Ⅴ、测试方法 Test Method

Tests T.1 to T.5 shall be conducted in sequence on the same cell or battery. Tests T.6 and T.8 shall be conducted using not otherwise tested cells or batteries. Test T.7 may be conducted using undamaged batteries previously used in tests T.1 to T.5 for purposes of testing on cycled batteries.

小型电池或电池组必须按顺序进行试验 T.1 至 T.5。试验 T.6 和 T.8 应使用未另外试验过的电池或电池组。试验 T.7 可以使用原先在试验 T.1 至 T.5 中使用过的未损坏电池组进行，以便测试经过充放电的电池组。

In order to quantify the mass loss, the following procedure is provided:

质量损失依照下式计算：

Mass loss 质量损失 (%)=$(M_1-M_2) / M_1 \times 100$

Where M_1 is the mass before the test and M_2 is the mass after the test. When mass loss does not exceed the values in Table below, it shall be considered as “no mass loss”.

式中 M_1 是试验前的质量，M_2 是试验后的质量。如质量损失不超过下表所列数值，即视为“无质量损失”。

Mass M of cell or battery 电池或电池组质量 M	Mass loss limit 质量损失限值
M<1g	0.5%
1g≤M≤75g	0.2%
M>75g	0.1%

T.1 Altitude simulation 高度模拟

Test cells and batteries shall be stored at a pressure of 11.6kPa or less for at least six hours at ambient temperature (20℃± 5℃).

Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

试验电池和电池组应在压力等于或低于 11.6 千帕和环境温度（20℃±5℃）下存放至少 6 小时。

要求电池和电池组无渗漏、无排气、无解体、无破裂和无起火，并且每个试验电池或电池组在试验后的开路电压不小于其在进行这一试验前电压的 90%。有关电压的要求不适用于完全放电状态的试验电池和电池组。

T.2 Thermal test 温度试验

Test cells and batteries are to be stored for at least six hours at a test temperature equal to 72℃± 2℃, followed by storage for at least six hours at a test temperature equal to - 40℃± 2℃. The maximum time interval between test temperature extremes is 30 minutes. This procedure is to be repeated until 10 total cycles are complete, after which all test cells and batteries are to be stored for 24 hours at ambient temperature (20℃± 5℃). For large cells and batteries the duration of exposure to the test temperature extremes should be at least 12 hours.

Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

试验电池和电池组应先在试验温度等于 72℃±2℃的条件下存放至少 6 小时，接着再在试验温度等于-40℃±2℃的条件下存放至少 6 小时。两个极端试验温度之间的最大时间间隔为 30 分钟。此程序重复进行，共完成 10 次，接着将所有试验电池和电池组在环境温度（20℃±5℃）下存放 24 小时。对于大型电池和电池组，暴露于极端试验温度的时间至少应为 12 小时。

要求电池和电池组无渗漏、无排气、无解体、无破裂和无起火，并且每个试验电池或电池组在试验后的开路电压不小于其在进行这一试验前电压的 90%。有关电压的要求不适用于完全放电状态的试验电池和电池组。

T.3 Vibration 振动

Cells and batteries are firmly secured to the platform of the vibration machine without distorting the cells in such a manner as to faithfully transmit the vibration. The vibration shall be a sinusoidal waveform with a logarithmic sweep between 7Hz and 200Hz and back to 7Hz traversed in 15 minutes. This cycle shall be repeated 12 times for a total of 3 hours for each of three mutually perpendicular mounting positions of the cell. One of the directions of vibration must be perpendicular to the terminal face.

The logarithmic frequency sweep shall differ for cells and batteries with a gross mass of not more than 12kg (cells and small batteries), and for batteries with a gross mass of more than 12kg (large batteries).

For cells and small batteries: from 7Hz a peak acceleration of $1g_n$ is maintained until 18Hz is reached. The amplitude is then maintained at 0.8mm (1.6mm total excursion) and the frequency increased until a peak acceleration of $8g_n$ occurs (approximately 50Hz). A peak acceleration of $8g_n$ is then maintained until the frequency is increased to 200Hz.

