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(BAJ/JSA)

**Safety requirements for portable sealed
secondary cells, and for batteries made
from them, for use in portable
applications — Part 2: Lithium systems**

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Contents

	Page
Introduction	1
1 Scope	1
2 Normative references	1
3 Terms and definitions	2
4 Parameter measurement tolerances	6
5 General safety considerations	7
5.1 General	7
5.2 Insulation and wiring	7
5.3 Venting	8
5.4 Temperature, voltage and current management	8
5.5 Terminal contacts	8
5.6 Assembly of secondary cells into secondary batteries	8
5.7 Quality plan	10
5.8 Battery safety components	10
6 Test items and sample size	10
7 Specific requirements and tests	13
7.0A General	13
7.1 Charging procedures for test purposes	13
7.2 Intended use	14
7.3 Reasonably foreseeable misuse	16
8 Information for safety	26
8.1 General	26
8.2 Small secondary cell and battery safety information	27
9 Marking	28
9.1 Secondary cell marking	28
9.2 Secondary battery marking	28
9.3 Caution for ingestion of small secondary cells and batteries	28
9.4 Other information	28
10 Packaging and transport	29
Annex A (normative) Charging and discharging range of secondary lithium ion cells for safe use	30
Annex B (informative) Recommendations to equipment manufacturers and battery assemblers	52

Annex C (informative)	Recommendations to the end-users (consumers)	53
Annex D (normative)	Measurement of the internal AC resistance for coin cells	55
Annex E (informative)	Packaging and transport	56
Annex F (informative)	Component standards references	57
Annex JA (informative)	Comparison table between JIS and corresponding International Standard	58

Foreword

This Japanese Industrial Standard has been established by the Minister of Economy, Trade and Industry through deliberations at the Japanese Industrial Standards Committee according to the proposal for establishment of Japanese Industrial Standard submitted by Battery Association of Japan (BAJ)/Japanese Standards Association (JSA) with a draft being attached, based on the provision of Article 12, paragraph (1) of the Industrial Standardization Act. This Standard partially replaces **JIS C 8712** : 2015, which has been withdrawn.

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JIS C 62133 series consists of the following 2 parts under the general title *Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications*:

Part 1: Nickel systems

Part 2: Lithium systems

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Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications — Part 2 : Lithium systems

Introduction

This Japanese Industrial Standard has been prepared based on **IEC 62133-2 : 2017**, Edition 1, with some modifications of the technical contents to satisfy technical requirements of the safety standards for electrical appliances in Japan.

In this Standard, subclause numbers followed by a capital letter of Latin alphabet starting with “A” indicate that the subclause includes items not given in the corresponding International Standard.

The vertical lines on both sides and dotted underlines indicate changes from the corresponding International Standard. A list of modifications with the explanations is given in Annex JA.

1 Scope

This Standard specifies requirements and tests for the safe operation of portable sealed secondary lithium cells and batteries, under intended use and reasonably foreseeable misuse.

NOTE The International Standard corresponding to this Standard and the symbol of degree of correspondence are as follows.

IEC 62133-2 : 2017 *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Safety requirements for portable sealed secondary cells, and for batteries made from them, for use in portable applications — Part 2 : Lithium systems* (MOD)

In addition, symbols which denote the degree of correspondence in the contents between the relevant International Standard and **JIS** are IDT (identical), MOD (modified), and NEQ (not equivalent) according to **ISO/IEC Guide 21-1**.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this Standard. The most recent editions of the standards (including amendments) indicated below shall be applied.

JIS C 6065 *Audio, video and similar electronic apparatus — Safety requirements*

JIS C 6950-1 *Information technology equipment — Safety — Part 1 : General requirements*

JIS C 8711 *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Secondary lithium cells and batteries for portable ap-*

plications

NOTE Corresponding International Standard : IEC 61960-3 *Secondary cells and batteries containing alkaline or other non-acid electrolytes — Secondary lithium cells and batteries for portable applications — Part 3 : Prismatic and cylindrical lithium secondary cells and batteries made from them*

JIS C 60068-2-27 *Environmental testing — Part 2-27 : Tests — Test Ea : Shock*

JIS Z 8051 *Safety aspects — Guidelines for their inclusion in standards*

NOTE Corresponding International Standard : ISO/IEC GUIDE 51 *Safety aspects — Guidelines for their inclusion in standards*

IEC 60050-482 *International Electrotechnical Vocabulary — Part 482 : Primary and secondary cells and batteries*

3 Terms and definitions

For the purpose of this Standard, the terms and definitions given in **IEC 60050-482** and **JIS Z 8051**, and the following apply.

3.1

safety

freedom from unacceptable risk

3.2

risk

combination of the probability of occurrence of harm and the severity of that harm

3.3

harm

physical injury or damage to the health of people or damage to property or to the environment

3.4

hazard

potential source of harm

3.5

intended use

use in accordance with information provided with a product or system, or, in the absence of such information, by generally understood patterns of usage

NOTE.....This is a synonym for “normal use”.

