance	Items	Discharging energy	Energy efficiency	Appendix 1.12
	Temp.			
	45°C	$E_4^* \geq 98\% * E_0^*$	$E_4^*/E_4 \geq 95\%$	
	5°C	$E_5^* \geq 80\% * E_0^*$	$E_5^*/E_5 \geq 80\%$	
Capacity Retention and Recovery	Items	Discharging energy retention	Discharging energy recovery	Appendix 1.13
	Temp.			

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(100% SOC)					
	25°C & 28 days	$E_6^* \geq 95\% * E_0^*$	$E_7^* \geq 97\% * E_0^*$		
	45°C & 7 days	$E_8^* \geq 95\% * E_0^*$	$E_9^* \geq 97\% * E_0^*$		
Storage (50% SOC)	Items	Discharging energy recovery		Appendix 1.14	
	Temp.				
	25°C & 28days	$\geq 98\% * E_0^*$			
	45°C & 28days	$\geq 97\% * E_0^*$			
Cycle Life	25°C Cycle	8000 cycles, 70% SOH		Appendix 1.15	
Cell temperature rise	25°C, 0.5P, discharge	$\leq 10^\circ\text{C}$		Temperature rise refers to the difference of the cell surface temperature before and after discharging	
Swelling Force	70% SOH	$\leq 45000 \text{ N}$		Appendix 1.16	
	60% SOH	$\leq 55000 \text{ N}$			

2.3 Charging Parameters

2.3.1 Charging Mode

Table 4 Charging Mode Parameters

Parameters	Specifications	Conditions
Standard charging power	0.5P	25°C ± 2°C
Maximum continuous charging power	0.5P	25°C ± 2°C
Standard charging voltage	Single cell ≤ 3.65 V	
Standard charging mode	Charge to 3.65 V with a constant power of 1004.8 W	

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Standard charging temperature	25°C ± 2°C				
Absolute charging temperature (cell temperature)	0°C ~ 60°C	No matter what charging mode the cell is in, once the cell temperature exceeds the absolute charging temperature range, stop charging.			
Absolute charging voltage	Max 3.8 V	No matter what charging mode the cell is in, once the cell voltage exceeds the absolute charging voltage, stop charging.			

2.3.2 Other Charging Modes

Table 5 Continuous Charging Modes (unit: P-Rate)

Cell temperature /°C		0	5	10	15	20	25	45	50	55	60
Max charging power	0% ~ 100% SOC	0.05	0.12	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0

2.4 Discharging Parameters

2.4.1 Discharging Mode

Table 6 Discharging Mode Parameter

Parameters	Product specifications	Conditions
Standard discharging power	0.5P	25°C ± 2°C
Maximum continuous discharging power	0.5P	25°C ± 2°C
Standard discharge mode	Discharge to 2.5 V with a constant power of 1004.8 W	
Discharge cut-off voltage	2.5 V	Temperature T > 0°C

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			T > 0°C		
	2.0 V	Temperature T ≤ 0°C			
Standard discharging temperature	25°C ± 2°C				
Absolute discharging temperature (cell temperature)	-35°C ~ 65°C	No matter what discharging mode the cell is on, once the cell temperature exceeds the absolute discharge temperature range, stop discharging.			
Absolute discharging voltage	Min 1.8 V	No matter what kind of discharging mode the cell is on, once the cell voltage is less than the absolute discharge voltage, stop discharging.			

2.4.2 Other Discharging Modes

Table 7 Continuous Discharging Rate (unit: P-Rate)

Cell temperature /°C		-30	-20	-10	-5	0	5	45	50	55	60
Max discharging power	0% ~ 100% SOC	0	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0

2.5 Safety Performance

Table 8 Safety Performance Parameters

Items	Specifications	Test Methods
Over-charge	No fire, No explosion	Appendix 1.17.1
Over-discharge	No fire, No explosion	Appendix 1.17.2
External Short-circuit	No fire, No explosion	Appendix 1.17.3
Crush Test	No fire, No explosion	Appendix 1.17.4

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Drop Test		No fire, No explosion		Appendix 1.17.5	
Low Pressure		No leakage, No fire, No explosion		Appendix 1.17.6	
Heating		No fire, No explosion		Appendix 1.17.7	
Thermal Runaway		No fire, No explosion		Appendix 1.17.8	

Notes

The descriptions above only represent compliance at the cell level. The safety compliance at the module and the system level requires the customer to perform design verification.

3 Product End-life Management

The cell life is limited. Customers should establish an effective tracing system to monitor and record the internal resistance and capacity of each cell during its life. The measurement method and calculation method of internal resistance and capacity need to be discussed and agreed between the customer and EVE. When the internal resistance of the cell in use exceeds 150% of the initial internal resistance, or the capacity is less than 60% of nominal capacity, the cell should not to be used any more. Violation of this requirement will exempt EVE from its responsibility for product quality assurance in accordance with the product sales agreement and this specification, as well as all related liabilities such as loss compensation caused thereby.

4 Application Conditions

Customer shall ensure strict compliance with the following cell application conditions:

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4.1 Customer shall configure a battery management and monitoring system to strictly monitor, manage and protect each cell, and provide detailed information of the BMS, including but not limited to its design, features, setting, and data file format to EVE for design review and record keeping. And a battery management archive shall be established to keep all monitoring data of the cells, so as to be a reference for problems tracing and product quality responsibility division. EVE is not responsible for product quality assurance if no complete monitoring data of the battery system during its service life is provided.

4.2 Waterproof and dustproof problems shall be fully considered in the pack design, and the pack must meet the waterproof and dustproof grade stipulated by relevant national standards. EVE is not responsible for the damage (such as corrosion, rust, etc.) of the cell caused by waterproof and dustproof problems.

4.3 It is forbidden to mix different types of cells in the same battery system, otherwise, EVE will not be responsible for the quality assurance.

