

 跃动新能源	跃动新能源科技（浙江）有限公司 Valcon New Energy Technology Co.,Ltd.				
型号 Model	LFP71173204	规格书编号 Specification No.		版本 Version	A0

产品规格书

Product Specification

方形磷酸铁锂电池
Prismatic LFP Cells

型号: LFP71173204-314Ah
Model: LFP71173204-314Ah

编制 Drafted by	产品设计审核 Product Design Checked by	品质审核 Quality Checked by	销售审核 Sales Checked by	批准 Approved by

客户确认栏 Customer Recipient	
公司名称 Company Name:	
批准 Approved by:	
日期 Date:	

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客户要求 Customer Requirements

客户输出产品规格书以外的特殊需求信息需与跃动新能源科技（浙江）有限公司沟通并达成一致。例如客户有一些特别的应用或者操作条件不同于此文件中所描述的，跃动新能源科技（浙江）有限公司根据客户的特别要求进行产品的设计和生产。

Customers need to communicate and reach an agreement with Valcon New Energy Technology Co.,Ltd. regarding special needs beyond the product specifications. For example, if special applications and operation conditions are not consistent with the description in this specification, Valcon New Energy Technology Co.,Ltd design and manufacture products according to customer’s special requirements.

客户代码 Customer Code:

序号 No.	特殊要求 Special Requirements	标准 Standards
1		
2		
3		
4		



签字 Signature:

日期 Date:

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修订记录

Revision History

版本号 Version	修订日期 Date	变更内容 Contents	修订人 Author

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术语定义 Term Definitions

产品：本规格书中的“产品”是指跃动新能源科技（浙江）有限公司（以下简称 Valcon）生产的 LFP71173204-314Ah 可充电方形铝壳锂离子电池。

Product: Refers to the LFP71173204-314Ah rechargeable lithium-ion cell with prismatic aluminum shell manufactured by Valcon New Energy Technology Co.,Ltd. (here in after referred to as Valcon) in this specification.

客户：指与 Valcon 签署产品销售合同中的买方。

Customer: Refers to the buyer in the product sales contract signed with Valcon.

环境温度：电池所处的周围环境温度。

Environment temperature: The ambient temperature where the cell is located.

电池温度：接入电池表面中心、正负极柱的温度传感器测量的电池表面的温度。

Cell temperature: The temperature of the battery surface measured by the temperature sensor connected to the center of the battery surface and the positive and negative poles.

新鲜电池：指电池自生产完成日期算起 7 天内的状态。

Fresh cell: Refers to cell with in 7 days after production.

充放电倍率：充/放电电流与电池管理系统检测的电池容量值比值。例如：当电池容量为 314 Ah，充/放电电流为 157 A 时，则充/放电倍率为 0.5C；当电池容量跌落为 280 Ah，充/放电电流为 140 A 时，则充/放电倍率为 0.5C。

Charging/Discharging Rate: The ratio of the charging/discharging current to the capacity which measured by the battery management system. For example, if the cell capacity is 314 Ah and the charging/discharging current is 157 A, the charging/discharging rate is 0.5C. If the cell capacity drops to 280 Ah and the charging/discharging current is 140 A, the charging/discharging rate is 0.5C.

荷电状态：在无负载的情况下，以安培小时或以瓦特小时为单位计量的电池容量状态与标称容量的比值，缩写用 SOC 表示。例如：若将容量为 314 Ah 的状态视为 100%SOC，则容量为 157 Ah 时 SOC 为 50%。

State of charge: Under unloaded conditions, the ratio of the cell capacity state to the nominal capacity measured in Ah or Wh. The abbreviation is expressed by SOC. For example, if the capacity at 314 Ah considered as 100% SOC, the capacity at 157 Ah, considered as 50% SOC.

健康状态：电池实际容量与标称容量的比值，缩写用 SOH 表示。例如：电池容量 314 Ah 为 100%SOH，容量衰减为 251.2 Ah 时，SOH 为 80%。

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State of health: The ratio of actual cell capacity to nominal capacity, The abbreviation is expressed by SOH. For example, if the cell capacity at 314 Ah considered as 100% SOH, the cell capacity decays to 251.2 Ah, considered as 80% SOH.

循环: 电池按规定的充放电标准充放一次为一个循环。循环包括短时的正常充电或者再生充电和放电过程的组合，在充电过程中有时只有正常充电而无再生充电的情况。放电可以由一些部分放电组合在一起形成。

Cycle: The cell is charged and discharged once as a cycle according to the specified 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.

初始化充电: 本规格书中 4.8.1 条所述的充电模式。

Initial charge: The discharging mode described in 4.8.1 of this specification.

初始化放电: 本规格书中 4.8.2 条所述的放电模式。

Initial discharge: The discharging mode described in 4.8.2 of this specification.

开路电压: 电池在没有接入任何负载和电路时测得电压，缩写用 OCV 表示。

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

交流内阻: 给电池正负极注入 1 kHz 的正弦波电流，测试所得到的内阻值，缩写用 ACR 表示。

AC resistance: Apply 1 kHz sine wave current between the positive and negative poles of the cell, and the internal resistance obtained, which abbreviated as ACR.

直流内阻: 工作条件下电池的电压变化与相应的电流变化之比，缩写用 DCR 表示，测试方法如本规格书第 4.7 所述。

DC resistance: The ratio of the voltage change to the corresponding current change under working conditions, and the abbreviation is DCR. The test method is as described in section 4.7 of this specification.

模组: 锂离子电池经串并联方式组合，加装单体电池监控与管理装置后形成的电池与 pack 中间产品。

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.

压缩力: 模组组装时，电池可承受压缩力的安全边界。

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

膨胀力:在使用过程中，因极片厚度反弹等固有特性导致电池膨胀，而对约束夹具产生的作用力。

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.

电芯单体: 实现化学能和电能相互转化的基本单元，由正极、负极、隔膜、电解质、壳体和端子等组成。

Cell :The basic unit that realizes the mutual conversion of chemical energy and electric energy, composed of cathode, anode, diaphragm, electrolyte, shell and terminal.

室温条件: 缩写用 RT 表示，环境温度为 $25\pm 2\text{ }^{\circ}\text{C}$ 。

Room temperature: The abbreviation is RT, and the room temperature is $25\pm 2\text{ }^{\circ}\text{C}$.

额定容量: 在规定试验条件和试验方法下，电池以额定功率充电和放电容量。

Rated capacity: The capacity of battery that be charged and discharged with rated power under the specified test conditions and test methods.

额定能量: 在规定试验条件和试验方法下，满足全生命周期电池内可稳定获得的充电能量以及稳定输出的放电能量。

Rated energy: Under the specified test conditions and test methods, the battery can be stably obtained charging energy and stable output discharge energy during the whole life cycle .

额定充放电功率:额定功率与电池系统多次测量的电芯能量值的比率，用字母 P 表示，本规格书中使用 P_{rc} 代表额定充电功率（ $1P_{rc} = 0.5P$ ）， P_{rd} 代表额定放电功率（ $1P_{rd} = 0.5P$ ）。例如当电池能量为 1004.8 Wh，充电或放电功率为 502.4 W 时，则额定充电或放电功率为 $1P_{rc}/1P_{rd}$ 。

Rated power: The ratio of the charge/discharge power to the battery energy value measured multiple times by the battery system, denoted by P. In this specification, P_{rc} rests for rated charging power（ $1P_{rc} = 0.5P$ ）, and P_{rd} rests for rated discharge power（ $1P_{rd} = 0.5P$ ）. For example, when the battery energy is 1004.8 Wh and the charge/discharge power is 502.4 W, the charge/discharge power is $1P_{rc}/1P_{rd}$.

能量效率:在规定的试验条件和试验方法下，电池的放电能量与充电能量的比值用百分数表示。

Energy efficiency: Under specified test conditions and test methods, The ratio of discharge energy to charge energy of a battery is expressed as a percentage.

能量保持率:在规定试验条件和试验方法下，电池的充电能量、放电能量分别与初始充电能量、初始放电能量的比值，用百分数表示。

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Energy retention rate: Under the specified test conditions and test methods, the charging energy and discharge energy of the battery are respectively compared with the initial charging energy and initial discharge energy, expressed as a percentage.

测量单位: 见下表

Units of measurement: Refer to following table

表 1 测量单位

Table 1 Units of measurement

序号 No.	单位 Units	单位类型 Type of units
1	“V” (Volt) 伏特	电压单位 Voltage
2	“A” (Ampere) 安培	电流单位 Current
3	“Ah” (Ampere-Hour) 安培-小时	容量单位 Capacity
4	“Wh” (Watt-Hour) 瓦特-小时	能量单位 Energy
5	“Ω” (Ohm) 欧姆	电阻单位 Resistance
6	“mΩ” (MilliOhm) 毫欧姆	电阻单位 Resistance
7	“°C” (Degree Celsius) 摄氏度	温度单位 Temperature
8	“mm” (Millimeter) 毫米	长度单位 Length
9	“s” (Second) 秒	时间单位 Time
10	“kN” (KiloNewton) 千牛顿	力单位 Force
11	“kHz” (KiloHertz) 千赫兹	频率单位 Frequency

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1 基本信息 Fundamental Information

1.1 适用范围 Scope of Application

本产品规格书适用于跃动新能源科技（浙江）有限公司生产的 LFP71173204-314Ah 锂离子电池。

This document describes the specification of the LFP71173204-314Ah lithium-ion cell manufactured by Valcon New Energy Technology Co.,Ltd.

1.2 产品类型 Product Type

方形铝壳锂离子电池。

Prismatic lithium-ion cell with aluminum shell.