For large batteries: from 7Hz to a peak acceleration of $1g_n$ is maintained until 18Hz is reached. The amplitude is then maintained at 0.8mm (1.6mm total excursion) and the frequency increased until a peak acceleration of $2g_n$ occurs (approximately 25Hz). A peak acceleration of $2g_n$ is then maintained until the frequency is increased to 200Hz.

Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire during the test and after the test and if the open circuit voltage of each test cell or battery after testing in its perpendicular mounting position is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

电池和电池组紧固于振动机平台，但不得造成电池变形，并能准确可靠地传播振动。振动应是正弦波形，对数扫描频率在 7 赫兹和 200 赫兹之间，再回到 7 赫兹，跨度为 15 分钟。这一振动过程须对三个互相垂直的电池安装方位的每一方向重复进行 12 次，总共为时 3 小时。其中一个振动方向必须与端面垂直。

作对数式频率扫描，对总质量不足 12 千克的电池和电池组（电池和小型电池组），和对 12 千克及更大的电池组（大型电池组）有所不同。

对电池和小型电池组：从 7 赫兹开始，保持 $1g_n$ 的最大加速度，直到频率达到 18 赫兹。然后将振幅保持在 0.8 毫米（总偏移 1.6 毫米），并增加频率直到最大加速度达到 $8g_n$（频率约为 50 赫兹）。将最大加速度保持在 $8g_n$ 直到频率增加到 200 赫兹。

对大型电池组：从 7 赫兹开始，保持 $1g_n$ 的最大加速度，直到频率达到 18 赫兹。然后将振幅保持在

0.8 毫米（总偏移 1.6 毫米），并增加频率直到最大加速度达到 $2g_n$（频率约为 25 赫兹）。将最大加速度保持在 $2g_n$ 直到频率增加到 200 赫兹。

要求电池和电池组试验中和试验后无渗漏、无排气、无解体、无破裂和无起火，并且每个试验电池或电池组在第三个垂直安装方位上的试验后测得的开路电压不小于在进行这一试验前电压的 90%。有关电压的要求不适用于完全放电状态的试验电池和电池组。

T.4 Shock 冲击

Test cells and batteries shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery.

Each cell shall be subjected to a half-sine shock of peak acceleration of $150g_n$ and pulse duration of 6 milliseconds. Alternatively, large cells may be subjected to a half-sine shock of peak acceleration of $50g_n$ and pulse duration of 11 milliseconds.

Each battery shall be subjected to a half-sine shock of peak acceleration depending on the mass of the battery. The pulse duration shall be 6 milliseconds for small batteries and 11 milliseconds for large batteries. The formulas below are provided to calculate the appropriate minimum peak accelerations.

试验电池和电池组用坚硬支架紧固在试验装置上，支架支撑着每个试验电池组的所有安装面。

每个小型电池必须经受峰值加速度 150gn 和脉冲持续时间 6 毫秒的半正弦波冲击。针对大型电池必须经受最大加速度 50gn 和脉冲持续时间 11 毫秒的半正弦波冲击。

每个电池须经受的正弦波冲击的最低限度最大加速度依照下式计算。对于小型电池组的脉冲持续时间应为 6 毫秒，对于大型电池组的脉冲持续时间应为 11 毫秒。

Battery **电池组**	**Minimum peak acceleration** **最小峰值加速度**	**Pulse duration** **脉冲持续时间**
Small batteries 小型电池组	$150g_n$ or result of formula $150g_n$ 或公式计算结果 Acceleration 加速度 $(g_n)=\sqrt{\left(\frac{100850}{\text{mass / 质量 *}}\right)}$ Whichever is smaller 中的较小值	6ms
Large batteries 大型电池组	$50g_n$ or result of formula $50g_n$或公式计算结果 Acceleration 加速度 $(g_n)=\sqrt{\left(\frac{30000}{\text{mass / 质量 *}}\right)}$ Whichever is smaller 中的较小值	11ms

* Mass is expressed in kilograms /质量单位用千克计算

Each cell or battery shall be subjected to three shocks in the positive direction and to three shocks in the negative direction in each of three mutually perpendicular mounting positions of the cell or battery for a total of

18 shocks.

