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General specification of lithium-ion battery for cellular phone

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Preface

This specification refers to GB/T 15844.2-1995 Environmental Requirements and Test Methods for Radio Transceiver Employing F3E Emission Used in the Mobile Services for the compilation of some terms. It incorporates related requirements in IEC 61960 (draft), which is adapted for international trade. This Standard also addresses the requirements for the technical properties and application scenarios of Lithium-ion battery for cellular phone, which will further facilitate the development of Lithium-ion battery for cellular phone.

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General Specification of Lithium-ion Battery for Cellular Phone

1 Scope

This Standard specifies the definition, requirements, test method, quality evaluation procedure and mark, packaging, transportation, and storage of Lithium-ion battery for cellular phone.

This Standard is applied for Lithium-ion battery for cellular phone (hereinafter referred to as the “battery”).

2. Quoted Standards

The following standards contribute the stipulations of the specification after being quoted. At the release of this specification, the illustrated versions are valid. All standards will be revised. Users are encouraged to explore the possibility to use the latest version of the specifications.

GB191-1990 Packaging – Pictorial Markings for Handling of Goods;

GB/T 2828-1987 Sampling Procedures and Tables for Lot-by-Lot Inspection by Attributes (Apply to Inspection of Successive Lots of Batches);

GB/T 2829-1987 Sampling Procedures and Tables for Periodic Inspection by Attributes (Apply to Inspection of Stability for Productive Process);

GB/T 2900.11-1988 Terminology of (Secondary) Cell or Battery (eqv IEC 60486:1986)

3 Definition

This Standard uses the terms defined in GB/T 2900.11 and the following definitions.

3.1 Lithium-ion Battery for Cellular Phone

It refers to the battery composed of one or more lithium-ion single battery and accessories, which is used for cellular phone.

3.2 Limited Charge Voltage

The factory voltage when the battery is switched from constant current charging to constant voltage charging.

3.3 Rated Capacity

The battery capacity indicated by the manufacturer, which refers to the electricity required for 5h discharge to cut-off voltage at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$, which is expressed as C_5 in Ah (ampere hour) or mAh.

3.4 Nominal Voltage

It is used to indicate approximate value of battery voltage.

3.5 Cut-off Voltage

It is the define load voltage of the battery when discharge is complete, value being $n \times 2.75\text{V}$ (number of single lithium-ion batteries in series is indicated with “n”. The same below).

4 Requirements

4.1 Appearance

a) The outer surface of the battery shall be clean without mechanical damage, contact element being corrosion-free; b) There shall be necessary product ID on the battery surface (see Section 7.1); c) Match cellular phone or simulation tester, and it shall operate normally after power-on with reliable buckle.

4.2 Discharge Performance at 20°C

4.2.1 Discharge performance at $0.2C_5\text{A}$

The battery shall perform discharging as defined in section 5.3.2.3 and the discharging time shall be no less than 5h.

4.2.1 Discharge performance at 1C₅A

The battery shall perform discharging as defined in section 5.3.2.4 and the discharging time shall be no less than 51min.

4.3 High-temperature Performance

The battery shall perform discharging at 55°C±2°C as defined in section 5.3.3, and the discharging time shall be no less than 51min. There shall be no deformation or cracks on the appearance of the battery.

4.4 Low-temperature Performance

The battery shall perform discharging at -20°C±2°C as defined in section 5.3.4, and the discharging time shall be no less than 3h. There shall be no deformation or cracks on the appearance of the battery.

For polymer lithium-ion battery, the battery shall perform discharging at -10°C±5°C as defined in section 5.3.5, and the discharging time shall be no less than 3.5h. There shall be no deformation or cracks on the appearance of the battery.

4.5 Charge Retention Capacity

The battery shall be tested as defined in section 5.3.5 and the discharging time shall be no less than 4.25h.

4.6 Cycle Life

The battery shall be tested as defined in section 5.3.6 and the cycle life shall be no less than 300 times.