1.3 产品型号 Product Model

LFP71173204-314Ah

2 电池规格参数 Cell Specifications and Parameters

2.1 基本规格参数 Basic Specifications and Parameters

表 2 基本规格参数

Table 2 Basic specifications and parameters

项目 Items	参数 Parameters	备注 Remarks
外观 Appearance	表面清洁、无锈蚀、无划痕、无毛刺、无变形及机械损伤，无电解液泄露 No scratches, cracks, rust and burrs on the battery surface stains, deformation and mechanical damage or electrolyte leakage	/
尺寸（含蓝膜） Dimension （With Insulation Film）	厚度(T)Thickness: (71.72±0.5) mm 宽度(L)Length: (173.82±0.5) mm 肩高(H ₁)Can-top Height: (204.22±0.5) mm 总高(H ₂)Terminal Height: (207.01±0.5) mm	30%SOC, 300 kgf
重量 Weight	5530±120 g	/
标称容量 Nominal Capacity	314.0 Ah	参见本规格书 4.8 Specification 4.8
标称能量 Nominal Energy	1004.8 Wh	
标称电压 Nominal Voltage	3.2 V	/

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工作电压 Work Voltage Range			2.50~3.65 V	T>0℃	
			2.00~3.65 V	T≤0℃	
最大充电截止电压（Vmax） Maximum charge cut-off Voltage			3.65 V	/	
最小放电截止电压（Vmin） Minimum discharge cut-off Voltage			2.5 V	T>0 °C	
初始内阻 Initial IR			0.10~0.25 mΩ	ACR, RT, 1 kHz	
			≤0.4 mΩ	DCR, RT, 50%SOC, 1.5C10 s	
工作温度（充电） Operation Temperature（Change）			0~60 °C	/	
工作温度（放电） Operation Temperature（Dischange）			-30~60 °C	/	
出货荷电状态 Delivery SOC			28~32% SOC	/	
出货电压 Delivery Voltage			3.295~3.305 V	/	
存储温度 Storage Temperature			-30~60 °C	出货 SOC 状态 Delivery SOC	
质量能量密度 Gravimetric Specific Energy			≥180 Wh/kg	参见本规格书 4.8 Specification 4.8	
体积能量密度 Volumetric Specific Energy			≥394 Wh/L		

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2.2 外形图纸 Cell Drawin

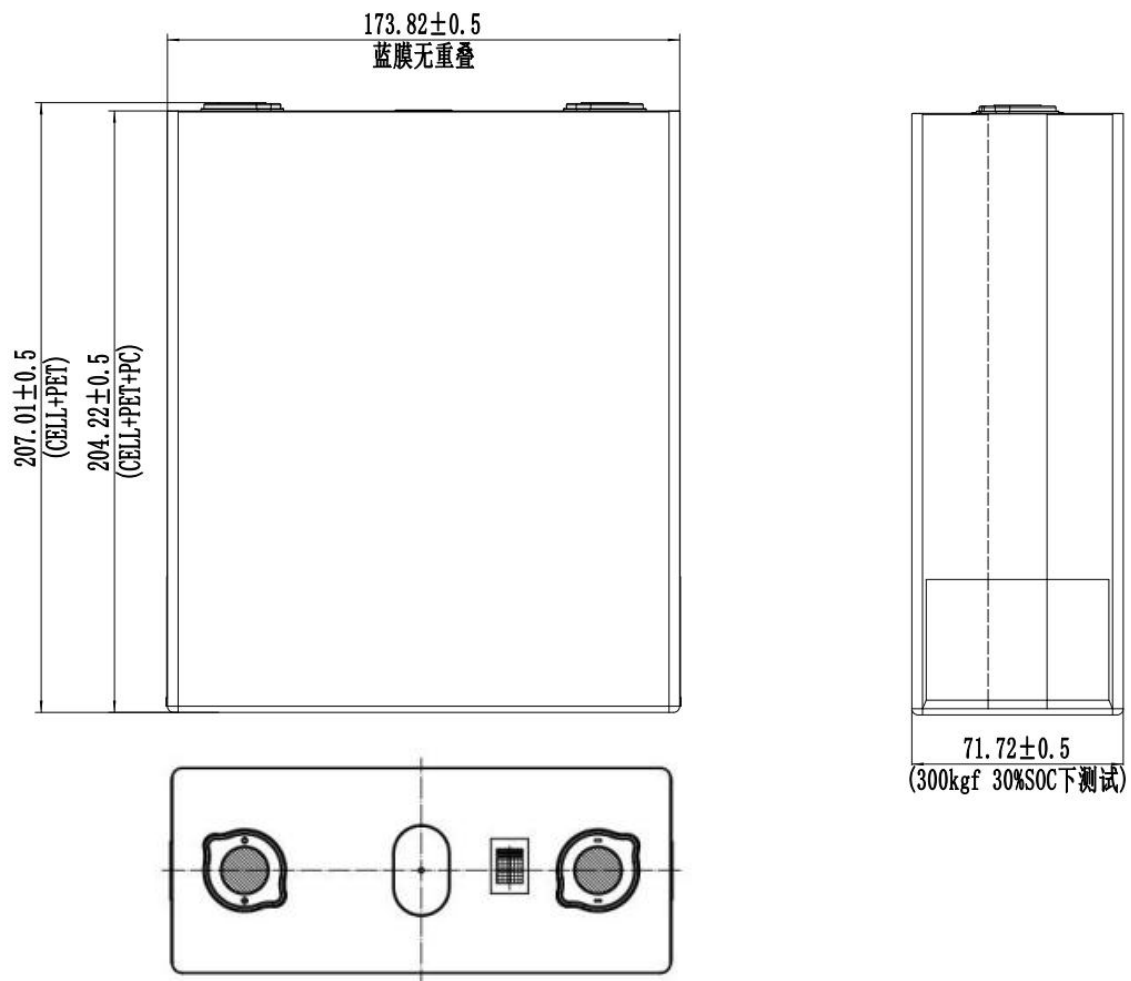


图 1 电池尺寸及外观图

Fig.1 Diagram of cell size and appearance

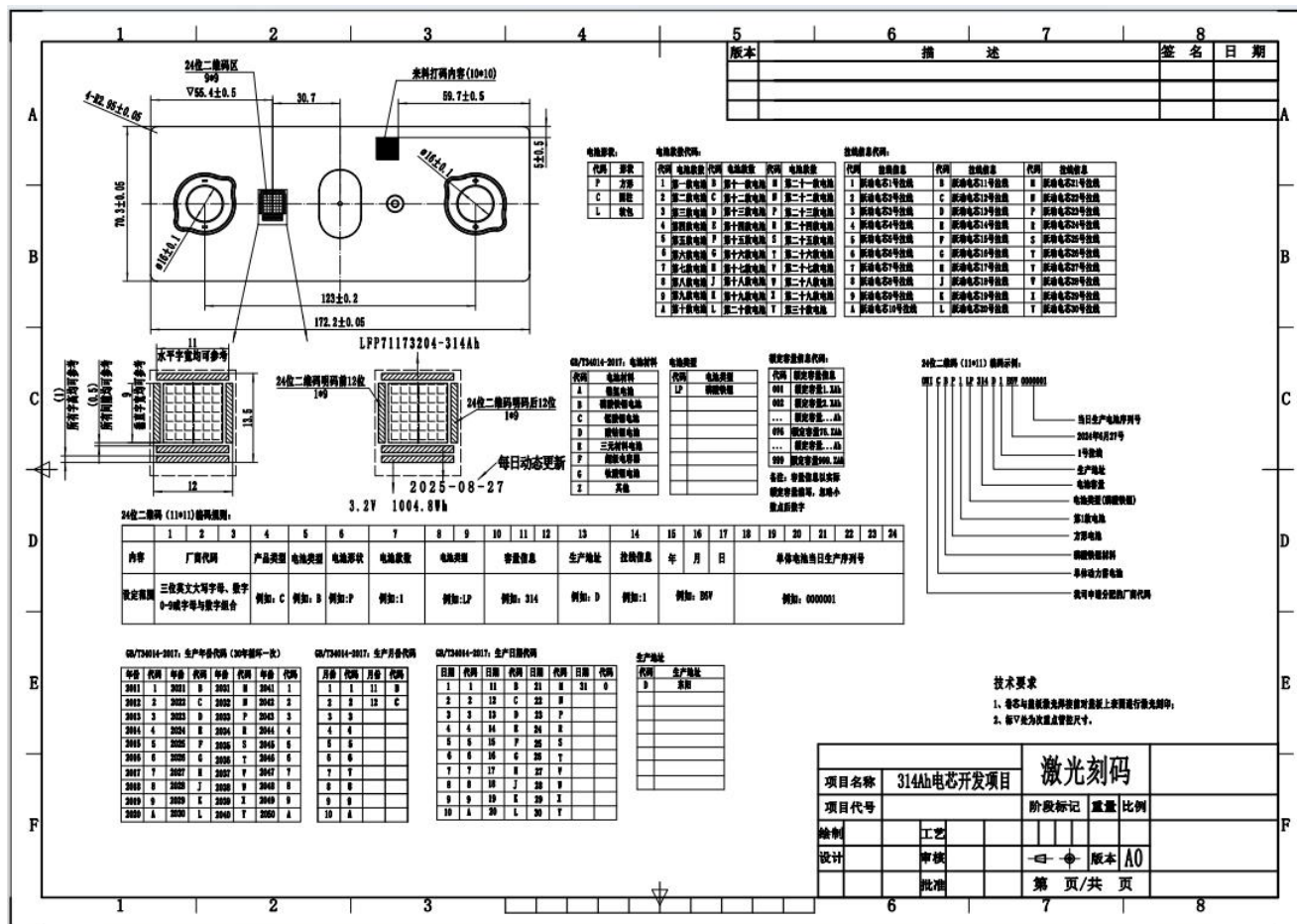
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Initial Charge and Discharge	25 °C	≥额定充电能量 ≥ Rated Charge Energy 极差≤4.0%平均值 Range ≤4.0% average		≥额定放电能量 ≥ Rated Discharge Energy 极差≤4.0%平均值 Range ≤4.0% average		≥93.0%	
	45 °C	/		/		≥93.0%	
	5 °C	/		/		≥80.0%	
倍率充放电性能 Rated Charge /Discharge Energy	充电倍率 Charge Rate	放电倍率 Discharge Rate	充电能量 Charge Energy	放电能量 Discharge Energy	能量效率 Energy Efficiency	4.10	
	1Prc	1Prd	E _{1c}	E _{1d}	/		
	2Prc	2Prd	E _{2c} E _{2c} /E _{1c} ≥95.0%	E _{2d} E _{2d} /E _{1d} ≥95.0%	E _{2d} /E _{2c} ≥90.0%		
功率特性 Power Performance	初始充放电 功率 Initial Charge /Discharge Power	递减步长 Step	充电能量 Charge Energy	放电能量 Discharge Energy	能量效率 Energy Efficiency	4.11	
	Prc, Prd	5%Prc, 5%Prd	≥额定充电能量 ≥ Rated Charge Energy	≥额定放电能量 ≥ Rated Discharge Energy	≥93.0%		
高低温性能 High/Low Temperature Performance	温度 Temp.	充电能量 Charging energy		放电能量 Discharging energy		能量效率 Energy Efficiency	4.12
	50 °C	≥额定充电能量 ≥ Rated Charge Energy		≥额定放电能量 ≥ Rated Discharge Energy		≥ 93.0%	
	-30 °C	≥额定充电能量 ≥ Rated Charge Energy		≥额定放电能量 ≥ Rated Discharge Energy		≥ 93.0%	