4.4 The design of the BMS shall meet the safety voltage and operating temperature limitations in Tables 9 and Table 10

Table 9 Safety Limit Voltage Parameters

Items	Categories	Parameters	Protective Actions
Charging Voltage	Charging Ends	3.65 V	When the cell voltage reaches 3.65 V, stop charging.
	Third	3.7 V	BMS alarms
	Second	3.75 V	Reduce cell charging current or power

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	First	3.80 V	Cut off the current, force the cell to stop working and lock the BMS until the technician solves the problem.		
Discharging Voltage	Discharging Ends	2.5 V (> 0°C) 2.0 V (≤ 0°C)	When the cell voltage reaches 2.5 V (0°C) or 2.0 V (≤ 0°C), stop charging.		
	Third	2.0 V (> 0°C) 1.9 V (≤ 0°C)	BMS alarms		
	Second 二级	1.9 V (> 0°C) 1.8 V (≤ 0°C)	Reduce cell discharging current or power		
	First	1.85 V (> 0°C) 1.75 V (≤ 0°C)	Cut off the current, force the cell to stop working and lock the BMS until the technician solves the problem.		
BMS protection	Short circuit protection	Short circuit is not allowed	When a short circuit occurs, the overcurrent protection device will disconnect the cell.		
Over current protection	Reference 2.3 & 2.4		BMS controls the charging/discharging current within specifications.		
Upper limit charging capacity 保	Charging capacity < 709.64 Ah		The charging capacity shall be less than 113% of the nominal capacity.		

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Table 10 Safety Limit Temperature Parameters

Items	Parameters	Remarks
Recommended operating temperature range	10°C ~ 45°C	Recommended cell using temperature range
Maximum operating temperature	60°C	If the cell temperature exceeds the maximum operating temperature, the cell power needs to be reduced to 0.
Minimum operating temperature	-30°C	If the cell temperature exceeds the minimum operating temperature, the cell power needs to be reduced to 0.
Maximum safe temperature	65°C	If the battery temperature exceeds the maximum safe temperature, it will cause irreversible and permanent damage to the battery, and the user should not use it higher than the maximum safe temperature.
Minimum safe temperature	-35°C	If the battery temperature exceeds the minimum safe temperature, it will cause irreversible and permanent damage to the battery, and the user should not lower the minimum safe temperature when using it.
Over heat protection	Reference 2.3 & 2.4	Stop charging/discharging when the temperature exceeds the limitation in this specification

Notes

a) If the cell charging voltage exceeds the cut-off voltage, corresponding protective actions need to be taken. If the cell discharging voltage reaches the cut-off voltage, it is necessary to charge as soon as possible to prevent it from being over-discharged. EVE shall not be responsible for any cell quality issues caused by over-discharge and exceeding the protection voltage.

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b) It's prohibited to charge the cell at low temperatures (lower than 0°C) and the minimum safety temperature of this specification, otherwise EVE will not be responsible for any quality assurance liability. The heat dissipation design of pack may affect cell electrical performance, EVE will not be responsible for any liability regarding cell quality issues caused by the pack heat dissipation design.

4.5 Recommendations for Module Welding Parameters

Table11 Welding Parameters

Items	Specifications	Remarks	
Welding Parameter of Al Busbar	Laser Welding Depth	≤ 2.0 mm	/
	Max Pressure on Poles	500 N	The maximum force on the poles in vertical direction with no deformation.
	Max Torque on Poles	6 N·m	The maximum torsion on the poles with no loosen.
	Max Temperature of Poles	130°C	The maximum temperature that the poles bear before the plastic pad deforms.
	Suggested number of welding rings	1~2	When using under high-power conditions, it is recommended to weld 2 circles 2 圈

4.6 Cell Compression Force

When forming modules, a compression force in the direction of vertical thickness is applied to the cells in order to make them better arranged and fixed. If the compression force is too large, the cells may be damaged or even leak. Cell compression force test conditions are as follows:

-Compression area 352.3 mm × 205.1 mm (L × H2)

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- Compression speed 0.02 mm/s
- Compression direction Y direction
- Cell SOC : 15 % ~ 40 %

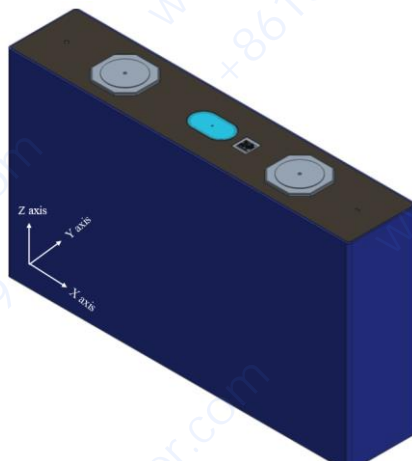


Fig. 12 Diagram of MB56 cell directions

Table 13 Cell Compression Force Limit Parameters

Items	Compression Force
Recommended compression force	3000 N ~ 7000 N
Instantaneous maximum compression force	≤ 10000 N

The compression force of the cell shall be no larger than 10000 N, otherwise the cell may be damaged.

4.7 Cell Swelling Force

The inherent characteristics such as the rebound of the electrode thickness may lead to cell expansion during use which generates force on the clamp, and the force increases with the attenuation of the cell capacity. The cell swelling force at BOL and EOL (60% SOH) refer to Table 3:

Customer shall fully consider the influence of the cell swelling force when designing the module. The product generates expansion force during use, and the expansion force is about 60000 N when the cell capacity attenuates to 60% under the

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test conditions of 15 mm steel plate + 0.0 mm GAP (the space for cells to expand). Customers shall consider the reliability of structural strength in the product design process, and it is suggested to reserve 2.0 mm ~ 2.5mm expansion space while grouping the cells.

4.8 Recommended Temperature Control

The recommended temperature collection points are the poles and the code when collecting temperature of the cell surface. The cell thermodynamic parameters needed in the thermal management system are shown in the following table.

Table 14 Cell Thermal Conductivity Parameters

Mean thermal conductivity	Thermal Conductivity W/(m·K)	
	X/Z direction	Y direction
	9 ~ 11 W/(m·K)	2 ~ 3 W/(m·K)
Mean heat capacity	Heat Capacity (kJ/(kg·K))	
	0.9 ~ 1.1 kJ/(kg·K)	

4.9 After charging, the cell should be used as soon as possible to avoid loss of usable capacity due to self-discharge. If long-term storage is required, adjust the cell SOC to 30% ~ 40%. The recommended storage conditions are: 0°C ~ 25°C, relative humidity ≤ 60%.

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4.10 The state of charge (SOC, capacity state) of the cell should be kept at 15% ~ 40% during storage. In order to prevent the performance differences after long-term storage (more than three months), perform a standard charge-discharge cycle every 3 months. It is recommended that the storage time after receiving the cells should not exceed half a year to avoid quality problems due to storage overdue.

4.11 It is not allowed to ship with inflammable, explosive and corrosive articles in the same vehicle during transportation, and stacking is prohibited during large package transportation; The product shall not be exposed to rain, snow and other liquid substances without any protection, or suffer from mechanical damage;

4.12 While handling, lift trucks or special tools shall be used to load and unload products; Handle with care, and do not throw or squeeze, which may cause cell damage or personal injury. It is strictly prohibited to put cells together with corrosive substances such as acid and alkali.