Cells and batteries meet this requirement if there is no leakage, no venting, no disassembly, no rupture and no fire and if the open circuit voltage of each test cell or battery after testing is not less than 90% of its voltage immediately prior to this procedure. The requirement relating to voltage is not applicable to test cells and batteries at fully discharged states.

每个电池或电池组须在三个互相垂直的安装方位的正方向经受三次冲击，接着在反方向经受三次冲击，总共经受 18 次冲击。

要求电池和电池组无渗漏、无排气、无解体、无破裂和无起火，并且每个试验电池或电池组在试验后的开路电压不小于其在进行这一试验前电压的 90%。有关电压的要求不适用于完全放电状态的试验电池和电池组。

T.5 External short circuit 外部短路

The cell or battery to be tested shall be heated for a period of time necessary to reach a homogeneous stabilized temperature of 57℃±4℃, measured on the external case. This period of time depends on the size and design of the cell or battery and should be assessed and documented. If this assessment is not feasible, the exposure time shall be at least 6 hours for small cells and small batteries, and 12 hours for large cells and large batteries. Then the cell or battery at 57℃±4℃ shall be subjected to one short circuit condition with a total external resistance of less than 0.1 ohm. This short circuit condition is continued for at least one hour after the cell or battery external case temperature has returned to 57℃±4℃, or in the case of the large batteries, has decreased by half of the maximum temperature increase observed during the test and remains below that value. The short circuit and cooling down phases shall be conducted at least at ambient temperature.

Cells and batteries meet this requirement if their external temperature does not exceed 170℃ and there is no disassembly, no rupture and no fire during the test and within six hours after the test.

待测试的电池或电池组应加热一段必要时间，以从外壳测量的温度达到均匀稳定的 57℃±4℃的温度，应对加热持续时间进行评估和记录；如果这种评估不可行，对于小型电池和小型电池组至少在 57±4℃的环境下存放 6 小时，对于大型电池和大型电池组至少在 57℃±4℃的环境下存放 12 小时。然后，电池或电池组在 57℃±4℃的环境中，应接受一个外部总电阻小于 0.1 欧姆的短路条件。这一短路条件应在电池或电池组外壳温度回到 57℃±4℃后继续至少 1 小时，或对于大型电池组其外壳温度降幅达试验中观察到最高温升幅的二分之一，并保持低于该值。进行短路和降温阶段试验的温度至少相当于环境温度。

要求电池和电池组外壳温度不超过 170℃，并且在试验过程中及试验后 6 小时内无解体、无破裂、无起火。

T.6 Crush 挤压

Crush (applicable to prismatic, pouch, coin/button cells and cylindrical cells less than 18 mm in diameter)

A cell or component cell is to be crushed between two flat surfaces. The crushing is to be gradual with a speed of approximately 1.5 cm/s at the first point of contact. The crushing is to be continued until the first of the three options below is reached.

(a) The applied force reaches 13 kN ± 0.78 kN;

(b) The voltage of the cell drops by at least 100 mV; or

(c) The cell is deformed by 50% or more of its original thickness.

Once the maximum pressure has been obtained, the voltage drops by 100 mV or more, or the cell is deformed by at least 50% of its original thickness, the pressure shall be released.

A prismatic or pouch cell shall be crushed by applying the force to the widest side. A button/coin cell shall be crushed by applying the force on its flat surfaces. For cylindrical cells, the crush force shall be applied perpendicular to the longitudinal axis.

Each test cell or component cell is to be subjected to one crush only. The test sample shall be observed for a further 6 h. The test shall be conducted using test cells or component cells that have not previously been subjected to other tests.