表 4 静态 SOC-OCV

Table 4 Static SOC-OCV

SOC	充电电压（V） Charge Voltage (V)	放电电压（V） Discharge Voltage (V)
0%	2.8116	2.8116
5%	3.1930	3.1717
10%	3.2220	3.2061
15%	3.2496	3.2290

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20%	3.2782			3.2535	
25%	3.2976			3.2699	
30%	3.3026			3.2871	
35%	3.3034			3.2888	
40%	3.3041			3.2898	
45%	3.3049			3.2909	
50%	3.3062			3.2921	
55%	3.3090			3.2952	
60%	3.3349			3.3203	
65%	3.3401			3.3295	
70%	3.3399			3.3296	
75%	3.3399			3.3297	
80%	3.3398			3.3299	
85%	3.3398			3.3303	
90%	3.3391			3.3313	
95%	3.3373			3.3331	
100%	3.4677			3.4951	

2.4 电芯长期电性能参数 Electrical Performance Parameters (Long term)

表 5 电性能参数表(长期)

Table 5 Electrical performance parameter (Long term)

项目 Items	规格 Specifications		测试方法 Testing Methods
循环性能 Cycle Life	温度 Temp.	性能要求 Specifications	4.14
	25 °C	循环 8000 周电池健康状态 $\geq 70\%$ 8000 cycles $\geq 70\%$ SOH 循环 8000 周电芯剩余放电能量 $\geq 703.4\text{Wh}$ Ed(8000 cycles) $\geq 703.4\text{Wh}$	
	45 °C	循环 3500 周电池健康状态 $\geq 70\%$ 3500 cycles $\geq 70\%$ SOH 循环 3500 周电芯剩余放电能量 $\geq 703.4\text{Wh}$ Ed(3500 cycles) $\geq 703.4\text{Wh}$	
贮存性能	温度 Temp.	充电能量恢复率 Charge Energy Recovery	放电能量恢复率 Discharge Energy Recovery 4.15

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型号 Model	LFP71173204	规格书编号 Specification No.		版本 Version	A0
Storage	50 °C	≥96.5%		≥96.5%	
能量保持和恢复 The Energy Retention and Recovery	温度 Temp.	能量保持率 Energy Retention	充电能量恢复率 Charge Energy Recovery	放电能量恢复率 Discharge Energy Recovery	4.16
	25 °C & 28 days	≥97%	≥97%	≥97%	
	45 °C & 30 days	≥95%	≥95%	≥95%	

3 安全性能参数 Safety Performance Parameters

表 6 安全性能参数

Table 6 Safety performance parameters

序号 No.	项目 Items	标准 Standards	测试方法 Testing Methods
1	过充电 Overcharge	不起火，不爆炸，不应在防爆阀或泄压点之外的位置发生破裂 No fire, No explosion, No rupture should occur outside the explosion-proof valve or pressure relief point	5.1
2	外部短路 External Short-circuit	不起火，不爆炸，不应在防爆阀或泄压点之外的位置发生破裂 No fire, No explosion, No rupture should occur outside the explosion-proof valve or pressure relief point	5.2
3	挤压 Crush	不起火，不爆炸，不漏液，不冒烟，不应在防爆阀或泄压点之外的位置发生破裂 No fire, No explosion, No rupture should occur outside the explosion-proof valve or pressure relief point	5.3
4	针刺 Nail Penetration	不起火，不爆炸 No fire, No explosion	5.4
5	加热 Heating	不起火，不爆炸 No fire, No explosion	5.5
6	过载 Overload	不起火，不爆炸，不漏液，不冒烟，不应在防爆阀或泄压点之外的位置发生破裂 No fire, No explosion, No rupture should occur outside the explosion-proof valve or pressure relief point	5.6
7	热失控 Thermal Runaway	判定： 1) 电压≤1.0 V 且连续三个温升速率值≥3 °C/s 或起火或爆炸； 2) 电池单体在全寿命周期内，热失控温度应>90 °C； 3) 不起火，不爆炸，不应在防爆阀或泄压点之外的位置发生破裂	5.7

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		Verdict: 1) Voltage ≤ 1.0 V and three consecutive temperature rise rate values ≥ 3 °C/s or fire or explosion; 2) During the whole life cycle of the battery, the thermal runaway temperature should be > 90 °C; 3) No fire, No explosion, No rupture should occur outside the explosion-proof valve or pressure relief point			

4测试条件及方法 Test Conditions and Methods

4.1 环境条件 Environmental Conditions

除另有规定外，试验应在温度为 $25\text{ °C} \pm 2\text{ °C}$ ，相对湿度 15 ~ 80%，大气压力为 86 kPa~106 kPa 的环境中进行。本规格书中所提到的室温，是指 $25\text{ °C} \pm 2\text{ °C}$ 。

Unless otherwise specified, the test should be carried out in an environmental temperature of $25\text{ °C} \pm 2\text{ °C}$, the relative humidity is 15 ~ 80%, and atmospheric pressure of 86 kPa to 106 kPa. The room temperature mentioned in this specification refers to $25\text{ °C} \pm 2\text{ °C}$.

4.2 测试设备 Measuring Instrument

试验装置应符合如下要求：

The accuracy of measuring device should meet the following requirements:

- 1) 电压测试装置 Voltage measuring device: $\pm 0.5\%$;
- 2) 电流测试装置 Current measuring device: $\pm 0.5\%$;
- 3) 温度测试装置 Temperature measuring device: $\pm 0.5\text{ °C}$;
- 4) 时间测试装置 Time measuring device: $\pm 0.1\%$;
- 5) 尺寸测试装置 Dimension measuring device: $\pm 0.1\%$;
- 6) 质量测试装置 Weight measuring device: $\pm 0.1\%$ 。

4.3 测试温度要求 Testing Temperature Requirements

电芯表面贴附热电偶，记录电芯表面温度变化。1、2、3 号温度线分别监控正极柱、负极柱、大面中心 3 个点的温度；若电芯带夹板测试时，3 号温度线监控正极柱侧面中心点的温度。

A thermocouple is attached to the surface of the cell to record the temperature change on the surface of the cell. Temperature lines 1, 2 and 3 respectively monitor the temperature of the positive column, negative column and three points in the center of the large surface; If the cell is tested with a splint, the temperature line No. 3 monitors the temperature at the center point on the side of the positive pole.

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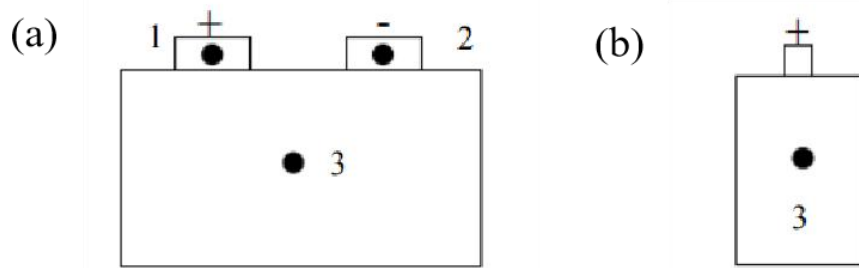


图 3 测试温度点(a)带夹板侧面温度点(b)

Fig.3 Test temperature point (a) Temperature point on side with splint(b)

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

4.4.1 普通钢夹具 Ordinary Steel Clamp

单个电池需采用钢夹板（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 M6 螺栓固定，夹板各个面需要有绝缘膜，夹具工装如图所示：

The single cell should be clamped with steel splints (thickness: 15 mm). The splints need to cover the large surfaces of the cell and be fixed with 6 M6 bolts. All sides of the splints need to be covered with insulating film.