5 Safety Precautions

- It is strictly forbidden to immerse the cell in water. When it is not in use, it should be placed in a cool and dry environment.
- Do not over-charge the cell. Otherwise, cell overheating and fire may occur. During cell installation and use, hardware and software must be protected against multiple over-charge failures. See 4.3 of this specification for the minimum requirements of protection.
- It's necessary to set a reasonable charging time limit, otherwise, the cell may overheat, resulting in thermal runaway or fire. BMS management failure of this kind shall be considered during module design.
- If improper charge termination occurs, the root reasons shall be found and resolved before reuse to avoid negative effects on electrical and safety performances.

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- It is forbidden to over-discharge. During the normal use of the cell, charge the cell regularly to keep the voltage above 2.8 V, so as to avoid over-discharge.
- It is forbidden to use or place the cell at a high temperature environment. Otherwise, cell overheat, function failure or life shorten may occur.
- The temperature of the cell shall not exceed 65°C in any normal use, otherwise the BMS must shut down the cell and stop cell operation.
- Please use a special charger for lithium-ion batteries when charging.
- During use, please connect the positive and the negative of the cell strictly according to the labels and instructions, and reverse charging is forbidden.
- It is forbidden to use metal to directly connect the positive and the negative of the cell to short-circuit. Otherwise, strong current and high temperature may cause personal injury or fire.
- It is forbidden to transport or store the cell with metal, such as hairpins, necklaces, etc.
- It is forbidden to knock, throw, step on or bend the cell.
- It is forbidden to directly weld the cell.
- It is forbidden to directly pierce the cell with nails or other sharp objects.
- Prevent the cell from mechanical shock, collision and pressure impact. Otherwise, the cell may be short-circuited internally, resulting in high temperature and fire.
- It is forbidden to use it in places with strong static electricity and strong magnetic fields; otherwise cell safety protection devices may be damaged and cause safety hazards.
- Customer shall securely fix the cell to a solid surface and bind the power cord in a proper place to avoid arcing and sparks caused by friction.

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- It is forbidden to use plastic for cell encapsulation and electrical connection. Improper electrical connection may cause overheat during cell use.
- If the cell leaks and the electrolyte spills onto the skin or clothes, immediately wash the affected area with running water. If the cell leaks and the electrolyte enters the eyes, mouth, nose and other open parts of the human body, immediately wash with plenty of water and seek medical treatment immediately, otherwise serious injuries will be caused to the human body. No person or animal is allowed to swallow any part of the cell or any substance contained in the cell.
- If the cell emits peculiar smell, heat, discoloration, deformation, or any abnormality during use, storage, or charging, immediately remove the cell from the device or charger and stop using it.
- It is prohibited to disassemble the product without the written consent of EVE.

6 Disclaimer

- If the product demand party or user does not use the product in accordance with the provisions of this specification, EVE will no longer take any relevant responsibility such as product quality assurance liability and loss compensation caused thereby. In case of any negative impact on EVE's reputation due to the above-mentioned actions, EVE reserves the right to investigate the legal liability of the product demand party.
- EVE reserves the right to modify the product specification. Before ordering EVE products, customers need to confirm the latest status of the products in advance with EVE.
- This specification is written in English.

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7 Risk Warning

7.1 Warning Declaration

Warning

The cell has potential hazards. Please take proper precautions when operating and maintaining the cell!

The cell must be operated with proper tools and protective equipment.

Cell maintenance must be performed by professionals with cell expertise and safety training.

Failure to comply with these warnings may result in multiple disasters.

7.2 Types of Hazards

Customer must be aware of the following potential hazards in the use and operation of cells:

- a) There is a risk from electric shocks or electric arcs during operation.
- b) There is a risk from the electrolyte or other chemicals.
- c) Proper operation methods and protective equipment shall be selected to avoid accidental short circuit, leading to electric arcs, explosion or thermal runaway.

8 Others

8.1 Rights and Obligations of EVE

- EVE shall inspect according to the inspection standards in the protocol signed with the customer, and the products provided shall meet the requirements of various parameters in the protocol;
- EVE shall provide customer with stable and reliable products confirmed by both parties;

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- EVE is obliged to provide high-quality services for its products, and the service standards shall be in accordance with the standards promised by EVE;
- EVE shall provide timely technical support and service in case of any problem or failure during the use and maintenance of system products by customer.

8.2 Rights and Obligations of Customer

- Customer must conduct production in strict accordance with the technical data provided by EVE, and strictly implement the cell prevention measures, safety limits and cell operation instructions in the technical data provided by EVE.
- Customer has the obligation to ensure the safety of products by EVE and shall take corresponding fire prevention, waterproof and other measures.
- Customer has the obligation to make fair and detailed use records and monitoring data of product operation for EVE's products, which can be used as a reference for the division of product quality responsibilities. If there is no complete monitoring data within the service life of the battery system, EVE shall not be responsible for product quality assurance.
- Customer has the obligation to notify EVE's personnel to be present and be informed of the actual situation when products of EVE operate abnormally.
- In the process of product manufacturing, customer shall take all corresponding responsibilities for the problems or accidents caused by the operation in violation of the safety rules, the use beyond the conditions specified in this technical agreement, or the combination of the product and the circuit (not the quality defects of the product itself).
- Any matter not mentioned in this specification must be negotiated and determined by both parties.



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8.3 Confidentiality agreement

The customer shall keep the cooperation content highly confidential. Without the permission of EVE, the customer shall not disclose any content of the technical agreement to a third party. Otherwise, the customer will be held responsible according to relevant laws.

9 Contact Information

Address: EVE Power Co., Ltd., No. 68 Jingnan Avenue High-Tech Zone, Duodao District, Jingmen, Hubei.