3.6

reasonably foreseeable misuse

use of a product or system in a way which is not intended by the supplier, but which may result from readily predictable human behaviour

3.7

secondary cell

basic manufactured unit providing a source of electrical energy by direct conversion of chemical energy, that consists of electrodes, separators, electrolyte, container and terminals, and that is designed to be charged electrically

3.8

secondary battery

assembly of secondary cell(s) ready for use as a source of electrical energy characterized by its voltage, size, terminal arrangement, capacity and discharge performance

3.9

leakage

unplanned, visible escape of liquid electrolyte

3.10

venting

release of excessive internal pressure from a cell or battery in a manner intended by design to preclude rupture or explosion

3.11

rupture

mechanical failure of a cell container or battery case induced by an internal or external cause, resulting in exposure or spillage of materials

3.12

explosion

failure that occurs when a cell container or battery case opens violently and major components are forcibly expelled

3.13

fire

emission of flames from a cell or battery

3.14

(The term of the corresponding International Standard is not adopted.)

3.15

(The term of the corresponding International Standard is not adopted.)

3.16

lithium ion polymer cell

secondary cell using gel polymer electrolyte or solid polymer electrolyte, not liquid electrolyte

3.17

(The term of the corresponding International Standard is not adopted.)

3.18

reference test current, I_t

current specified in 7.1 of JIS C 8711

In this Standard, it refers to current expressed according to the formula $I_t A = C_5$ Ah/1 h corresponding to reference time 5 h.

3.19

upper limit charging voltage

highest charging voltage in the cell operating region, which is specified by the cell manufacturer

3.20

maximum charging current

maximum charging current in the cell operating region, which is specified by the cell manufacturer

3.20A

standard temperature range

temperature range on the surface of a secondary cell which can be charged at upper limit charging voltage and maximum charging current specified by the cell manufacturer

3.20B

lower limit test temperature

ambient temperature used in the test which is performed at the lower limit of standard temperature range

NOTE The lower limit test temperature is specified in Table 2.

3.20C

upper limit test temperature

ambient temperature used in the test which is performed at the upper limit of standard temperature range

NOTE The upper limit test temperature is specified in Table 2.

3.20D

lower limit charging temperature

lower limit value of the surface temperature of a secondary cell in which charging specified by the cell manufacturer is permissible

3.20E

upper limit charging temperature

upper limit value of the surface temperature of a secondary cell in which charging specified by the cell manufacturer is permissible

3.20F

low temperature range

temperature range on the surface of a secondary cell in which charging is permissible by changing maximum charging current and/or upper limit charging voltage, of which the upper limit is adjacent to standard temperature range and the lower limit is lower limit charging temperature

3.20G

high temperature range

temperature range on the surface of a secondary cell in which charging is permissible by changing maximum charging current and/or upper limit charging voltage, of which the lower limit is adjacent to standard temperature range and the upper limit is upper limit charging temperature

3.21

coin cell, coin battery

small round secondary cell or battery in which the overall height is less than the diameter

3.22

cylindrical cell

secondary cell with a cylindrical shape in which the overall height is equal to or greater than the diameter

3.23

prismatic cell

secondary cell having the shape of a parallelepiped whose faces are rectangular

NOTE Prismatic cells include those with curved surfaces and secondary cells in laminated film containers.

3.24

cell block

arrangement of multiple secondary cells wherein all the positive terminals and all the negative terminals, respectively, are connected together

3.24A

protection element

current control (cutoff) element such as a PTC element and fuse

This element blocks energization and prevents a cell explosion or fire when cell temperature becomes unusually high.

3.24B**protection circuit**

electronic circuit with the function to detect the overvoltage at the time of overcharging and to suspend charging, the function to suspend discharging at the time of low voltage due to overdischarging, the function to prevent the charge and discharge of excessive current, the function to detect temperature and to control operation, etc.

3.24C**secondary battery with special structure**

secondary battery to be used by fixing to an electronic device in a state where it cannot be easily removed by soldering and other joining methods, secondary battery of which the terminal arrangement is not fixed, or secondary battery without a battery container with the sufficient strength which can hold parts

These secondary batteries are not designed to be replaced by the user (consumer).

3.25**functional safety**

part of the overall safety that depends on functional and physical units operating correctly in response to their inputs

3.26**end-of-discharge voltage, final voltage**

specified voltage of a battery at which the discharge of a cell or battery is terminated

NOTE The final voltage shall be specified by the manufacturer.

3.26A**model**

group of products in which material, parts, their amount used, size, arrangement, etc. are similarly designed

4 Parameter measurement tolerances

The overall accuracy of controlled or measured values, relative to the specified or actual parameters, shall be within these tolerances :

- a) ± 1 % for voltage;
- b) ± 1 % for current;
- c) ± 2 °C for temperature;

- d) ± 0.1 % for time;
- e) ± 0.1 mm for dimension;
- f) ± 1 % for capacity ¹⁾.