4.7 Environment Adaptability

4.7.1 Constant hydrothermal properties

After the battery is tested as defined in section 5.3.7.1, there shall be no obvious deformation, corrosion, smoking or explosion on the appearance of the battery. The discharging time shall be no less than 36min.

4.7.2 Vibration

Battery is tested according to section 5.3.7.2, and there shall be no obvious damage, leakage, smoking or explosion on the appearance of the battery. The battery voltage shall not be less than $n \times 3.6V$.

4.7.3 Collision

Battery is tested according to section 5.3.7.3, and there shall be no obvious damage, leakage, smoking or explosion on the appearance of the battery. The battery voltage shall not be less than $n \times 3.6V$.

4.7.4 Free fall

Battery is tested as defined in section 5.3.7.4, and there shall be no leakage, smoking or explosion of the battery which can be inserted into the cellular phone with reliable buckle. The discharging time shall be no less than 51min.

4.8 Safety Protection Performance

4.8.1 Overcharge protection

Battery is tested as defined in section 5.3.8.1, and the battery shall not explode, ignite, smoke or leak.

4.8.2 Over-discharge protection

Battery is tested as defined in section 5.3.8.2, and the battery shall not explode, ignite, smoke or leak.

4.8.3 Short-circuit protection

Battery is tested as defined in section 5.3.8.3, and the battery shall not explode, get on fire, smoke or leak. After instantaneous charge, the battery voltage shall not be less than $n \times 3.6V$.

4.9 Battery Safety Requirements

This test is required to simulate the potential safety problems in case of battery misuse or abuse.

4.9.1 Heavy impact

Battery is tested as defined in section 5.3.9.1, and it shall not ignite or explode.

4.9.2 Thermal shock

Battery is tested as defined in section 5.3.9.2, and it shall not ignite or explode.

4.9.3 Overcharge

Battery is tested as defined in section 5.3.9.3, and it shall not ignite or explode.

4.9.4 Short-circuit

Battery is tested as defined in section 5.3.9.4, and it shall not ignite or explode, and the external temperature of the battery shall not exceed 150°C.

4.10 Storage

Store the battery for 12 months. After fully charged, the discharging time at 0.2C₅A shall be no less than 4h.

5 Test Method

5.1 Test Conditions

Unless otherwise specified, tests in this Standard shall be performed under standard atmospheric conditions:

Temperature: 15°C-35°C;

Relative humidity: 45% to 75%;

Atmospheric pressure: 86kPa~106 kPa.

5.2 Requirements for Tester and Equipment

5.2.1 The accuracy of the voltage meter shall not be lower than 0.5 level, and internal resistance shall be no less than 10kΩ/V.

5.2.2 The accuracy of the current meter shall not be lower than 0.5 level.

5.2.3 The accuracy of the time meter shall not be less than $\pm 0.1\%$.

5.2.4 The accuracy of the meter for temperature measurement shall not be lower than $\pm 0.5^\circ\text{C}$.

5.2.5 The current of constant current source is constantly adjustable with current fluctuation within $\pm 0.1\%$ during charging or discharging.

5.2.6 Voltage of constant voltage source is adjustable with voltage fluctuation within $\pm 0.5\%$.

5.3 Test Method

5.3.1 Appearance

Visually inspect the appearance of the battery under test, and check the matching of battery with cellular phone or simulation equipment. It shall comply with section 4.1.

5.3.2 Discharge performance at 20°C

5.3.2.1 Pre-cycle

Charge at 0.2C₅A at an ambient temperature of 20°C $\pm$ 5°C. When the voltage at battery side reaches limited charge voltage, lay it aside for 0.5h-1h, and then discharge it at 0.2C₅A to cut-off voltage.

5.3.2.2 Charging mode

Battery can be charged in one of the following schemes:

a) Charge it at 0.2C₅A at an ambient temperature of 20°C $\pm$ 5°C. When the voltage at the battery side reaches limited charge voltage, switch it to constant voltage charging until the

charging current is less than or equal to $0.01C_5A$ with the maximum charging duration no more than 8h, and stop charging. This charging mode is the arbitration charging mode of the test.

b) Charge it at $1C_5A$ at an ambient temperature of $20^{\circ}C \pm 5^{\circ}C$. When the voltage at the battery side reaches limited charge voltage, switch it to constant voltage charging until the charging current is less than or equal to $0.01C_5A$ with the maximum charging duration no more than 8h, and stop charging.