Website: <http://www.evepower.com>

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Appendix 1: Cell Drawing of MB56 附录 1: MB56 电池图纸

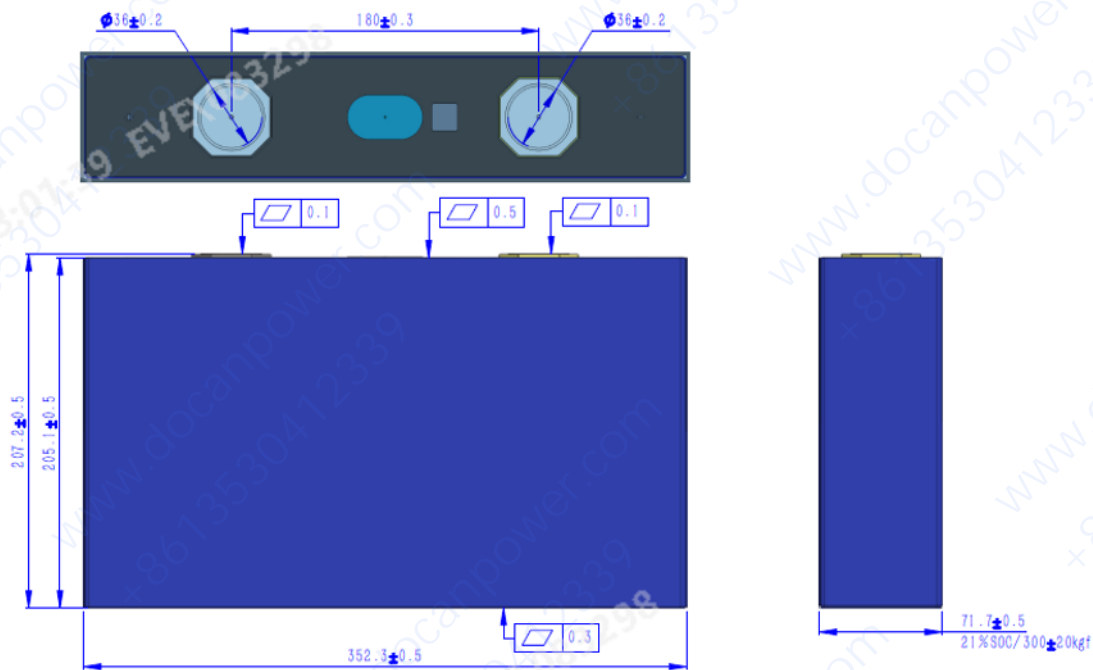


Fig. 15 Diagram of cell size and appearance
图 15 电池尺寸及外观图

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Appendix 2: Test Conditions and Methods 附录 2: 试验条件及方法

1.1 Environmental Conditions 环境条件

Unless otherwise specified, the test should be carried out in an environmental temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, relative humidity of 10% ~ 90%, and atmospheric pressure of 86 kPa to 106 kPa. The room temperature mentioned in this specification refers to $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$.

除另有规定外，试验应在温度为 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ，相对湿度 10% ~ 90%，大气压力为 86 kPa ~ 106 kPa 的环境中进行。本规格书所提到的室温，是指 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 。

1.2 Measuring Instruments 测量设备

The accuracy of measuring instruments shall meet the following requirements:

试验装置应符合下列要求：

- A. Voltage measuring device 电压测量装置： $\pm 0.05\%$ FS；
- B. Current measuring device 电流测量装置： $\pm 0.05\%$ FS；
- C. Temperature measuring device 温度测量装置： $\pm 1^{\circ}\text{C}$ ；
- D. Dimension measuring device 尺寸测量装置： $\pm 0.01\text{ mm}$ ；
- E. Weight measuring device 重量测量装置： $\pm 0.1\text{ g}$ 。

Note: During the testing process, voltage, current, ambient temperature, and cell temperature must be recorded. It is recommended to collect the cell temperature at the terminal and the center of the large surface (or side surface).

备注：测试过程中，均需记录电压、电流、环境温度和电池温度，电池温度采集点建议布置在极柱和大面（或侧面）中心处。

1.3 Test Clamp Preparation and Installation 测试夹具准备和安装

1.3.1 Ordinary Steel Clamp 普通钢夹具

The single cell shall be clamped with steel splints (thickness: 15 mm). The splints need to cover the large surfaces of the cell and be fixed with 6 M8 bolts. All sides of the splints need to be covered with insulating film. Clamp as shown below:

单体电池需采用钢夹板（厚度：15 mm）固定，夹板需要覆盖住电池大面，夹板之间采用 6 个 M8 螺栓固定，夹板各个面需要有绝缘膜，夹具工装如下图所示：

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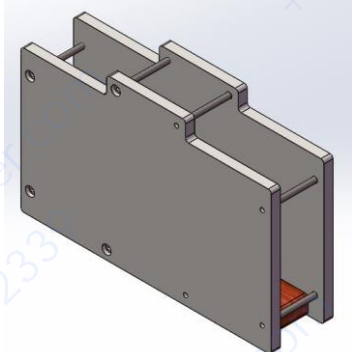


Fig. 1 Diagram of the clamp
图 1 夹具示意图

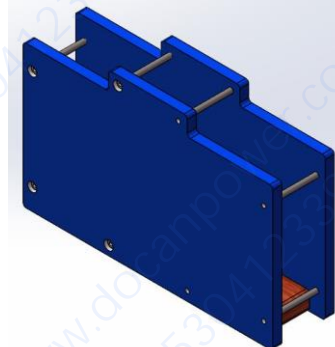


Fig. 2 Diagram of the clamp covered with insulation film
图 2 电池夹具包绝缘膜图

Place the cell (15% ~ 40% SOC) which is covered with blue film (material: PET, thickness: 0.1 mm) and top film (material: PC, thickness: 0.3 mm) in the middle of the splint, fix the clamp with 6 M8 bolts to ensure the initial compression force on the cell is $300 \text{ kgf} \pm 20 \text{ kgf}$. Then use a micrometer to measure the thickness of the cell (at upper, middle and bottom) with splints, and the thickness tolerance shall be controlled within 0.3 mm.

将包覆有蓝膜 (材质: PET, 厚度 0.1 mm) 和顶底部贴片 (材质: PC, 厚度 0.3 mm) 的电池 (15% ~ 40% SOC) 准备好后, 置于夹具中间, 使用 6 个 M8 螺栓固定钢夹具保证电池受夹具初始预紧力为 $300 \text{ kgf} \pm 20 \text{ kgf}$, 需采用千分尺测量带夹板电池的厚度 (上、中、下), 厚度差异需控制小于等于 0.3 mm。



Fig. 3 Diagram of cell filming
图 3 电池包膜示意图

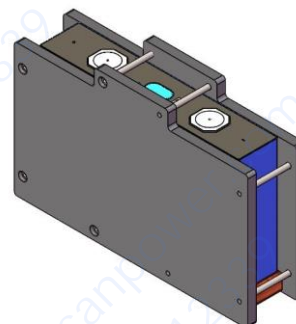


Fig. 4 Diagram of cell with clamp
图 4 电池带夹具示意图

1.3.2 Swelling Force Clamp 膨胀力夹具

Place the cell (15% ~ 40% SOC) which is covered with blue film (material: PET, thickness: 0.1 mm) and top film (material: PC, thickness: 0.3 mm) in the middle of the splint, and adjust the swelling force clamp pre-tensioning device until the initial compression force is $(300 \text{ kgf} \pm 20 \text{ kgf})$. Then use a micrometer to measure the thickness of the cell (at upper, middle and bottom) with splints, and the thickness tolerance shall be controlled within 0.3 mm.