Clamp as shown below:

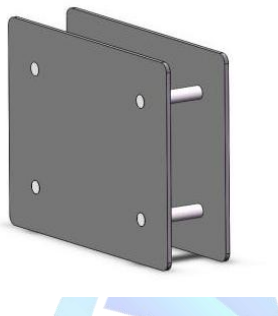


图 4 夹具示意图

Fig. 4 Diagram of cell clamp

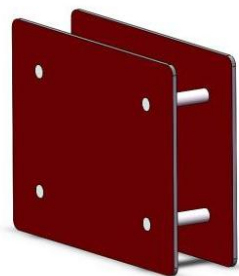


图 5 电池夹具包膜图

Fig.5 Diagram of the clamp covered with insulation

将包覆有蓝膜（材质 PET，厚度 0.11 mm）的电池（15%~40%SOC）准备好后，置于夹具中间，使用 6 个 M6 螺栓固定夹具保证电池受夹具初始预紧力为 300 kgf $\pm$ 20 kgf，需采用游标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。

Place the cell (15% ~ 40%SOC) which is covered with blue film (material: PET, thickness: 0.11 mm) in the middle of the splint, fix the steel fixture with 6 M6 bolts to ensure that the initial preload of the battery on the fixture is 300 kgf $\pm$ 20 kgf. Then use a vernier caliper to measure the thickness of the cell (at upper, middle and lower) with

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splints, and the thickness tolerance shall be controlled within 0.3 mm.



图 6 电池包膜示意图

Fig. 6 Diagram of cell filming

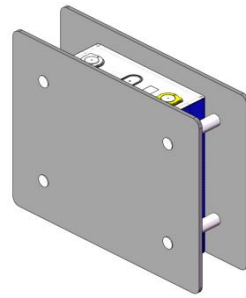


图 7 电池上夹具示意图

Fig. 7 Diagram of cell with clamp

4.4.2 膨胀力夹具 Swelling Force Clamp

将包有蓝膜（材质 PET，厚度 0.11 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，需采用游标卡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。

Place the cell (15% ~ 40%SOC) which is covered with blue film (material: PET, thickness: 0.11 mm) in the middle of the splint, adjusting swelling force clamp pretensioning device and the initial compression force is ($300 \text{ kgf} \pm 20 \text{ kgf}$). Then use a vernier caliper to measure the thickness of the cell (at upper, middle and lower) with splints, and the thickness tolerance should be controlled within 0.3 mm.

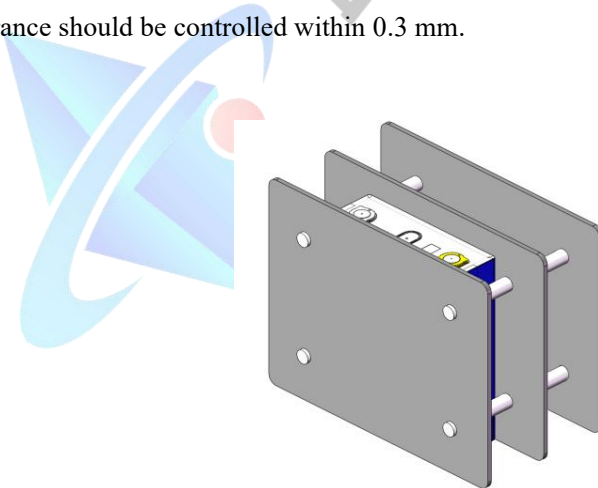


图 8 电池上膨胀力夹具图

Fig. 8 Diagram of cell with swelling force clamp

4.5 尺寸 Dimensions

测试方法：使用自动包膜机测试电池长度、宽度和高度，施加 $300 \text{ kgf} \pm 20 \text{ kgf}$ 的压力。

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

4.6 重量 Weight

测试方法：使用电子秤测量电池的重量。

Test method: Measure the weight of the cell by electronic scale.

4.7 内阻 Internal Resistance

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

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

直流内阻（DCR）

室温下

- 1) 静置 300 min;
- 2) 0.5C DC Vmin, 静置 30 min;
- 3) 0.5C CC Vmax CV 0.05C, 静置 30 min;
- 4) 0.5C DC Vmin, 静置 30 min;
- 5) 循环 3) ~4) 三次, 取第三次计量容量 C_0 ;
- 6) 1C CC Vmax CV 0.05C, 静置 30 min;
- 7) 1C DC 20% C_0 调整至 80%SOC, 静置 30 min;
- 8) 2C DC 30s, 静置 30 min, 计算放电 DCR;
- 9) 2C CC 30s, 静置 30 min, 计算充电 DCR;
- 10) 1C DC 30% C_0 调整至 50%SOC, 静置 30 min;
- 11) 2C DC 30s, 静置 30 min, 计算放电 DCR;
- 12) 2C CC 30s, 静置 30 min, 计算充电 DCR;
- 13) 1C DC 30% C_0 调整至 20%SOC, 静置 30 min;
- 14) 2C DC 30s, 静置 30 min, 计算充电 DCR;
- 15) 2C CC 30s, 静置 30 min, 计算充电 DCR。

DCR 计算（以 80%SOC 为例）：a) 放电 DCR：工步 7) 静置末端电压为 U_1 ，工步 8) 放电末端电压为 U_2 ，计算 80%SOC 放电 $DCR=(U_1-U_2)/I$ ；b) 充电 DCR：工步 8) 静置末端电压为 U_3 ，工步 9) 充电末端电压为 U_4 ，计算 80%SOC 充电 $DCR=(U_4-U_3)/I$ 。

DCR

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Room temperature

- 1) Rest for 300 min;
- 2) 0.5C DC Vmin, rest for 30 min;
- 3) 0.5C CC Vmax CV 0.05C, rest for 30 min;
- 4) 0.5C DC Vmin, rest for 30 min;
- 5) Repeat 3) ~4) three times, take the third measurement capacity C_0 ;
- 6) 1C CC Vmax CV 0.05C, rest for 30 min;
- 7) 1C DC 20% C_0 adjusted to 80%SOC, and rest for 30 min;
- 8) 2C DC 30s, rest for 30 min, calculate the discharge DCR;
- 9) 2C CC 30s, rest for 30 min, calculate the charge DCR;
- 10) 1C DC 30% C_0 adjusted to 50%SOC and rest for 30 min;
- 11) 2C DC 30s, rest for 30 min, calculate the discharge DCR;
- 12) 2C CC 30s, rest for 30 min, calculate the charge DCR;
- 13) 1C DC 30% C_0 adjusted to 20%SOC and rest for 30 min;
- 14) 2C DC 30 s, rest for 30 min, calculate the charge DCR;
- 15) 2C CC 30 s, rest for 30 min, calculate the charge DCR.

DCR calculation (Take 80%SOC as an example): a) Discharge DCR: working step 7) static terminal voltage is U_1 , working step 8) Discharge terminal voltage is U_2 , calculate 80%SOC discharge $DCR=(U_1-U_2)/I$; b) Charging DCR: working step 8) static terminal voltage is U_3 , working step 9) Charging terminal voltage is U_4 , calculate 80%SOC charging $DCR=(U_4-U_3)/I$.

4.8 预处理 Pretreatment

4.8.1 初始化充电 Initial Charge

- 1) 在室温下静置 5 h;
 - 2) 以 1Prd 恒功率放电至电压为 2.5 V，静置 10 min;
 - 3) 以 1Prc 恒功率充电至电压为 3.65 V，静置 10 min;
 - 4) 初始化充电结束。
- 1) Rest for 5 h at room temperature;
 - 2) Discharge cell to 2.5 V with constant power 1Prd, rest for 10 min;
 - 3) Charge cell to 3.65 V with constant power 1Prc, rest for 10 min;

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4) End of charging.

4.8.2 初始化放电 Initial Discharge

- 1) 在室温下静置 5 h;
- 2) 以 1Prc 恒功率充电至电压为 3.65 V，静置 10 min;
- 3) 以 1Prd 恒功率放电至电压为 2.5 V，静置 10 min;
- 4) 初始化放电结束。

- 1) Rest for 5 h at room temperature;
- 2) Charge cell to 3.65 V with constant power 1Prc, rest for 10 min;
- 3) Discharge cell to 2.5 V with constant power 1Prd, rest for 10 min;
- 4) End of discharging.

4.9 初始充放电性能 Initial Charge and Discharge Performance

4.9.1 25 °C 初始充放电性能 Initial Charge and Discharge Performance at 25 °C

- 1) 初始化放电;
- 2) 1Prc Vmax，静置 10 min;
- 3) 1Prd Vmin，静置 10 min;

4) 以步骤 2) 的初始充电能量和步骤 3) 的初始放电能量计算每个试验样品初始充放电能量效率; 计算所有试验样品的初始充电能量平均值、初始放电能量平均值、初始充放电能量效率平均值、初始充电能量极差、初始放电能量极差; 计算初始充电能量极差与初始充电能量平均值的百分比、初始放电能量极差与初始放电能量平均值的百分比。

- 1) Initial discharge;
- 2) 1Prc Vmax, rest for 10 min;
- 3) 1Prd Vmin, rest for 10 min;

4) The initial charge and discharge energy efficiency of the test sample was calculated using the initial charge energy of step 2 and the initial discharge energy of step 3; The average value of initial charge energy, average value of initial discharge energy, average value of initial charge and discharge energy efficiency, initial charge energy range and initial discharge energy range of all test samples were calculated. Calculate the percentage between the initial charging energy range and the average initial charging energy, and the percentage between the initial discharge energy range and the average initial discharge energy.

4.9.2 45 °C 初始充放电性能 Initial Charge and Discharge Performance at 45 °C

- 1) 初始化放电;

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2) 设置环境模拟装置温度为 45 °C，在(45±2)°C下静置 16 h;

3) 在(45±2)°C下，1Prc Vmax，静置 10 min;

4) 在(45±2)°C下，1Prd Vmin，静置 10 min;

5) 以步骤 2)的初始充电能量和步骤 3)的初始放电能量计算能量效率。

1) Initial discharge;

2) Set the temperature of the environmental simulation device to 45 °C, and rest for 16 h at (45±2)°C;

3) 1Prc Vmax, rest for 10 min at (45±2)°C;

4) 1Prd Vmin, rest for 10 min at (45±2)°C;

5) Calculate the energy efficiency with the initial charging energy of step 2 and the initial discharge energy of step 3.