Cells and component cells meet this requirement if their external temperature does not exceed 170 °C and there is no disassembly and no fire during the test and within six hours after this test.

挤压（适用于棱柱形、袋装、硬币/纽扣电池和直径小于 18 毫米的圆柱形电池）

将电池或元件电池放在两个平面之间挤压，挤压力度逐渐加大，在第一个接触点上的速度大约为 1.5 厘米/秒。挤压持续进行，直到出现以下三种情况之一：

(a) 施加的力量达到 13 千牛± 0.78 千牛；

(b) 电池的电压下降至少 100 毫伏；或

(c) 电池变形达原始厚度的 50%或以上。

一旦达到最大压力、电压下降 100 毫伏或更多，或电池变形至少达原厚度的 50%，即可解除压力。棱柱形或袋装电池应从最宽的一面施压。纽扣/硬币形电池应从其平坦表面施压。圆柱形电池应从与纵轴垂直的方向施压。

每个试样电池或元件电池只做一次挤压试验。试样应继续观察 6 小时。试验应使用之前未做过其他试验的电池或元件电池进行。

要求电池和电池组外壳温度不超过 170℃，并且在试验过程中及试验后 6 小时内无解体、无起火。

T.7 Overcharge 过度充电

The charge current shall be twice the manufacturer’s recommended maximum continuous charge current. The minimum voltage of the test shall be as follows:

(a) When the manufacturer’s recommended charge voltage is not more than 18V, the minimum voltage of the test shall be the lesser of two times the maximum charge voltage of the battery or 22V.

(b) When the manufacturer’s recommended charge voltage is more than 18V, the minimum voltage of the test shall be 1.2 times the maximum charge voltage.

Tests are to be conducted at ambient temperature; the duration of the test shall be 24 hours.

Rechargeable batteries meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.

充电电流必须是制造商建议的最大持续充电电流的两倍。试验的最小电压如下：

(a) 制造商建议的充电电压不大于 18 伏时，试验的最小电压应是电池组最大充电电压的两倍或 22 伏两者中的较小者；

(b) 制造商建议的充电电压大于 18 伏时，试验的最小电压应为最大充电电压的 1.2 倍。

试验应在环境温度下进行，进行试验的时间应为 24 小时。

要求充电电池组在试验过程中和试验后 7 天内无解体，无起火。

T.8 Forced discharge 强制放电

Each cell shall be forced discharged at ambient temperature by connecting it in series with a 12V D.C. power supply at an initial current equal to the maximum discharge current specified by the manufacturer.

The specified discharge current is to be obtained by connecting a resistive load of the appropriate size and rating in series with the test cell. Each cell shall be forced discharged for a time interval (in hours) equal to its rated capacity divided by the initial test current (in ampere).