将包覆有蓝膜 (材质: PET, 厚度 0.1 mm) 和顶底部贴片 (材质: PC, 厚度 0.3 mm) 的电池 (15% ~ 40% SOC) 准备好后, 置于膨胀力夹具中间, 调节膨胀力夹具预紧装置, 使传感显示装置压缩力为 $300 \text{ kgf} \pm 20 \text{ kgf}$, 上夹板后, 需采用千分尺测量带夹板电池的厚度 (上、中、下), 厚度差异需控制小于等于 0.3 mm。

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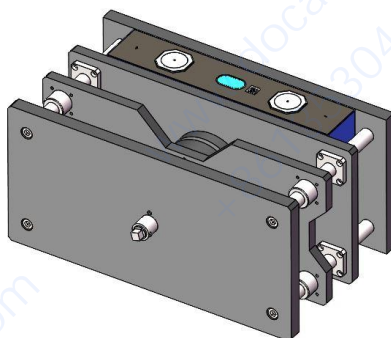


Fig. 5 Diagram of cell with swelling force clamp

图 5 电池带膨胀力夹具示意图

1.4 Dimensions 尺寸

Test instrument: Automatic wrapping machine;

试验设备：自动包膜机；

Test method: Use the wrapping machine to measure the length, width and height of the cell. And apply a 300 kgf ± 20 kgf force on it.

试验方法：使用自动包膜机测试电池长度、宽度和高度，施加 300 kgf ± 20 kgf 的压力。

The thickness of the cell will increase as the SOC increases as well as with the using time. The thickness here indicates the thickness of the cell at delivery.

电池厚度随着 SOC 增加会有所增加，随着使用时间增加会有所增加，此处厚度指出货时电池的厚度。

1.5 Weight 重量

Test instrument: Electronic scale;

试验设备：电子秤；

Test method: measure the weight of the cell with the electronic scale.

试验方法：使用电子秤测量电池的重量。

1.6 Internal Resistance 内阻

a. ACR: test the cell at delivery SOC with 1kHz sine wave current at room temperature.

a. 交流内阻 (ACR)：在室温条件下，出货 SOC 电池采用 1 kHz 正弦波电流进行测试。

b. DCR: Charge the cell to 3.65 V with constant current of 0.5C, and then charge at a constant voltage of 3.65 V until the current decreases to 0.05C. Rest for 30 minutes, and discharge at a constant current of 0.5C for 60 minutes afterwards (adjust the SOC to 50%). Then rest for 1 h, and record the voltage V_1 at the end of the period. Discharge the cell with a constant current of 1C for 10 seconds and record the voltage V_2 at the end of the rest, and calculate the DCR., $DCR = (V_1 - V_2) \times 1000 / 628 \text{ (m}\Omega\text{)}$.

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b. 直流内阻 (DCR): 电池以 0.5C 的电流恒流充电至 3.65 V 后, 转恒压充电至充电电流为 0.05C 截止, 搁置 30 min, 然后以 0.5C 恒流放电 60 min (调整 SOC 为 50%), 搁置 1 h, 记录搁置末期电压 V_1 , 用 1C 恒流放电 10 s, 记录放电末期电压 V_2 , 计算 DCR, $DCR = (V_1 - V_2) \times 1000 / 628$ (mΩ)。

1.7 Pretreatment 预处理

Before the formal test, pretreat the cell to ensure it is activated and stable. The steps are as follows:

正式测试开始前, 电池需要先进行预处理循环, 以确保试验对象的性能处于激活和稳定的状态。其步骤如下:

a. Charge the cell according to the standard charging mode;

a. 电池按照标准充电模式充电;

b. Discharge the cell according to the standard discharging mode;

b. 电池按照标准放电模式放电;

c. Repeat a~b no more than 5 times;

c. 重复 a~b 不超过 5 次;

If the discharge capacity of the cell changes no more than 3% of the nominal capacity for two consecutive times, it is considered that the cell has completed the pretreatment, and the pretreatment can be terminated.

如果电池连续两次的放电容量变化不高于标称容量的 3%, 则认为电池完成了预处理, 预处理可以中止。

1.8 Charge Calibration 初始化充电

At the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$, rest for 5 h;

Discharge at a constant power of 1004.8 W to 2.5 V, and rest for 30 min;

Charge at a constant power of 1004.8 W to 3.65 V, and rest for 30 min.

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 搁置 5 h;

对电池以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min;

对电池以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min。

1.9 Discharge Calibration 初始化放电

At the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$, rest for 5 h;

Charge at a constant power of 1004.8 W to 3.65 V, and rest for 30 min;

Discharge at a constant power of 1004.8 W to 2.5 V, and rest for 30 min.

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 搁置 5 h;

对电池以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min;

对电池以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min。

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1.10 Capacity and Energy Calibration 初始化充放电能量

Capacity calibration is to discharge the cell according to (1.9) at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$. Charge the cell at a constant power of 1004.8 W to 3.65 V and rest for 30 min. Discharge the cell at a constant power of 1004.8 W to 2.5 V and rest for 30 min. Repeat 5 times and record the average of the last three charging energy as E_0 , the average of the last three discharging energy as E_0^* and the average of the last three discharging capacity as C_0^* .

容量标定是在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ，对电池按照 (1.9) 进行初始化放电。以 1004.8 W 恒功率充电至 3.65 V，搁置 30 min；以 1004.8 W 恒功率放电至 2.5 V，搁置 30 min。重复 5 次，记录后 3 次充电能量平均值为 E_0 ，后 3 次放电能量平均值为 E_0^* ，后 3 次放电容量平均值为 C_0^* 。

1.11 Rate Discharge Performance 倍率放电性能

Discharge the cell according to (1.9) at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$;

Charge the cell to 3.65 V at a constant power of 1004.8 W and rest for 30 min, note as E_1 ;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note as E_1^* ;

Charge the cell to 3.65 V at a constant power of 2009.6 W and rest for 30 min, note as E_2 ;

Charge the cell to 3.65 V at a constant power of 1004.8 W and rest for 30 min;

Discharge to 2.5 V at a constant power of 2009.6 W and rest for 30 min, note as E_2^* ;

Discharge the cell to 2.5 V at a constant power of 1004.8 W and rest for 30 min;

Charge the cell to 3.65 V at a constant power of 2009.6 W and rest for 30 min, note as E_3 ;

Discharge to 2.5 V at a constant power of 2009.6 W and rest for 30 min, note as E_3^* ;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min;

1P discharge energy retention rate = E_2^*/E_1^* ;

0.5P energy efficiency = E_1^*/E_1 ;

1P energy efficiency = E_3^*/E_3 .