4.9.3 5°C 初始充放电性能 Initial Charge and Discharge Performance at 5°C

1) 初始化放电;

2) 设置环境模拟装置温度为 5 °C，在(5±2)°C下静置 20 h;

3) 在(5±2)°C下，1Prc Vmax，静置 10 min;

4) 在(5±2)°C下，1Prd Vmin，静置 10 min;

5) 以步骤 2)的初始充电能量和步骤 3)的初始放电能量计算能量效率。

1) Initial discharge;

2) Set the temperature of the environmental simulation device to 5 °C and rest for 20 h at (5±2) °C;

3) 1Prc Vmax, rest for 10 min at (5±2) °C;

4) 1Prd Vmin, rest for 10 min at (5±2) °C;

5) Calculate the energy efficiency with the initial charging energy of step 2 and the initial discharge energy of step 3.

4.10 倍率充放电性能 Rate Charge and Discharge Performance

1) 室温下初始化放电;

2) 1Prc Vmax，静置 10 min;

3) 1Prd Vmin，静置 10 min;

4) 2Prc Vmax，静置 10 min;

5) 1Prc Vmax，静置 10 min;

6) 2Prd Vmin，静置 10 min;

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7) 1Prd Vmin, 静置 10 min;

8) 2Prc Vmax, 静置 10 min;

9) 2Prd Vmin, 静置 10 min;

10) 以步骤 2)的充电能量和步骤 4)的充电能量计算 2Prc 充电能量相对于 1Prc 充电能量的能量保持率, 以步骤 3)的放电能量和步骤 6)的放电能量计算 2Prd 放电能量相对于 1Prd 放电能量的能量保持率, 以步骤 8)的充电能量和步骤 9)的放电能量计算 2Prc、2Prd 恒功率充放电能量效率。

1) Initial discharge at room temperature;

2) 1Prc Vmax, rest for 10 min;

3) 1Prd Vmin, rest for 10 min;

4) 2Prc Vmax, rest for 10 min;

5) 1Prc Vmax, rest for 10 min;

6) 2Prd Vmin, rest for 10 min;

7) 1Prd Vmin, rest for 10 min;

8) 2Prc Vmax, rest for 10 min;

9) 2Prd Vmin, rest for 10 min;

10) Calculate the energy retention rate of 2Prc charging energy relative to 1Prc charging energy based on the charging energy of step 2 and the charging energy of step 4, and calculate the energy retention rate of 2Prd discharging energy relative to 1Prd discharging energy based on the discharge energy of step 3 and step 6. The constant power charge and discharge energy efficiency of 2Prc and 2Prd is calculated with the charge energy of step 8 and discharge energy of step 9.

4.11 功率特性 Power Performance

1) 室温下静置 5 h;

2) 100%Prd Vmin, 静置 10 min;

3) 100%Prc Vmax, 静置 10 min;

4) 100%Prd Vmin, 静置 10 min;

5) 以额定充放电功率的 5%为步长,逐次递减充放电功率至 5%额定充放电功率,重复步骤 2)~4);

6) 以步骤 3)的充电能量和步骤 4)的放电能量计算每个试验样品不同功率充放电能量效率, 计算所有试验样品同一功率条件下的充放电能量效率平均值;计算所有试验样品同一功率条件下的充电能量平均值、放电能量平均值。

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7) 以步骤 6)的充电能量平均值分别与额定充电能量的百分比作为不同功率条件下的充电特性特征值,以步骤 6)的放电能量平均值分别与额定放电能量的百分比作为不同功率条件下的放电特性特征值;

8) 以额定功率的百分数为横轴,以步骤 7)的充电特性特征值和放电特性特征值、步骤 6)的充放电能量效率平均值为纵轴, 绘制电池单体的功率特性曲线图。

1) Rest for 5 h at room temperature;

2) 100%Prd V_{min} , rest for 10 min;

3) 100%Prc V_{max} , rest for 10 min;

4) 100%Prd V_{min} , rest for 10 min;

5) Take 5% of the rated charge and discharge power as the step length, gradually decrease the charge and discharge power to 5% of the rated charge and discharge power, repeat step 2 to 4;

6) The charging and discharging energy efficiency of each test sample at different powers was calculated based on the charging energy of step 3 and discharge energy of step 4, and the average charging and discharging energy efficiency of all test samples at the same power was calculated; The average charging energy and discharge energy of all test samples under the same power condition were calculated.

7) Take the average charging energy of step 6 and the percentage of rated charging energy respectively as the characteristic values of charging characteristics under different power, and take the average discharge energy of step 6 and the percentage of rated discharge energy respectively as the characteristic values of discharge characteristics under different power conditions;

8) Take the percentage of rated power as the horizontal axis, the characteristic values of charging characteristics and discharge characteristics of step 7 and the average value of charge and discharge energy efficiency of step 6 as the vertical axis, and draw the power characteristic curve of the battery cell.

4.12 高低温性能 High/Low Temperature Performance

4.12.1 高温性能 High Temperature Performance

1) 初始化充电;

2) 50 °C下: 静置 24 h;

3) 25 °C下: 静置 12 h;

4) 1Prd V_{min} , 静置 10 min;

5) 1Prc V_{max} , 静置 10 min;

6) 1Prd V_{min} , 静置 10 min;

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7) 以步骤 5)的充电能量和步骤 6)的放电能量计算每个试验样品的能量效率。

1) Initial charge;

2) Rest for 24 h at 50 °C;

3) Rest for 12 h at 25 °C;

4) 1Prd Vmin, rest for 10 min;

5) 1Prc Vmax, rest for 10 min;

6) 1Prd Vmin, rest for 10 min;

7) Calculate the energy efficiency of each test sample with the charging energy of step 5 and the discharge energy of step 6.

4.12.2 低温性能 Low Temperature Performance

1) 初始化充电;

2) -30 °C下: 静置 24 h;

3) 25 °C下: 静置 24 h;

4) 1Prd Vmin, 静置 10 min;

5) 1Prc Vmax, 静置 10 min;

6) 1Prd Vmin, 静置 10 min;

7) 以步骤 5)的充电能量和步骤 6)的放电能量计算每个试验样品的能量效率。

1) Initial charge;

2) Rest for 24 h at -30 °C;

3) Rest for 24 h at 25 °C ;

4) 1Prd Vmin, rest for 10 min;

5) 1Prc Vmax, rest for 10 min;

6) 1Prd Vmin, rest for 10 min;

7) Calculate the energy efficiency of each test sample with the charging energy of step 5 and the discharge energy of step 6.

4.13 SOC-OCV

4.13.1 动态 SOC-OCV Dynamic SOC-OCV

室温下

1) 静置 300 min;

2) 0.02C DC Vmin, 静置 30 min;

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3) 0.02C CC Vmax, 静置 30 min;

4) 0.02C DC Vmin, 静置 30 min。

Room temperature

1) Rest for 300 min;

2) 0.02C DC Vmin, rest for 30 min;

3) 0.02C CC Vmax, rest for 30 min;

4) 0.02C DC Vmin, rest for 30 min.

4.13.2 静态 SOC-OCV Static SOC-OCV

室温下

1) 静置 300 min;

2) 0.5C DC Vmin, 静置 30 min;

3) 0.5C CC Vmax CV 0.05C, 静置 30 min;

4) 0.5C DC Vmin, 静置 30 min;

5) 循环 3) ~4) 三次, 取第三次计量容量 C_0 ;

6) 0.5C CC Vmax CV 0.05C, 静置 2 h;

7) 0.5C DC 5% C_0 (间隔 5%SOC 调整 SOC), 静置 2 h;

8) 重复步骤 7) 19 次;

9) 0.5C DC Vmin, 静置 2 h;

10) 0.5C CC 5% C_0 (间隔 5%SOC 调整 SOC), 静置 2 h;

11) 重复步骤 10) 19 次;

12) 0.5C CC Vmax CV 0.05C, 静置 2 h。

Room temperature

1) Rest for 300 min;

2) 0.5C DC Vmin, rest for 30 min;

3) 0.5C CC Vmax CV 0.05C, rest for 30 min;

4) 0.5C DC Vmin, rest for 30 min;

5) Repeat 3) ~4) three times, take the third measurement capacity C_0 ;

6) 0.5C CC Vmax CV 0.05C, rest for 2 h;

7) 0.5C DC 5% C_0 (adjust SOC with 5%SOC interval), rest for 2 h;

8) Repeat step 7) 19 times;

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9) 0.5C DC V_{min} , rest for 2 h;

10) 0.5C CC 5% C_0 (adjust SOC with 5%SOC interval), rest for 2 h;

11) Repeat 10) 19 times;

12) 0.5C CC V_{max} CV 0.05C, rest for 2 h.

4.14 循环性能 Cycle Performance

室温循环性能 Room Temperature Cycle Performance

1) 初始化放电;

2) 1Prc V_{max} , 静置 10 min;

3) 1Prd V_{min} , 静置 10 min;

4) 循环 2) ~3) 8000 次。

1) Initial discharge;

2) 1Prc V_{max} , rest for 10 min;

3) 1Prd V_{min} , rest for 10 min;

4) Repeat 2) ~3) 8000 times.