5.3.2.3 Discharge performance at $0.2C_5A$

After charge the battery as defined in section 5.3.2.2, lay it aside for 0.5h -1h. Then discharge it to cut-off voltage at $0.2C_5A$ at an ambient temperature of $20^{\circ}C \pm 5^{\circ}C$.

The above test can be repeated for 5 times, and when the battery capacity meets the definition in section 4.2.1 in one cycle, the test may be terminated.

5.3.2.4 Discharge performance at $1C_5A$

After charge the battery as defined in section 5.3.2.2, lay it aside for 0.5h -1h. Then discharge it to cut-off voltage at $1C_5A$ at an ambient temperature of $20^{\circ}C \pm 5^{\circ}C$.

5.3.3 High-temperature performance

After completing battery charging as defined in section 5.3.2.2, put the battery into high-temperature box of $55^{\circ}C \pm 2^{\circ}C$, and keep constant temperature for 2hs. Then discharge it to cut-off voltage at $1C_5A$, and the discharging time shall comply with the specification in section 4.3. After concluding the test, take out the battery and keep it at an ambient temperature of $20^{\circ}C \pm 5^{\circ}C$ for 2hs, then visually inspect battery appearance. It shall comply with the definition in section 4.3

5.3.4 Low-temperature performance

After completing battery charging as defined in section 5.3.2.2, put the battery into low-temperature box of $-20^{\circ}\text{C}\pm 2^{\circ}\text{C}$, and keep constant temperature for 16hs - 24hs. Then discharge it to cut-off voltage at $0.2C_5A$, and the discharging time shall comply with the specification in section 4.4. After concluding the test, take out the battery and keep it at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for 2hs, then visually inspect battery appearance. It shall comply with the definition in section 4.4

For polymer lithium-ion battery, after the battery is charged as defined in section 5.3.2.2, put the battery into low-temperature box of $-10^{\circ}\text{C}\pm 2^{\circ}\text{C}$, and keep constant temperature for 16hs - 24hs. Then discharge it to cut-off voltage at $0.2C_5A$, and the discharging time shall comply with the definition in section 4.4. After concluding the test, take out the battery and keep it at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for 2hs, then visually inspect battery appearance. It shall comply with the definition in section 4.4

5.3.5 Charge retention capacity

After the battery completes charging as defined in section 5.3.2.2, it is placed at 28d power source in open loop mode at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$. Then the battery is discharged to the cut-off voltage at $0.2C_5A$, and the discharging time shall comply with the specification in section 4.5.

5.3.6 Cycle life

5.3.6.1 The battery cycle life test shall be performed at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$.

5.3.6.2 Charge the battery at $1C_5A$ at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$, and switch to constant voltage charging when the voltage at battery side reaches limited charge voltage until charging current is less than or equal to 20mA. Stop charging, and lay it aside for 0.5h – 1h, then discharge it to cut-off voltage at $1C_5A$. After completing discharging, lay it aside for 0.5h – 1h, and perform the next charge/discharge cycle until the duration of 2 successive discharges is less than 36min. it is assumed that the battery life ends. Lifecycle of the battery shall comply with the specification in section 4.6.

5.3.7 Environment Adaptability

5.3.7.1 Constant hydrothermal properties

After completing battery charging as defined in section 5.3.2.2, put the battery in a constant temperature and humidity chamber with $40^{\circ}\text{C}\pm 2^{\circ}\text{C}$ and relative humidity of 90%~95%. After keep it for 48hs, take it out and lay it aside at an ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$ for 2hs. Visually inspect the battery appearance, and it shall comply with the specification in section 4.7.1. Then discharge it to cut-off voltage at $1\text{C}_5\text{A}$, and the discharging time shall comply with the specification in section 4.7.1.