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.9) 初始化放电。

以 1004.8W 恒功率充电至 3.65 V，搁置 30 min，记为 E_1 ；

以 1004.8 W 恒功率放电至 2.5 V，搁置 30 min，记为 E_1^* ；

以 2009.6 W 恒功率充电至 3.65 V，搁置 30 min，记为 E_2 ；

以 1004.8 W 恒功率充电至 3.65 V，搁置 30 min；

以 2009.6 W 恒功率放电至 2.5 V，搁置 30 min，记为 E_2^* ；

以 1004.8W 恒功率放电至 2.5 V，搁置 30 min；

以 2009.6 W 恒功率充电至 3.65 V，搁置 30 min，记为 E_3 ；

以 2009.6 W 恒功率放电至 2.5 V，搁置 30 min，记为 E_3^* ；

以 1004.8 W 恒功率放电至 2.5 V，搁置 30 min；

1P 放电能量保持率 = $E_2^*/E_1^* \times 100\%$ ；

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0.5P 能量效率= $E_1^*/E_1^*100\%$;

1P 能量效率= $E_3^*/E_3^*100\%$;

1.12 High/Low Temperature Discharge Performance 高/低温放电性能

1.12.1 45°C Charge/discharge Performance 45°C充放电性能

Discharge the cell according to (1.9) at the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$;

Rest the cell for 5 h under the ambient temperature of $45^\circ\text{C} \pm 2^\circ\text{C}$;

Charge to 3.65 V at a constant power of 1004.8 W and then rest for 30 min, note the energy as E_4 ;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_4^* ;

Discharge energy retention rate = E_4^*/E_0^* , energy efficiency = E_4^*/E_4 .

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 对电池按照 (1.9) 初始化放电;

在 $45^\circ\text{C} \pm 2^\circ\text{C}$ 条件下搁置 5 h;

以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min, 记为 E_4 ;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_4^* ;

放电能量保持率= $E_4^*/E_0^*100\%$, 能量效率= $E_4^*/E_4*100\%$ 。

1.12.2 5°C Charge-discharge Performance 5°C充放电性能

Discharge the cell according to (1.9) at the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$;

Rest the cell for 5 h at the ambient temperature of $5^\circ\text{C} \pm 2^\circ\text{C}$;

Charge to 3.65 V at a constant power of 1004.8 W and then rest for 30 min, note the energy as E_5 ;

Discharge to 2.5 V at a constant power of 1004.8W and rest for 30 min, note the energy as E_5^* ;

Discharge energy retention rate = E_5^*/E_0^* , energy efficiency = E_5^*/E_5 .

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 对电池按照 (1.9) 初始化放电;

在 $5^\circ\text{C} \pm 2^\circ\text{C}$ 条件下搁置 5 h;

以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min, 记为 E_5 ;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_5^* ;

放电能量保持率= $E_5^*/E_0^*100\%$, 能量效率= $E_5^*/E_5*100\%$ 。

1.13 Capacity Retention and Capacity Recovery 荷电保持与恢复

1.13.1 25°C Capacity Retention and Capacity Recovery 25 °C荷电保持与恢复

Charge the cell according to (1.8) at the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$;

Store the cell for 28 days at the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_6^* ;

Charge to 3.65 V at a constant power of 1004.8 W and rest for 30 min, note as E_6 ;

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Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_7^* ;

Discharge energy retention rate = E_6^*/E_0^* ; Discharge energy recovery rate = E_7^*/E_0^* .

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 对电池按照 (1.8) 初始化充电;

电池在 $25^\circ\text{C} \pm 2^\circ\text{C}$ 条件下储存 28 天;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_6^* ;

以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min, 记为 E_6 ;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_7^* ;

放电能量保持率 = $E_6^*/E_0^* \times 100\%$; 放电能量恢复率 = $E_7^*/E_0^* \times 100\%$ 。

1.13.2 45°C Capacity Retention and Capacity Recovery 45 °C 荷电保持与恢复

Charge the cell according to (1.8) at the ambient temperature of $25^\circ\text{C} \pm 2^\circ\text{C}$;

Store the cell for 7 days at $45^\circ\text{C} \pm 2^\circ\text{C}$ and rest for 5 h at $25^\circ\text{C} \pm 2^\circ\text{C}$;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_8^* ;

Charge to 3.65 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_7 ;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_9^* ;

Discharge energy retention rate = E_8^*/E_0^* ; Discharge energy recovery rate = E_9^*/E_0^* .

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 对电池按照 (1.8) 初始化充电;

电池在 $45^\circ\text{C} \pm 2^\circ\text{C}$ 条件下储存 7 天, 在 $25^\circ\text{C} \pm 2^\circ\text{C}$ 条件下搁置 5 h;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_8^* ;

以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min, 记为 E_7 ;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_9^* ;

放电能量保持率 = $E_8^*/E_0^* \times 100\%$; 放电能量恢复率 = $E_9^*/E_0^* \times 100\%$ 。

1.14 Storage 存储性能

1.14.1 25°C Storage 25°C 存储

Charge the cell according to (1.8) at $25^\circ\text{C} \pm 2^\circ\text{C}$;

Discharge for 60 min at a constant power of 1004.8 W and rest for 30 min;

Store the cell for 28 days at $25^\circ\text{C} \pm 2^\circ\text{C}$ and rest for 5 h at $25^\circ\text{C} \pm 2^\circ\text{C}$;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min;

Charge to 3.65 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_8 ;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_{10}^* ;

Charge energy recovery rate = E_8/E_0 , discharge energy recovery rate = E_{10}^*/E_0^* .