高温循环性能 High Temperature Cycle Performance

1) 初始化放电;

2) 在 45 °C 下静置 5 h;

3) 1Prc V_{max} , 静置 10 min;

4) 1Prd V_{min} , 静置 10 min;

5) 循环 3) ~4) 3500 次;

1) Initial discharge ;

2) Rest for 5 h at 45 °C;

3) 1Prc V_{max} , rest for 10 min;

4) 1Prd V_{min} , rest for 10 min;

5) Repeat steps 3) ~4) 3500 times;

4.15 贮存性能 Storage

1) 初始化充电;

2) 1Prd 50%初始放电能量;

3) 50 °C 下: 静置 30 天;

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4) 25 °C下：静置 5 h；

5) 1Prd Vmin，静置 10 min；

6) 1Prc Vmax，静置 10 min；

7) 1Prd Vmin，静置 10 min；

8) 以 25 °C初始充电能量和步骤 6)的充电能量计算充电能量恢复率，以 25 °C初始放电能量和步骤 7)的放电能量计算放电能量恢复率。

1) Initial charge;

2) 1Prd 50% initial discharge energy;

3) Rest for 30 days at 50 °C ;

4) Rest for 5 h at 25 °C;

5) 1Prd Vmin, rest for 10 min;

6) 1Prc Vmax, rest for 10 min;

7) 1Prd Vmin, rest for 10 min;

8) The charge energy recovery rate is calculated using the initial charging energy of 25 °C and the charging energy of step 6, and the discharge energy recovery rate is calculated using the initial discharge energy of 25 °C and the discharge energy of step 7.

4.16 能量保持率和恢复率 Energy Retention and Energy Recovery

室温能量保持率和恢复率 Room Temperature Energy Retention and Energy Recovery

1) 室温下静置 5 h;

2) 1Prd Vmin，静置 10 min；

3) 1Prc Vmax，静置 10 min；

4) 1Prd Vmin，静置 10 min；

5) 循环 3) ~4) 三次，取第三次计为初始充放电能量；

6) 1Prc Vmax，静置 10 min；

7) 在室温下存储 28 d；

8) 1Prd Vmin，静置 10 min；

9) 1Prc Vmax，静置 10 min；

10) 1Prd Vmin。

1) Rest for 5 h at room temperature;

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- 2) 1Prd Vmin, rest for 10 min;
- 3) 1Prc Vmax, rest for 10 min;
- 4) 1Prd Vmin, rest for 10 min;
- 5) Repeat step 3) ~4) three times, take the third time to measure the initial charge/discharge energy;
- 6) 1Prc Vmax, rest for 10 min;
- 7) Store for 28 days at room temperature;
- 8) 1Prd Vmin, rest for 10 min;
- 9) 1Prc Vmax, rest for 10 min;
- 10) 1Prd Vmin.

高温能量保持率和恢复率 High Temperature Energy Retention and Energy Recovery

- 1) 初始化充电;
- 2) 45 °C静置 30 d;
- 3) 25 °C静置 5 h;
- 4) 1Prd Vmin, 静置 10 min;
- 5) 1Prc Vmax, 静置 10 min;
- 6) 1Prd Vmin, 静置 10 min;

7) 以 25 °C初始放电能量和步骤 4)的放电能量计算每个试验样品能量保持率,以 25 °C初始充电能量和步骤 5)的充电能量计算每个试验样品充电能量恢复率,以 25 °C初始放电能量和步骤 6)的放电能量计算每个试验样品放电能量恢复率。

- 1) Initial charge;
- 2) Rest for 30 d at 45 °C;
- 3) Rest for 5 h at 25 °C ;
- 4) 1Prd Vmin, rest for 10 min;
- 5) 1Prc Vmax, rest for 10 min;
- 6) 1Prd Vmin, rest for 10 min;

7) The energy retention rate of each test sample was calculated with the initial discharge energy of 25 °C and the discharge energy of step 4; the charging energy recovery rate of each test sample was calculated with the initial charging energy of 25 °C and the charging energy of step 5; the discharge energy recovery rate of each test sample was calculated with the initial discharge energy of 25 °C and the discharge energy of step 6.

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5安全试验 Safety Test Methods

5.1 过充电 Overcharge

室温下

- 1) 初始化充电;
- 2) $I = \text{额定充电功率} / \text{标称电压}$, 恒流充电至充电终止电压的 1.5 倍或时间达到 1 h;
- 3) 观察 1 h。

Room temperature

- 1) Initial charge;
- 2) $I = \text{rated charging power} / \text{nominal voltage}$, charge the cell to 1.5 times of the termination voltage, or 1 h with

constant current;

- 3) Observe for 1 h.

5.2 外部短路 External Short-circuit

室温下

- 1) 初始化充电;
- 2) 按照公式(1)计算外部线路电阻:

$$R_e = R_t + R_p + R_n \dots\dots\dots (1)$$

式中:

R_e ---外部线路电阻

R_t ---试验装置电阻, 电阻值 $[0.8, 1.0] \text{ m}\Omega$

R_p ---正极接触电阻, 电阻值 $\leq 0.1 \text{ m}\Omega$

R_n ---负极接触电阻, 电阻值 $\leq 0.1 \text{ m}\Omega$

- 3) 将电池单体正负极经外部短路 10 min;
- 4) 断开回路, 观察 1 h。

Room temperature

- 1) Initial charge;
- 2) Calculate the external line resistance according to formula (1)

$$R_e = R_t + R_p + R_n \dots\dots\dots (1)$$

Formula:

R_e -- External line resistance

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Rt-- Resistance of the test device, resistance [0.8,1.0]mΩ

Rp-- Positive contact resistance, resistance≤0.1 mΩ

Rn-- Negative contact resistance, resistance≤0.1 mΩ

3) Short-circuit the positive and negative electrodes of the battery for 10 min;

4) Disconnect the loop and observe for 1 h.

5.3 挤压 Crush

室温下

1) 初始化充电;

2) 按下列条件试验:

a.挤压方向: 垂直于电池单体极板方向施压;

b.挤压板形式: 半径为 75 mm 的半圆柱体, 半圆柱体的长度 L 大于被挤压电池的尺寸;

c.挤压速度: 5 mm/s;

d.挤压程度: 挤压力达到 50 kN, 保压 10 min, 停止挤压;

e.观察 1 h。

Room temperature

1) Initial charge;

2) Test according to the following conditions:

a. Extrusion direction: pressure perpendicular to the direction of battery cell plate;

b. Extrusion plate form: a half cylinder with a radius of 75 mm, the length of the half cylinder L is greater than the size of the extruded battery;

c. Extrusion speed: 5 mm/s;

d. Extrusion degree: extrusion pressure reaches 50 kN, hold pressure for 10 min, stop extrusion;

e. Observe for 1 h.

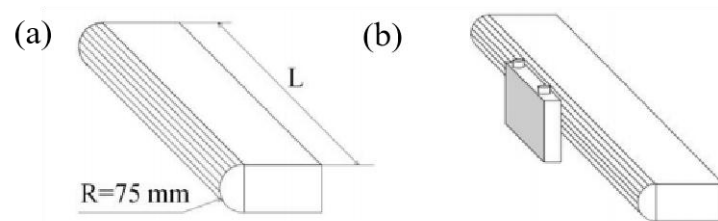


图 9 挤压头 (a) 和电池单体挤压 (b) 示意图

Fig.9 Schematic diagram of extrusion head (a) and battery cell extrusion (b)

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5.4 针刺 Nail Penetration

1) 初始化充电;

2) 用 $\phi 5\text{ mm} \sim \phi 8\text{ mm}$ 的高温钢针, 针尖的圆角度为 $45^\circ \sim 60^\circ$, 针表面光洁无锈蚀及油污, 以 $(25 \pm 5)\text{ mm/s}$ 的速度, 从垂直于电池极板的方向贯穿, 贯穿位置宜靠近所刺面的几何中心, 钢针停留在蓄电池中;

3) 观察 1 h。

1) Initial charge;

2) With the $\phi 5\text{ mm} \sim \phi 8\text{ mm}$ high temperature steel needle, the circular angle of the needle tip is $45^\circ \sim 60^\circ$, needle surface clean without rust and oil, at the speed of $(25 \pm 5)\text{ mm/s}$, from the direction perpendicular to the battery plate, the penetration position should be close to the geometric center of the stabbed surface, the steel needle stays in the battery;

3) Observe for 1 h.

5.5 加热 Heating

1) 初始化充电;

2) 将电池放入试验箱, 温度以 $5\text{ }^\circ\text{C/min}$ 的速率从环境温度升至 $(130 \pm 2)\text{ }^\circ\text{C}$ 并保持 30 min.

3) 观察 1 h。

1) Initial charge;

2) Put the cell into the temperature chamber, and the temperature chamber will rise from room temperature to $130\text{ }^\circ\text{C} \pm 2\text{ }^\circ\text{C}$ at a rate of $5\text{ }^\circ\text{C/min}$, and keep this temperature for 30 min before stop heating..

3) Observe for 1 h.

5.6 过载 Overload

室温下

1) 初始化放电;

2) $4\text{Prc } V_{\text{max}}$, 静置 10 min;

3) $4\text{Prd } V_{\text{min}}$;

4) 观察 1 h。

At room temperature

1) Initial discharge;

2) $4\text{Prc } V_{\text{max}}$, standing for 10min;

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3) 4Prd Vmin;

4) Observe for 1h.

5.7 热失控 Thermal Runaway

室温下

1) 初始化充电;

2) 按表 7 要求选取加热部件和温度传感器并布置于试验样品表面, 设置温度采样周期为 1 s, 设定连续监测到三个温升速率值均 $>3\text{ }^{\circ}\text{C/s}$ 或起火或爆炸为发生热失控的判定条件;

3) 恒流充电, $I=\text{额定充电功率/标称电压}$, 同时以最大功率启动加热装置;

4) 触发热失控的判定条件或者温度达到 $300\text{ }^{\circ}\text{C}$ 或者试验时间达到 4 h 时, 停止充电和加热;

5) 观察 1 h。

At Room temperature

1) Initial charge;

2) Heating components and temperature sensors were selected and placed on the surface of the test sample according to the requirements in the following table 7. The temperature sampling period was set to be 1 s, and the determination conditions for the occurrence of thermal runaway were set when the three temperature rise rates were all $>3\text{ }^{\circ}\text{C/s}$ or fire or explosion were continuously monitored.