5.3.7.2 Vibration

After the battery is charged according to the definition in section 5.3.2.2, mount the battery directly or through the clamps on the surface of the shaking table. Adjust the testers according to the following vibration frequency and the corresponding amplitude: perform round robin sweep vibration from 10Hz to 55Hz for 30min in each direction of X, Y, and X, and the sweep rate is 1oct/min;

Vibration frequency: 10 Hz – 30 Hz; Shift amplitude (single amplitude): 0.38mm

Vibration frequency: 30 Hz – 55 Hz; Shift amplitude (single amplitude): 0.19mm

After vibration, the battery appearance and battery voltage shall comply with the definition in section 4.7.2.

5.3.7.3 Collision

After the battery is charged according to the definition in section 5.3.7.2, mount the battery directly or through the clamps on the surface of the shaking table along X, Y, and Z axes which are mutually perpendicular. Adjust the acceleration, pulse duration according to the requirements below to perform collision test.

Pulse peak acceleration: 100m/s^2

Collision frequency per minute: 40~80

Pulse duration: 16ms

Collision times: 1000±10

After the collision completes, take the battery from the shaking table, and the battery appearance and battery voltage shall comply with the definition in section 4.7.3.

5.3.7.4 Free fall

After the battery is tested according to the definition in section 5.3.7.3, freely fall the sample battery from the position with height (the lowest height) of 1000mm to the surface of a hardwood board with thickness of 18mm~20mm that is placed on cement floor. Fall freely in each positive and negative directions of X, Y, and Z axes (6 directions) for one time.

After freefall, the battery shall be discharged to cut-off voltage at $1C_5A$. Then perform charge/discharge cycle according to the definition in section 5.3.2.4 until the discharging time complies with the definition in section 4.7.4, i.e. it is allowed to terminate the charge/discharge cycle which shall not be more than 3 times.

5.3.8 Safety protection properties

5.3.8.1 Overcharge protection

After the battery is charged according to the definition in section 5.3.2.2, keep charging the battery with constant current and constant voltage power supply for 8h. The voltage of constant-current and constant-voltage power supply is set to 2 times of nominal voltage, and the current is set to $2C_5A$ external current. The battery shall comply with the definition in section 4.8.1.

5.3.8.2 Over-discharge protection

After the battery is discharged to cut-off voltage at $0.2C_5A$ at an ambient temperature of $20^{\circ}C \pm 5^{\circ}C$, keep discharging for 24h with external $(30 \times n)\Omega$ load, and the battery shall comply with the definition in section 4.8.2.

5.3.8.3 Short-circuit protection

After the battery is charged as defined in section 5.3.2.2, short-circuit the positive and negative poles with 0.1Ω resistor. The battery shall comply with the requirements defined in section 4.8.3.

Disconnect positive and negative poles. After the battery is instantaneously charged for 5s at $1C_5A$, use a voltmeter to measure the battery voltage, which shall comply with the requirements defined in section 4.8.3.

Note: The above safety performance test shall be performed with protective measures.

5.3.9 Battery Safety Requirements

If the single lithium-ion battery being used has passed security authentication or can provide the report that the manufacturer has performed the following 4 security tests, it shall not perform the test defined in this item.

The following tests shall be performed in devices with mandatory ventilation and explosion-proof measures. All batteries shall be charged as defined in section 5.3.2.2 before the test. Leave them without any operation for 24h, and then perform the following tests.

5.3.9.1 Heavy shock

The battery is placed on the shock table, and a 10kg heavy hammer falls from 1m height freely and hit the battery fixed in the clamp (the maximum area of the battery is perpendicular to the table surface), deformation of the battery is allowed but shall be compliant with the requirements in section 4.9.1.

5.3.9.2 Thermal shock

Place the battery in the hotbox, the temperature rises to $150^{\circ}\text{C}\pm 2^{\circ}\text{C}$ at $(5^{\circ}\text{C}\pm 2^{\circ}\text{C})/\text{min}$ and keeps for 30min. The battery shall comply with the requirements defined in section 4.9.2.