在环境温度 $25^\circ\text{C} \pm 2^\circ\text{C}$ 的条件下, 对电池按照 (1.8) 初始化充电;

以 1004.8 W 恒功率放电 60 min, 搁置 30 min;

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电池在 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 条件下储存 28 天, 在 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 条件下搁置 5 h;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min;

以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min, 记为 E_8 ;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_{10}^* ;

充电能量恢复率 = $E_8 / E_0 * 100\%$, 放电能量恢复率 = $E_{10}^* / E_0 * 100\%$ 。

1.14.2 45°C Storage 45°C 存储

Charge the cell according to (1.8) at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$;

Discharge for 60 min at a constant power of 1004.8 W and rest for 30 min;

Store the cell for 28 days at the ambient temperature of $45^{\circ}\text{C} \pm 2^{\circ}\text{C}$ and rest for 5 h at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min;

Charge to 3.65 V at a constant power of 1004.8 W and rest for 30 min;

Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 min, note the energy as E_{10}^* ;

Discharge energy recovery rate = E_{10}^* / E_0^* .

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下, 对电池按照 (1.8) 初始化充电;

以 1004.8 W 恒功率放电 60 min, 搁置 30 min;

电池在 $45^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 条件下储存 28 天, 在 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 条件下搁置 5h;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min;

以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min;

以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min, 记为 E_{11}^* ;

放电能量恢复率 = $E_{11}^* / E_0 * 100\%$ 。

1.15 25°C Cycle life 25°C 循环寿命

Before the test, prepare and install the clamp according to 1.3.1.

测试前按照 1.3.1 进行夹具准备和安装。

Pre-cycle initial capacity test: test the cell energy according to (1.10).

循环前初始容量测试: 对电池按照 1.10 的方法进行能量测试。

Cycle test: at ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$;

循环测试: 环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$;

a. Discharge the cell in accordance with (1.9);

b. Charge the cell to 3.65 V at a constant power of 1004.8 W and rest for 30 minutes;

c. Discharge to 2.5 V at a constant power of 1004.8 W and rest for 30 minutes;

d. Repeat steps b~c 8000 cycles.

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- a. 对电池按照 (1.9) 初始化放电;
- b. 以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min;
- c. 以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min;
- d. 重复 b~c 循环 8000 圈。

Capacity test after cycling at ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$:

Charge the cell to 3.65 V at a constant power of 0.5P, rest for 30 min; Discharge to 2.5 V at a constant power of 0.5P, rest for 30 min; Charge the cell to 3.65 V at a constant power of 0.5P, rest for 30 min; Discharge to 2.5 V at a constant power of 0.5P, record the discharge capacity C_{11}^* . rest for 30 min; The capacity retention rate = $C_{11}^* / 628 \text{ Ah} \times 100\%$.

在 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的环境温度下循环后容量测试: 以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min; 以 1004.8 W 恒功率放电至 2.5 V, 搁置 30 min; 以 1004.8 W 恒功率充电至 3.65 V, 搁置 30 min; 以 1004.8 W 恒功率放电至 2.5 V, 记录电池容量为 C_{11}^* , 搁置 30 min; 放电容量保持率 = $C_{11}^* / 628 \text{ Ah} * 100\%$ 。

When the cell is at 80% SOH and 70% SOH, modify the charging and discharging power according to the capacity of the cell: 100% ~ 80% SOH, 1004.8 W; 80% ~ 70% SOH; 803.84 W; 70% ~ 60% SOH, 703.36W.

电池在 80% SOH、70% SOH, 需按照电池容量, 修正充放电功率: 100% ~ 80% SOH, 1004.8 W; 80% ~ 70% SOH, 803.84 W; 70% ~ 60% SOH, 703.36 W;

1.16 Swelling Force Test 膨胀力测试

Prepare and install the clamp according to 1.3.2. before the test.

测试前按照 1.3.2 进行夹具准备和安装。

Cycle according to (1.15.1), and record cell swelling force and discharge capacity retention rate during test process.

按照 (1.15.1) 进行循环, 记录每圈充放电过程中的电池最大膨胀力和放电容量保持率。

1.17 Safety Performance 安全性能

1.17.1 Over-charge Test 过充电试验

Charge the cell according to (1.8) at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, and install the test clamp according to the methods in (1.3.1). Charge the cell to 5.475 V at a constant current of 628 A or for 1 hour, and then stop charging. Observe for 1 hour. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下, 对电池按照 (1.8) 初始化充电, 然后按照 (1.3.1) 的方法安装测试夹具。以 628 A 的电流恒流充电至 5.475 V 或充电时间达到 1 h, 停止充电。观察 1 h。(参考 GB/T 36276-2018 《电力储能用锂离子电池》)

1.17.2 Over-discharge Test 过放电试验

Charge the cell according to (1.8) at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, and install the test clamp according to the methods in (1.3.1). Discharge the cell to 0 V at a constant current of 628 A or for 90 min, and then stop discharging.

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Observe for 1 hour. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.8) 初始化充电，然后按照 (1.3.1) 的方法安装测试夹具。以 628 A 的电流恒流放电 90 min 或电压达到 0 V 时停止放电。观察 1 h。(参考 GB/T 36276-2018 《电力储能用锂离子电池》)

1.17.3 External Short-circuit Test 外短路试验

Charge the cell according to (1.8) at the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, and install the test clamp according to the methods in (1.3.1). Short-circuit the positive and negative terminals of the cell externally for 10 min, and the resistance value of the external circuit shall be less than 5 m Ω . Observe for 1h. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.8) 初始化充电，然后按照 (1.3.1) 的方法安装测试夹具。将电池正、负极经外部短路 10 min，外部线路电阻值应小于 5 m Ω 。观察 1h。(参考 GB/T 36276-2018 《电力储能用锂离子电池》)

1.17.4 Crush Test 挤压试验

At the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, charge the cell according to (1.8). And carry out the test under the following conditions:

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.8) 初始化充电，按照如下条件进行试验：

- Crush direction: apply pressure perpendicular to the direction of the cell plate;
 - The form of the crush plate: a semi-cylinder with a radius of 75 mm, the length (L) of the semi-cylinder is greater than the size of the cell being crushed (refers to the figure below);
 - Crush speed: (5 ± 1) mm/s;
 - Crush degree: stop crushing when the voltage reaches 0V or the deformation reaches 30% or the crushing force reaches (13000 ± 780) N; keep it for 10 minutes.
 - Observe it for 1h. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)
- 挤压方向：垂直于电池极板方向施压；
 - 挤压板形式：半径 75 mm 的半圆柱体，半圆柱体的长度 (L) 大于被挤压电池单体的尺寸；
 - 挤压速度： 5 ± 1 mm/s；
 - 挤压程度：电压达到 0 V 或变形量达到 30% 或挤压力达到 (13000 ± 780) N 时停止挤压；保持 10 min。
 - 观察 1 h。(参考 GB/T 36276-2018 电力储能用锂离子电池)