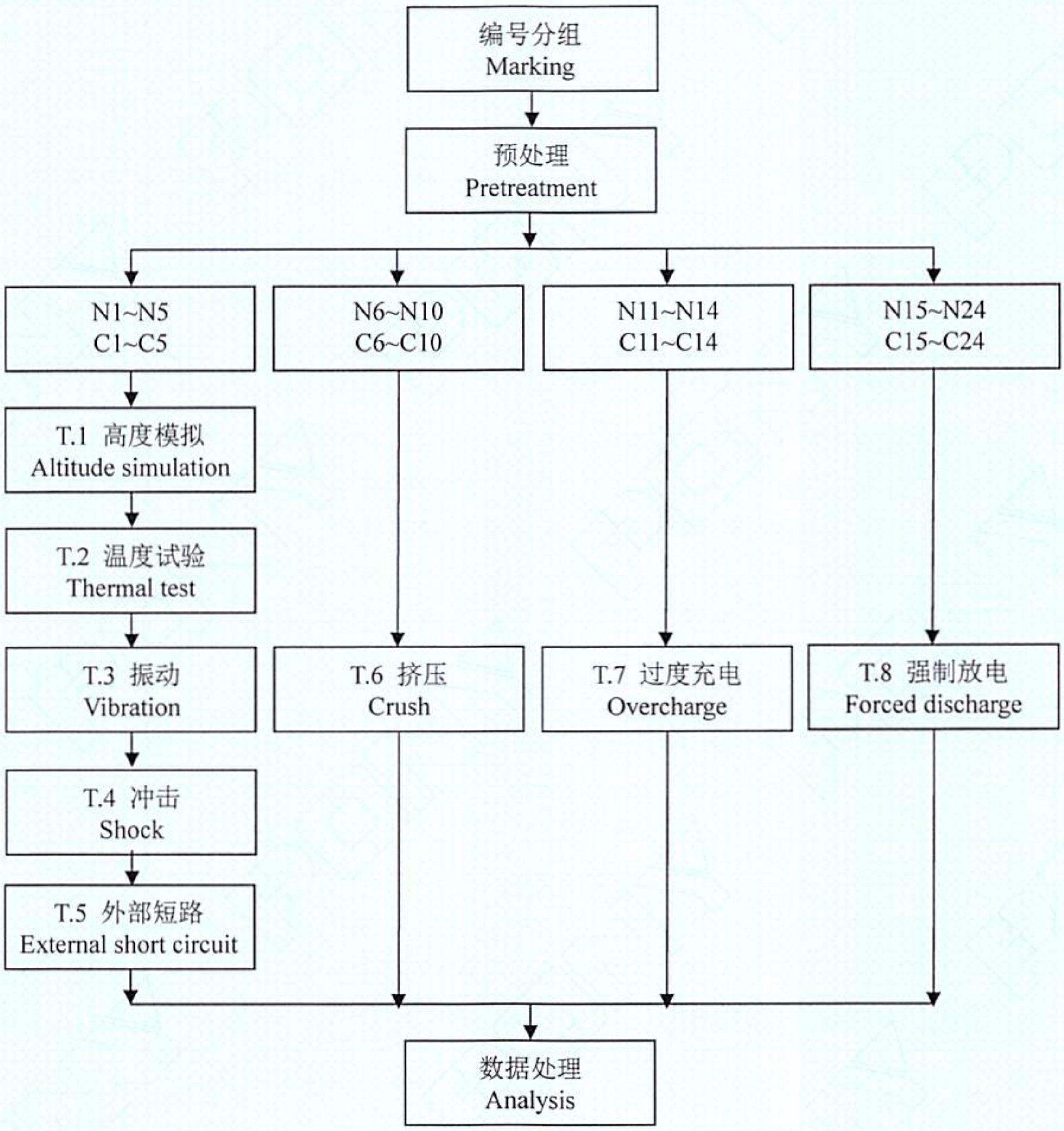
Primary or rechargeable cells meet this requirement if there is no disassembly and no fire during the test and within seven days after the test.

每个电池应在环境温度下与 12 伏直流电电源串联在起始电流等于制造商给定的最大放电电流的条件下强制放电。

将适当大小和额定值的电阻负荷与试验电池串联，计算得出给定的放电电流。对每个电池进行强制放电，放电时间（小时）应等于其额定容量除以初始试验电流（安培）。

要求原电池或充电电池在试验过程中和试验后 7 天内无解体，无起火。

Ⅵ、测试程序 Test Procedure



Ⅶ、测试设备 Test Apparatus

IE-0121	高精度电池测试系统	High precision battery test system
IE-0434	真空干燥箱	Vacuum drying oven
IE-0090	万用表	Multimeter
IE-0824	高原空盒气压表	Tableland air pressure gauge
IE-0259	电子天平	Electronic balance
IE-0128	电动振动试验系统	Electric vibration test system
IE-0664	气动垂直冲击试验台	Pneumatic vertical impact testing platform
IE-0281	温控短路试验机	Temperature controlled short circuit testing machine
IE-0185	数字温度表(电热偶)	The digital thermometer (TC)
IE-0568	多功能数字式毫欧计	Multi-function digital milliohmmeter
IE-0985	电池挤压/针刺试验机	Battery crush /needle testing machine
IE-0511	可程控直流电源	Programmable DC power source
IE-0512	可程控直流电源	Programmable DC power source
IE-1413	防爆高低温快速温变试验箱	Explosion-proof high and low temperature rapid temperature change test chamber