3) Constant current charging, $I=\text{rated charging power/nominal voltage}$, while starting the heating device with maximum power;

4) Stop charging and heating when the judgment condition of triggering thermal runaway or the temperature reaches $300\text{ }^{\circ}\text{C}$ or the test time reaches 4 h;

5) Observe for 1 h.

表 7 热失控性能试验加热及采样要求

Table 7 Thermal runaway performance test requirements

试验样品额定放电能量(Erd)W•h Rated discharge energy(Erd)W•h	加热功率 W Power W	加热部件形状及布置位置 Shape and position of heating components	温度传感器规格及布置位置 Temperature sensor specifications and location
Erd $<$ 50	250	片状,布置于试验样品面积较大的平面,尺寸不大于被加热面尺寸 Sheet, arranged on a plane with a large test sample area, the size is not greater than the size of the	感温头直径 $\leq 1\text{ mm}$,布置于被加热面对侧中心位置 Temperature sensing head diameter $\leq 1\text{ mm}$, arranged in the heating side of the central position
50 $\leq$ Erd $<$ 100	450		
100 $\leq$ Erd $<$ 400	650		
400 $\leq$ Erd $<$ 800	800		
800 $\leq$ Erd $<$ 1000	1000		

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Erd≥1000	>1000	heated surface			

6 电池安全使用管理 Battery Safety Management

6.1 应用条件 Application Conditions

客户应当确保遵守以下电池相关的应用条件：

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

1) 客户应配置电池管理和监控系统，严密监控、管理和保护每个电池，并建立电池管理档案，保存完整的电池运转的监测数据，用于问题追溯及产品质量责任划分的参考。不具备完整的电池系统使用期限内的监测数据的，Valcon 不承担产品质量保证责任。

1) Customer should configure a battery management and monitoring system to strictly monitor, manage and protect each cell. 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. Valcon is not responsible for product quality assurance if no complete monitoring data of the battery system during its service life is provided.

2) 电池包设计中应充分考虑电池的防水、防尘问题，电池包必须满足国家标准规定的防水、防尘等级。由于防水、防尘问题而导致的电池或电池包的损坏（如腐蚀、生锈等），Valcon 不承担质量保证责任。

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

6.2 电压限制 Voltage Limits

表 8 安全限制电压参数

Table 8 Safety limit voltage parameters

参数 Parameters	产品规格 Standards	保护动作 Protective Action
充电截止电压 Charge Cut-off Voltage	3.65 V	/
第三级过充电保护 Third Over-Charging Protection	≥3.70 V	断电 30 min，0.1C 放电 5 min，重启 最多允许操作次数：20 次 Power off for 30 minutes, discharge 0.1C for 5 minutes, and restart Maximum number of operations: 20
第二级过充电保护 Second Over-Charging Protection	≥3.75 V	断电 30 min，0.1C 放电 5 min，重启 最多允许操作次数：10 次 Power off for 30 minutes, discharge 0.1C for 5

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		minutes, and restart Maximum number of operations: 10
第一级过充电保护 First Over-Charging Protection	$\geq 3.80\text{ V}$	断电 30 min, 0.1C 放电 5 min, 重启 最多允许操作次数: 3 次 Power off for 30 minutes, discharge 0.1C for 5 minutes, and restart Maximum number of operations: 3
放电截止电压 Discharge Cut-off Voltage	2.50 V	/
第三级过放电保护 Third Over-Discharging Protection	2.40 V	断电 30 min, 重启 最多允许操作次数: 20 次 Power off for 30 minutes and restart Maximum number of operations: 20
第二级过放电保护 Second Over-Discharging Protection	2.20 V	断电 30 min, 重启 最多允许操作次数: 10 次 Power off for 30 minutes and restart Maximum number of operations: 10
第一级过放电保护 First Over-Discharging Protection	2.00 V	断电 30 min, 重启 最多允许操作次数: 3 次 Power off for 30 minutes and restart Maximum number of operations: 3

注意 Caution:

1) 操作次数超过最多允许次数, 需联系工程师售后处理。

1) If the number of operations exceeds the maximum number, contact technical support engineers.

2) 电池充电超过终止电压时, 需依据相应的保护动作采取措施, 对于超出保护电压带来的电池质量问题, Valcon 不承担任何责任。

2) If the cell charging voltage exceeds the cut-off voltage, corresponding protective actions need to be taken.

Valcon shall not be responsible for any cell quality issues caused by exceeding the protection voltage.

3) 电池放电超过终止电压时, 需尽快充电, 防止电池进入过放状态。因电池过放带来的电池质量问题, Valcon 不承担任何责任。

3) If the cell discharging voltage reaches the cut-off voltage, it is necessary to charge as soon as possible to prevent the cell from being overdischarged. Valcon shall not be responsible for any cell quality issues caused by overdischarge.

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6.3 温度限制 Temperature Limits

表 9 安全限制温度参数

Table 9 Safety limit temperature parameters

参数 Parameters	规格 Standards	备注 Notes
推荐操作温度范围 Recommended Operating Temperature Range	10°C~ 35°C	推荐使用电池的温度范围 Recommend cell usage temperature range
最高操作温度 Maximum Operating Temperature	60°C	如果电池使用温度超过最高温度，功率需要降为 0 If the cell temperature exceeds the maximum operating temperature, the power needs to be reduced to 0
最低操作温度 Minimum Operating Temperature	-30°C	如果电池使用温度超过最低温度，功率需要降为 0 If the cell temperature exceeds the minimum operating temperature, the power needs to be reduced to 0
最高安全温度 Maximum Safe Temperature	60°C	如果电池使用温度超过最高安全温度，将会造成电池不可逆的永久性损坏，用户使用时不得高于最高安全温度 If the cell temperature exceeds to the maximum safe temperature, and permanent damage will be caused. The user should not use it under environments higher than the maximum safe temperature
最低安全温度 Minimum Safe Temperature	-30°C	如果电池使用温度超过最低安全温度，将会造成电池不可逆的永久性损坏，用户使用时不得低于最低安全温度 If the cell temperature exceeds the minimum safe temperature, irreversible and permanent damage will be caused. The user should not use it under environments lower than the minimum safe temperature

注意 Attention:

1) 电池禁止在低温下充电及在规定的最低安全温度下放电，否则 Valcon 不承担任何电池质量保证责任。

1) Prohibit charging the cell at low temperature and the minimum safety temperature specified by this specification, otherwise Valcon will not be responsible for any quality assurance liability.

2) 电池包的散热设计会影响电池性能，因电池包散热设计问题导致的电池质量问题，Valcon 不承担质量保证责任。

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2) The heat dissipation design of battery may effect cell electrical performance, Valcon will not be responsible for any assurance liability regarding cell quality issues caused by the heat dissipation design.

6.4 模组参数设计建议 Parameters Recommendation for Module Design

6.4.1 电池方向 Cell Directions

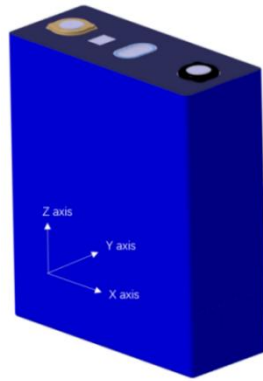


图 10 LFP71173204-314Ah 电池方向示意图

Fig10 Diagram of LFP71173204-314Ah cell direction

6.4.2 电池压缩力 Cell Compression Force

电池在模组成组时，为了使电池更好的排列固定，对电池施加一个垂直厚度方向的压缩力，压缩力过大，电池内部可能收到损伤，甚至漏液。电池压缩力测试条件如下：

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:

- 压缩面积 Compression area : 173.82 mm × 204.22 mm(L×H₁)
- 压缩速度 Compression speed : 0.02 mm/s
- 压缩方向 Compression direction : Y 方向 Y direction
- 电池 SOC Cell SOC : 15%~40%

表 10 电池压缩力限制参数

Table 10 Cell compression force limit parameters

现象 Observation	压缩力 Compression Force
推荐压缩力 Recommend Compression Force	3000 N~ 7000 N
瞬时最大压缩力 Instantaneous Maximum Compression Force	10000 N

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电池承受的压缩力不能超过 10000 N，否则电池可能会受到损害。

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

6.4.3 电池膨胀力 Cell Swelling Force

在使用过程中，因极片厚度反弹等固有特性导致电池膨胀，而对约束夹具产生的作用力;电池的膨胀力随着电池容量的衰减而增加，电池 BOL 和 EOL(70%SOH) 膨胀力如下表:

In the process of use, due to the intrinsic characteristics of the electrode thickness rebound caused by battery expansion, and the force generated by the restraint fixture; The expansion force of the battery increases with the decay of the battery capacity. The expansion force of the battery BOL and EOL(70%SOH) is as follows:

表 11 电池膨胀力参数

Table 11 Cell swelling force parameters

膨胀力 Swelling force	BOL	<3000 N
	EOL (70%SOH)	50000~60000N

客户在设计模组时，应充分考虑电池膨胀力的影响。

Customer shall fully consider the influence of the cell swelling force when designing the module.

6.4.4 推荐温度采集点 Recommend Temperature Collection Points

对电池表面进行温度采集时，建议温度采集点布置在极柱或刻码处。

The recommended temperature collection points are the poles or code when collecting temperature of the cell surface.

6.4.5 热力学参数 Thermodynamic Parameters

测试方法 Test Method:

参考标准: GB/T 10295-2008、ASTM E1269-2011。

Reference standards: GB/T 10295-2008、ASTM E1269-2011.