5.3.9.3 Overcharge

This test shall be performed after dismantling external protective circuit of the battery.

Place the battery connected with thermocouple in a fume hood, connect the positive and negative poles to a constant-current and constant-voltage power supply, adjust the current to $3C_5A$ and the voltage to $n\times 10V$, then charge the battery at $3C_5A$ until the battery voltage is $n\times 10V$ and the current reduces to close to $0A$. Observe the battery temperature change during the test. When the battery temperature drops to about 10°C lower than the peak, end the test. The battery shall comply with the requirements in Section 4.9.3.

5.3.9.4 Short-circuit

This test shall be performed after dismantling external protective circuit of the battery.

Place the battery connected with thermocouple in a fume hood, make it short-circuited (total resistance of the circuit shall not exceed $50m\Omega$). Observe the battery temperature change during the test. When the battery temperature drops to about 10°C lower than the peak, end the test. The battery shall comply with the requirements in Section 4.9.4.

5.3.10 Storage

For storage test, the battery with the life less than 3 months from production date to test date. Prior to the storage test, charge the battery with $40\%\sim 50\%$ of capacity using the scheme defined in section 5.3.2.2, then store the battery in an environment with the ambient temperature of $20^{\circ}\text{C}\pm 5^{\circ}\text{C}$, and relative humidity of $45\%\sim 85\%$. After the expiry of the storage,

the battery shall be charged/discharged according to section 5.3.2.2. The discharging time shall be compliant with the definition in section 4.10.

6 Quality Evaluation Procedure

6.1 Test Classification

The tests defined in this Standard are classified into:

- a) Certification test;
- b) Quality conformance test.

6.2 Certification Test

Certification test is generally performed when product design and the production is determined. In the event that the major design, process, components and materials have major modification that impacts the major properties of the product, and makes the original certification invalid, certification test is also required.

Table 1 Certification Test

Group Number	Test Item		Requirement Section Number	Test Method Section Number	Number of samples	Number of unqualified batteries allowed
1	Appearance		4.1	5.3.1	24	0
	Discharge performance at 0.2C ₅ A		4.2.1	5.3.2.3		
2	Discharge performance at 1C ₅ A		4.2.2	5.3.2.4	3	
	High-temperature Performance		4.3	5.3.3		
	Low-temperature Performance		4.4	5.3.4		
3	Charge retention capacity		4.5	5.3.5	3	
4	Environment Adaptability	Constant hydrothermal properties	4.7.1	5.3.7.1	3	
		Vibration	4.7.2	5.3.7.2		
		Collision	4.7.3	5.3.7.3		
		Free fall	4.7.4	5.3.7.4		
5	Safety Protection Performance	Overcharge protection property	4.8.1	5.3.8.1	3	

		Over-discharge protection property	4.8.2	5.3.8.2		
		Short-circuit protection property	4.8.3	5.3.8.3		
6	Battery Safety Requirements	Heavy shock	4.9.1	5.3.9.1	3	
		Thermal shock	4.9.2	5.3.9.2	3	
		Overcharge	4.9.3	5.3.9.3	3 ¹⁾	
		Short-circuit	4.9.4	5.3.9.4	3 ²⁾	
7	Cycle Life		4.6	5.3.6	3	
8	Storage		4.10	5.3.10	3	

1) Refer to the battery that has performed group 2 test.

2) Refer to the battery that has performed group 5 test.

6.2.1 Sampling Scheme

Samples for certification test are produced with the same material, equipment and craftsmanship as normal production and selected at random. See table 1 for quantity of samples.

6.2.2 Test Items

Items, sequence and grouping for certification test are compliant with the definition in Table 1.

6.2.3 Criteria

It is assumed "compliant" when all test items meet the requirements. If any item is not compliant with the specified requirements, the test shall be pended, and the manufacturer shall analyze the unqualified item. Continue with the test after the cause for incompliance is found out and corrective measures are taken. It will be assumed "compliant" if it is compliant in re-test; if there is any item incompliant with the specified requirements during re-testing, it shall be assumed "incompliant".