Ⅷ、测试数据 Test Data

T.1 高度模拟 Altitude simulation

编号 No.	测试前 Pre-test		测试后 After test		质量亏损 Mass loss (%)	电压亏损 Voltage loss (%)	有无泄露，排气，解体，破裂和起火 Whether leakage, venting, disassembly, rupture, fire (Yes/No)
	质量 Mass (g)	电压 Voltage (V)	质量 Mass (g)	电压 Voltage (V)			
N1	5.411	4.186	5.408	4.184	0.055	0.048	无 (No)
N2	5.442	4.186	5.439	4.184	0.055	0.048	无 (No)
N3	5.424	4.184	5.421	4.182	0.055	0.048	无 (No)
N4	5.436	4.183	5.434	4.181	0.037	0.048	无 (No)
N5	5.435	4.185	5.432	4.183	0.055	0.048	无 (No)
C1	5.441	4.186	5.438	4.184	0.055	0.048	无 (No)
C2	5.422	4.182	5.419	4.180	0.055	0.048	无 (No)
C3	5.419	4.181	5.417	4.180	0.037	0.024	无 (No)
C4	5.431	4.184	5.429	4.182	0.037	0.048	无 (No)
C5	5.444	4.186	5.442	4.184	0.037	0.048	无 (No)

T.2 温度试验 Thermal test

编号 No.	测试前 Pre-test		测试后 After test		质量亏损 Mass loss (%)	电压亏损 Voltage loss (%)	有无泄露，排气，解体，破裂和起火 Whether leakage, venting, disassembly, rupture, fire (Yes/No)
	质量 Mass (g)	电压 Voltage (V)	质量 Mass (g)	电压 Voltage (V)			
N1	5.408	4.184	5.402	4.091	0.111	2.223	无 (No)
N2	5.439	4.184	5.435	4.091	0.074	2.223	无 (No)
N3	5.421	4.182	5.417	4.086	0.074	2.296	无 (No)
N4	5.434	4.181	5.429	4.092	0.092	2.129	无 (No)
N5	5.432	4.183	5.426	4.088	0.110	2.271	无 (No)
C1	5.438	4.184	5.434	4.090	0.074	2.247	无 (No)
C2	5.419	4.180	5.414	4.092	0.092	2.105	无 (No)
C3	5.417	4.180	5.411	4.094	0.111	2.057	无 (No)
C4	5.429	4.182	5.425	4.093	0.074	2.128	无 (No)
C5	5.442	4.184	5.436	4.091	0.110	2.223	无 (No)

T.3 振动 Vibration

编号 No.	测试前 Pre-test		测试后 After test		质量亏损 Mass loss (%)	电压亏损 Voltage loss (%)	有无泄露，排气，解体，破裂和起火 Whether leakage, venting, disassembly, rupture, fire (Yes/No)
	质量 Mass (g)	电压 Voltage (V)	质量 Mass (g)	电压 Voltage (V)			
N1	5.402	4.091	5.402	4.090	0.000	0.024	无 (No)
N2	5.435	4.091	5.435	4.091	0.000	0.000	无 (No)
N3	5.417	4.086	5.417	4.085	0.000	0.024	无 (No)
N4	5.429	4.092	5.428	4.092	0.018	0.000	无 (No)
N5	5.426	4.088	5.426	4.088	0.000	0.000	无 (No)
C1	5.434	4.090	5.434	4.088	0.000	0.049	无 (No)
C2	5.414	4.092	5.414	4.092	0.000	0.000	无 (No)
C3	5.411	4.094	5.411	4.093	0.000	0.024	无 (No)
C4	5.425	4.093	5.424	4.092	0.018	0.024	无 (No)
C5	5.436	4.091	5.436	4.091	0.000	0.000	无 (No)