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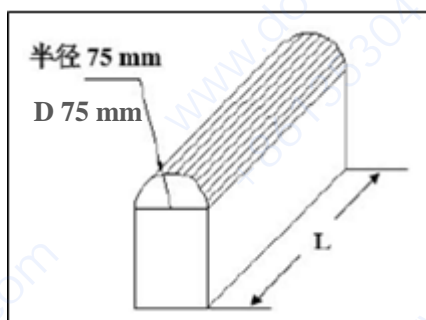


Fig. 6 Diagram of the Extrusion Device

图 6 挤压装置示意图

1.17.5 Drop Test 跌落试验

At the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, charge the cell according to (1.8). Drop the cell from a height of 1.5 meter to the concrete floor with its positive or negative terminals downwards. Then observe it for 1 hour. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.8) 初始化充电，将电池正负极柱向下从 1.5 m 高度处自由跌落至水泥地面上。观察 1 h。（参考 GB/T 36276-2018 《电力储能用锂离子电池》）

1.17.6 Low Pressure Test 低气压试验

At the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, charge the cell according to (1.8), and then install the test clamp according to (1.3.1). Put the cell into the low-pressure box, adjust the pressure to 11.6 kPa, keep the temperature at $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, and rest for 6 h. Then observe for 1 hour. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.8) 初始化充电，然后按照 (1.3.1) 的方法安装测试夹具。电池放入低气压箱中，调节试验箱中气压为 11.6 kPa，温度为 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ，静置 6 h。观察 1 h。（参考 GB/T 36276-2018 《电力储能用锂离子电池》）

1.17.7 Heating Test (130°C) 加热试验 (130°C)

At the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, charge the cell according to (1.8), and then install the test clamp according to (1.3.1). Put the cell into the temperature box, rise the temperature to $130^{\circ}\text{C} \pm 2^{\circ}\text{C}$ at a rate of $5^{\circ}\text{C}/\text{min}$, keep the temperature for 30 min and then stop heating. Observe for 1 hour. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下，对电池按照 (1.8) 初始化充电，然后按照 (1.3.1) 的方法安装测试夹具。将电池放入温度箱，温度箱按照 $5^{\circ}\text{C}/\text{min}$ 的速率由室温升至 $130^{\circ}\text{C} \pm 2^{\circ}\text{C}$ ，并保持此温度 30 min 后停止加热。观察 1 h。（参考 GB/T 36276-2018 《电力储能用锂离子电池》）

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1.17.8 Thermal Runaway Test 热失控试验

(1) At the ambient temperature of $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$, charge the cell according to (1.8), and then install the test clamp according to (1.3.1).

(1) 在环境温度 $25^{\circ}\text{C} \pm 2^{\circ}\text{C}$ 的条件下, 对电池按照 (1.8) 初始化充电, 然后按照 (1.3.1) 的方法安装测试夹具。

(2) Use a flat or rod-shaped heating device, and its surface should be covered with ceramic, metal or insulating layer. The heating power of the heating device should be in the range of 600 W ~ 1200 W. Complete the assembly of the cell and the heating device, the heating device should be in direct contact with the cell, and the size of the heating device should not be larger than the heated surface of the cell; Install a temperature monitor, and the detection point temperature sensor is arranged on the far side of the principle heat conduction. That is, on the opposite side of the heating device. (see the picture below) The temperature data sampling interval should be shorter than 1 s, the accuracy should be $\pm 2^{\circ}\text{C}$, and the diameter of the temperature sensor tip should be less than 1 mm.

(2) 使用平面状或者棒状加热装置, 并且其表面应覆盖陶瓷, 金属或绝缘层, 加热装置的功率要求为 600 W ~ 1200 W。完成电池单体与加热装置的装配, 加热装置与电池应直接接触, 加热装置的尺寸规格应不大于电池单体的被加热面; 安装温度监测器, 监测点温度传感器布置在远离热传导的一侧, 即安装在加热装置的对侧(如下图)。温度数据的采样间隔应小于 1 s, 准确度要求为 $\pm 2^{\circ}\text{C}$, 温度传感器尖端的直径应小于 1 mm。

(3) After the cell is fully charged, continue to charge for 12 minutes at a constant current of 1C.

(3) 电池充满之后, 继续对电池 1C 电流充电 12 min。

(4) Start the heating device and continue to heat the test object with its maximum power. When thermal runaway occurs or the temperature of the monitoring point reaches 300°C , stop heating and turn off the heating device.

(4) 启动加热装置, 并以其最大功率对电池单体进行持续加热, 当发生热失控或者监测点温度达到 300°C 时, 停止触发, 关闭加热装置。

(5) Stop the test whenever fire or explosion occurs within or after the heating process for 1 h.

a) The test object generates a pressure drop;

b) The temperature of the monitoring point reaches the protection temperature of the cell;

c) Temperature rise rate of monitoring points $\geq 1^{\circ}\text{C}/\text{s}$.

(5) 加热过程中及加热结束 1 h 内, 如果发生起火、爆炸现象, 则试验终止。

a) 测试对象产生电压降;

b) 监测点温度达到电池的保护温度;

c) 监测点的温升速率 $dT/dt \geq 1^{\circ}\text{C}/\text{s}$ 。

When a) & c) or b) & c) occurs, it is determined that the cell is thermally out of control. (Refer to GB/T 36276-2018 Lithium Ion Battery for Electrical Energy Storage)

当 a) & c) 或者 b) & c) 发生时, 判定发生热失控。(参考 GB/T 36276-2018 电力储能用锂离子电池)

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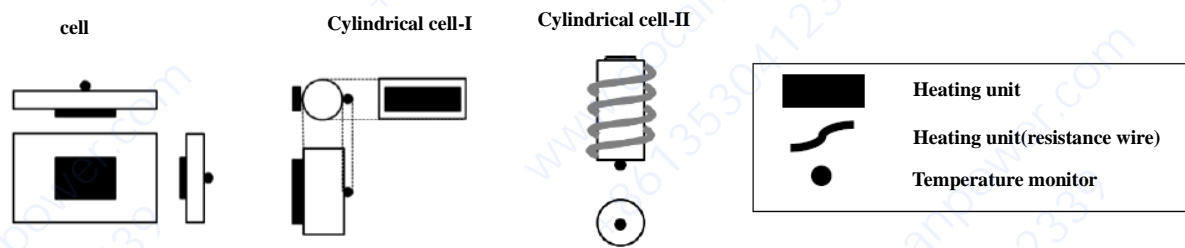


Fig. 7 Diagram of thermal runaway test

图 7 热失控试验加热示意图