表 12 电池导热系数参数

Table 12 Cell thermal conductivity parameter

导热系数均值 Mean Thermal Conductivity	导热系数 W/(m·K) Thermal Conductivity W/(m·K)	
	X/Z 方向 X/Z Direction	Y 方向 Y Direction
	20~25 W/(m·K)	2~4 W/(m·K)
热容均值 Mean Heat Capacity	热容 kJ/(kg.K) Heat Capacity kJ/(kg.K)	

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X/Z 方向 X/Z Direction		0.9~1.2 kJ/(kg·K)			

6.4.6 安全工作信息 Safety work information

安全工作参数 Safety work information	符号 symbol	数值 Value
充电上限电压 Charge upper voltage	Uup	3. 80 V
充电限制电压 Charge limit voltage	Ucl	3. 65 V
放电截止电压 Discharge cut-off voltage	Udo	2.0 V(T>0 °C) 1.75 V(T<0 °C)
放电终止电压 Discharge termination voltage	Ude	2. 5 V(T>0 °C) 2.0 V(T≤0 °C)
最大充电电流 Maximum charging current	Icm	157 A
最大放电电流 Maximum discharge current	Idm	157 A
上限充电温度 Upper charging temperature	Tcm	55 °C
下限充电温度 Lower charging temperature	Tcl	0 °C
上限放电温度 Upper discharge temperature	Tdm	-30 °C
下限放电温度 Lower limit discharge temperature	Tdl	60 °C

7使用注意事项 Precautions

7.1 产品寿命终止管理 Product End-life Management

电池使用期限是有限的，客户应建立有效的跟踪系统检测并记录每个使用期限内电池的内阻和容量。内阻及容量的测量方法和计算方法需要客户和 Valcon 共同讨论和双方同意。当使用中电池的内阻超过这个电池最初内阻的 150%或容量小于标称容量的 70%，应停止使用电池。违反该项要求，将免除 Valcon 依据产品销售协议以及本规格书所应承担的产品质量保证责任及由此引起的损失赔偿等一切相关责任。

The cell life is limited. Customers should establish an effective tracking 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 Valcon. When the internal resistance of the cell in use exceeds 150% of the initial internal resistance of the cell, or the capacity is less than 70%

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of the nominal capacity, the cell should not to be operated. Violation of this requirement will exempt Valcon 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.

7.2 长期储存 Long-term Storage

电池进行充电后，需尽快使用，以免因自放电而造成可用容量损失。若需要长期储存，应将 SOC 调整为 15%~40% SOC。推荐的储存条件为：0 °C~35 °C，相对湿度≤60%。

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 15%~40%. The recommended storage conditions are: 0 °C ~ 35 °C, relative humidity ≤ 60%.

电池单体贮存时，荷电状态（SOC,容量状态）应保持在 15%~ 40% ，长期贮存（三个月以上）时为防止电池性能差异，应每三个月进行一次充放电循环；建议收到货后储存时间不超过半年，避免存储超期造成质量问题。

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 per 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.

7.3 运输及装卸要求 Transportation and Handling Requirements

在运输过程中不允许和易燃易爆易腐蚀的物品同车装运，大包装运输过程中禁止堆叠；产品不允许经受雨、雪或液体物质的淋洗与机械损伤。

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 should not be exposed to rain, snow and other liquid substances without any protection, or suffer mechanical damage.

产品装卸时，需采用升降车或专用工具对产品进行上下车；要轻取轻放，不得扔掷、挤压，造成电池破坏火堆人身的意外伤害，严禁与酸碱等腐蚀物品放在一起。

While handling, lift trucks or special tools shall be used to load and unload products; Handle with care, 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.

7.4 操作说明 Operation Precautions

使用电池前，请仔细阅读本规格书和注意电池表面标识。

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Before using the battery, please read this specification carefully and pay attention to the battery surface identification.

包装前请检查正极和负极端子的方向。

Please check the direction of the positive and negative terminals before packing.

正确连接电池的正负极，严禁反向充电。若电池正负极接反，将导致电池报废并产生安全隐患。

Correctly connect the positive and negative terminals of the battery, and reverse charging is strictly prohibited.

If the positive and negative electrodes of the battery are reversed, the battery will be scrapped and security risks may arise.

不要将电池放置于阳光直射处或热源。

Do not place the battery in direct sunlight or heat sources.

处理电池时请勿穿戴金属饰品（如戒指、手表、饰件等）。

Do not wear metal accessories (such as rings, watches, accessories, etc.) when handling batteries.

请勿将电池放置在本文件规定的使用温度范围之外的地方。

Do not leave the battery outside the operating temperature range specified in this document.

请勿超过最大充电倍率充电。

Do not charge more than the maximum charging rate.

请勿拆卸或改装电池。

Do not remove or modify the battery.

请勿抛掷或撞击电池。

Do not throw or strike the battery.

请勿用锐器刺穿电池（例如刀子、钉子、笔、电钻）。

Do not Pierce the battery with sharp objects (such as knives, nails, pens, electric drills).

请勿与其它型号电池或模块单元混用。

Do not mix with other battery or module units.

使用过程中请勿过度挤压电池。

Do not over-squeeze the battery during use.

请勿将电池放置于高于 60℃高温处。

Do not place the battery at a temperature above 60℃.

不要将电池放于微波炉或高压容器中。

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Do not place batteries in microwave ovens or high pressure containers.

请勿用导电材料连接正、负极端子（例如金属、电线）。

Do not connect positive and negative terminals with conductive materials (e.g. metal, wire).

不允许弄湿或将电池浸入水或海水中。

Do not wet or immerse the battery in water or seawater.

请勿以制造商书面协议之外的方式使用电池。

Do not use the battery in a manner other than the manufacturer's written agreement.

7.5 保密协议 Confidentiality Agreement

客户应对合作内容高度保密，未经 Valcon 允许，不得向第三方透露规格书的内容，否则，将依照相关法律追究责任。

The customer shall keep the cooperation content highly confidential. Without the permission of Valcon, 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.

7.6 风险警告 Risk Warning

7.6.1 警示声明 Warning Declaration

电池存在潜在的危险，在操作和维护时必须采取适当的防护措施！

必须使用正确的工具和防护装备操作电池。

电池的维护必须由具有电池专业知识并经过安全培训的人士执行。

不遵守上述警告可能造成多种灾难。

The cell has potential hazards, and 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 professional with cell expertise and safety training.

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

7.6.2 危险类型 Types of Danger

客户知悉在电池使用和操作过程中存在以下潜在的危险：

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

1) 存在受到电击或者电弧伤害的风险。

1) There is a risk from electric shocks or electric arcs during operation.

2) 存在受到电解液或其他化学品危害的风险。

2) There is a risk from the electrolyte or other chemicals.

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3) 为防止发生意外短路, 造成电弧、爆炸或热失控, 需选择合适的操作方法及防护装备。

3) Proper operation methods and protective equipment shall be selected to avoid short circuit, explosion or thermal runaway.

7.7 免责声明 Disclaimer

如果由于产品需求单位或客户不按本说明书中的规定进行使用, Valcon 不再承担产品质量保证责任及由此引起的损失赔偿等一切相关责任。因前述行为, 对 Valcon 的声誉造成负面影响的, Valcon 保留追究产品需求单位的法律责任权利。

If the product demand party or user does not use the product in accordance with the provisions of this specification, Valcon 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 Valcon's reputation due to the above-mentioned actions, Valcon reserves the right to investigate the legal liability of the product demand party.

8其他 Others

8.1 Valcon 的权利和义务 Rights and Obligations of Valcon

Valcon 按照与客户签订的协议中的检验标准进行检验, 提供产品应符合协议中各项参数要求:

Valcon 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;

Valcon 向客户提供双方确认的、稳定可靠的产品;

Valcon shall provide customer with stable and reliable products confirmed by both parties;

Valcon 有义务为其产品提供优质的服务, 服务标准按 Valcon 所承诺的标准服务;

Valcon is obliged to provide high-quality services for its products, and the service standards shall be in accordance with the standards promised by Valcon;

在客户对系统产品的使用及维护过程中遇到问题或故障时, Valcon 进行及时的技术支持及服务。

Valcon 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 客户的权利和义务 Rights and Obligations of Customer

客户应严格按照 Valcon 提供的技术资料进行生产, 严格执行 Valcon 所提供的技术资料中的电池防范措施、安全限制和电池操作说明。

Customer must conduct production in strict accordance with the technical data provided by Valcon, and strictly

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implement the cell prevention measures, safety limits and cell operation instructions in the technical data provided by Valcon.

客户有义务保证 Valcon 产品的安全，应采取相应的防火、防水等措施。

Customer has the obligation to ensure the safety of products from Valcon, measures such as fire prevention and waterproofing should be taken accordingly.

客户有义务对 Valcon 的产品做出公平、公正详细的使用记录及产品运转的监测数据，用作于产品质量责任划分的参考，不具备完整的电池系统使用期限内的监测数据的，Valcon 不承担产品质量保证责任。

Customer has the obligation to make fair and detailed use records and monitoring data of product operation for Valcon'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, Valcon shall not be responsible for product quality assurance.

客户有义务在 Valcon 产品运作异常时，在可能的情况下通知 Valcon 人员到场，了解实际情况。

Customer has the obligation to notify Valcon's personnel to be present and be informed of the actual situation when products of Valcon operate abnormally.

客户在产品制造过程中，因违反安全守则操作、在本规格书说明条件之外使用及产品与电路等搭配（非产品自身质量缺陷）所产生的问题或事故，其责任与 Valcon 无关，应由客户承担相应的责任。

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 or the use beyond the conditions specified in this technical agreement and the combination of the product and the circuit (not the quality defects of the product itself).

备注：任何本规格书中未提及的事项，须经双方协商确定。

Remarks: Any matter not mentioned in this specification must be negotiated and determined by both parties.

9联系方式 Contact Information

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