6.3 Quality Conformance Test

The quality conformance test of batteries is classified into lot-by-lot test and periodic test to determine whether the product quality can be successfully and continuously stable during production.

6.3.1 Lot-by-lot Test

6.3.1.1 Samples for the test are selected at random from products for examination by using the one-time sampling scheme for normal inspection in GB/T 2828. The test items, test methods, inspection level (IL) and Accepted Quality Level (AQL) shall refer to table 2.

Table 2 Lot-by-lot Test

Group Number	Test Item	Requirement Section Number	Test Method Section Number	IL	AQL
1	Appearance	4.1	5.3.1	I	4.0
2	Discharge performance at 0.2C ₅ A	4.2.1	5.3.2.3	S-3	2.5
	Discharge performance at 1C ₅ A	4.2.2	5.3.2.4		

6.3.1.2 After lot-by-lot test, dispose the products in compliance with the definition in section 4.12 in GB/T 2828-1987.

6.3.2 Periodic Test

6.3.2.1 Samples for periodic test are selected at random from the products qualified in the lot-by-lot inspection by using the one-time sampling scheme defined in GB/T 2829. The test items, sequence and grouping, requirements, test methods, sampling period, DL, RQL and assessment group (A_CR_C) shall refer to table 3.

Table 3 Periodic Test

Group Number	Test Item	Requirement Section Number	Test Method Section Number	Sampling Period	DL	RQL(A _C R _e)
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1	High-temperature performance		4.3	5.3.3	90d	I	20(0 1)
	Low-temperature performance		4.4	5.3.4			
2	Charge retention capacity		4.5	5.3.5			
3	Environment adaptability	Constant hydrothermal properties	4.7.1	5.3.7.1	0.5a		15(0 1)
		Vibration	4.7.2	5.3.7.2			
		Collision	4.7.3	5.3.7.3			
		Free fall	4.7.4	5.3.7.4			
4	Safety protection properties	Overcharge protection property	4.8.1	5.3.8.1			20(0 1)
		Over-discharge protection property	4.8.2	5.3.8.2			
		Short-circuit protection property	4.8.3	5.3.8.3			
5	Battery safety requirements	Heavy shock	4.9.1	5.3.9.1			
		Thermal shock	4.9.2	5.3.9.2			
		Overcharge	4.9.3	5.3.9.3			
		Short-circuit	4.9.4	5.3.9.4			
6	Cycle life		4.6	5.3.6	1a		
7	Storage		4.10	5.3.10			

6.3.2.2 After periodic test, dispose the products in compliance with the definition in section 4.12 in GB/T 2829-1987.

7 Mark, Packaging, Transportation, and Storage

7.1 Mark

There shall be the following marks in Chinese on each battery: product name, model, nominal voltage, rated capacity, limited charge voltage, implementation standard number, positive and negative polarities, manufacturing date or batch number, manufacturer name, trademark and warning instructions, where it is allowed that the implementation standard number, factory address, postcode and telephone number be identified in the packaging or instruction manual.

7.2 Packaging

Each battery shall have external packing, and instruction manual of the product shall be attached in the packaging. The packaged products shall be placed in dry, dust-proof and moisture-proof packing boxes.

Product name, model, quantity, gross weight, manufacturer, date of production shall be indicated at the outside of the packing box. There shall be necessary marks like “Handle with care”, “Keep dry”, and “Keep upward”, and its pictorial markings for packaging storage shall be compliant with the definition in GB 191.

7.3 Transportation

Batteries shall be packed into boxes for transportation. Batteries shall be prevented from severe vibration, shock or extrusion, and sun and rain during transportation, and truck, railway, ship and airplane can be used for transportation.

7.4 Storage

Battery shall be stored in clean, dry and ventilated room with an ambient temperature of $-5^{\circ}\text{C}\sim 35^{\circ}\text{C}$, and relative humidity of no more than 75%, prevented from contact with corrosive substances, and kept away from fire or heat.