T.4 冲击 Shock

编号 No.	测试前 Pre-test		测试后 After test		质量亏损 Mass loss (%)	电压亏损 Voltage loss (%)	有无泄露，排气，解体，破裂和起火 Whether leakage, venting, disassembly, rupture, fire (Yes/No)
	质量 Mass (g)	电压 Voltage (V)	质量 Mass (g)	电压 Voltage (V)			
N1	5.402	4.090	5.402	4.090	0.000	0.000	无 (No)
N2	5.435	4.091	5.435	4.091	0.000	0.000	无 (No)
N3	5.417	4.085	5.417	4.085	0.000	0.000	无 (No)
N4	5.428	4.092	5.428	4.092	0.000	0.000	无 (No)
N5	5.426	4.088	5.426	4.087	0.000	0.024	无 (No)
C1	5.434	4.088	5.434	4.088	0.000	0.000	无 (No)
C2	5.414	4.092	5.414	4.092	0.000	0.000	无 (No)
C3	5.411	4.093	5.411	4.093	0.000	0.000	无 (No)
C4	5.424	4.092	5.424	4.092	0.000	0.000	无 (No)
C5	5.436	4.091	5.436	4.090	0.000	0.024	无 (No)

T.5 外部短路 External short circuit

编号 No.	最高温度 Peak temperature (℃)	有无解体，破裂，起火 Whether disassembly, rupture, fire (Yes/No)
N1	57.4	无 (No)
N2	57.6	无 (No)
N3	57.5	无 (No)
N4	57.1	无 (No)
N5	57.3	无 (No)
C1	57.1	无 (No)
C2	57.6	无 (No)
C3	57.5	无 (No)
C4	57.9	无 (No)
C5	57.3	无 (No)

T.6 挤压 Crush

编号 No.	测试前电压 Pre-test Voltage (V)	最高温度 Peak temperature (℃)	有无解体，起火 Whether disassembly, fire (Yes/No)
N6	3.862	24.0	无 (No)
N7	3.865	23.8	无 (No)
N8	3.861	24.1	无 (No)
N9	3.864	23.9	无 (No)
N10	3.862	24.2	无 (No)
C6	3.866	23.7	无 (No)
C7	3.864	23.8	无 (No)
C8	3.862	24.0	无 (No)
C9	3.861	24.2	无 (No)
C10	3.865	23.9	无 (No)

T.7 过度充电 Overcharge

编号 No.	测试前电压 Pre-test Voltage (V)	有无解体，起火 Whether disassembly, fire (Yes/No)
N11	4.186	无 (No)
N12	4.184	无 (No)
N13	4.185	无 (No)
N14	4.186	无 (No)
C11	4.182	无 (No)
C12	4.184	无 (No)
C13	4.186	无 (No)
C14	4.185	无 (No)

T.8 强制放电 Forced discharge

编号 No.	测试前电压 Pre-test Voltage (V)	有无解体，起火 Whether disassembly, fire (Yes/No)
N15	3.446	无 (No)
N16	3.443	无 (No)
N17	3.457	无 (No)
N18	3.455	无 (No)
N19	3.450	无 (No)
N20	3.448	无 (No)
N21	3.449	无 (No)
N22	3.452	无 (No)
N23	3.446	无 (No)
N24	3.447	无 (No)
C15	3.456	无 (No)
C16	3.451	无 (No)
C17	3.454	无 (No)
C18	3.453	无 (No)
C19	3.452	无 (No)
C20	3.449	无 (No)
C21	3.445	无 (No)
C22	3.456	无 (No)
C23	3.450	无 (No)
C24	3.453	无 (No)

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The original report which report No. is MSISKM0G5463867U5 be replaced by this report, and it will be canceled immediately and doesn't have any legal validity. Please compliance with this report. 2024-02-01

报告结束 End of report