Note ¹⁾ Capacity is expressed as a product of current and time.

These tolerances comprise the combined accuracy of the measuring instruments, the measurement techniques used, and all other sources of error in the test procedure.

The details of the instrumentation used shall be provided in any report of results.

5 General safety considerations

5.1 General

The safety of secondary cells and batteries requires the consideration of two sets of applied conditions :

- intended use;
- reasonably foreseeable misuse.

Secondary cells and batteries shall be so designed and constructed that they are safe under conditions of both intended use and reasonably foreseeable misuse. It is expected that secondary cells or batteries subjected to reasonably foreseeable misuse may fail to function following such experience. They shall not however present significant hazards. It may also be expected that secondary cells and batteries subjected to intended use shall not only be safe but shall continue to be functional in all respects.

Potential hazards which are the subject of this Standard are :

- a) fire,
- b) explosion,
- c) leakage of cell electrolyte,
- d) venting,
- e) fire from excessively high external temperatures,
- f) rupture of battery case with exposure of internal components.

Conformity with 5.2 to 5.8 for secondary cells and batteries other than coin cells, with an internal resistance greater than $3\ \Omega$, is checked by the tests of Clause 7, in accordance with the appropriate standard (see Clause 2) and in accordance with Table 1. The internal resistance of coin cells is to be measured in accordance with Annex D.

5.2 Insulation and wiring

The insulation resistance between the positive terminal and externally exposed metal surfaces of the battery excluding electrical contact surfaces shall be not less than $5\ \text{M}\Omega$ at 500 V DC when measured 60 s after applying the voltage.

Internal wiring and insulation shall be sufficient to withstand the maximum anticipated current, voltage and temperature requirements. The orientation of wiring shall be such that adequate clearances and creepage distances are maintained between conductors. The mechanical strength of internal connections shall be sufficient to accommodate conditions of intended use.

5.3 Venting

Battery cases and secondary cells shall incorporate a pressure relief mechanism or shall be so constructed that they will relieve excessive internal pressure at a value and rate that will preclude rupture, explosion and fire. If encapsulation is used to support secondary cells within an outer case, the type of encapsulant and the method of encapsulation shall neither cause the secondary battery to overheat during normal operation nor inhibit pressure relief.

5.4 Temperature, voltage and current management

The design of secondary batteries shall be such that abnormal temperature-rise conditions are prevented. Secondary batteries shall be designed to be within temperature, voltage and current limits specified by the cell manufacturer.

The cell manufacturer shall provide the information of temperature, voltage and current limits to the battery manufacturer. The battery manufacturer shall provide the information of temperature, voltage and current limits to the equipment manufacturer.

5.5 Terminal contacts

The size and shape of the terminal contacts shall ensure that they can carry the maximum anticipated current. External terminal contact surfaces shall be formed from conductive materials with good mechanical strength and corrosion resistance. Terminal contacts shall be arranged so as to minimize the risk of short circuits.

5.6 Assembly of secondary cells into secondary batteries

5.6.1 General

Each secondary battery shall have an independent control and protection for current, voltage, temperature and any other parameter required for safety and to maintain the secondary cells within their operating region. However this protection may be provided external to the secondary battery such as within the charger or the end devices. If protection is external to the secondary battery, the manufacturer of the battery shall provide this safety relevant information to the charger manufacturer and end device manufacturer for implementation.

If there is more than one secondary battery housed in a single battery case, each secondary battery should have protective circuitry that can maintain the secondary cells within their operating regions.

Manufacturers of cells shall specify current, voltage and temperature limits so that the battery manufacturer/designer may ensure proper design and assembly (see Annex A).

Secondary batteries that are designed for the selective discharge of a portion of their

series connected secondary cells shall incorporate protective circuitry to prevent operation of secondary cells outside the limits specified by the cell manufacturer.

Protective circuit components should be added as appropriate and consideration given to the end-device application. The manufacturer of the battery should provide a safety analysis of the battery safety circuitry with a test report including a fault analysis of the protection circuit under both charging and discharging conditions confirming the compliance.

5.6.2 Design recommendation

The voltage of each secondary cell, or each cell block constituting the secondary battery, ~~shall not exceed~~ the upper limit charging voltage specified in Table 2. ~~However, when there is the function to restrict these charging voltages of each cell or each cell block to not more than the upper limit charging voltage in the portable electronic device side, it shall be confirmed that the upper limit charging voltage is not exceeded in the electronic device side.~~

~~The requirements and recommendations to the battery designer are shown below.~~

- a) For the secondary battery consisting of a single secondary cell or a single cell block, the charging voltage of the secondary cell ~~shall not exceed~~ the upper limit charging voltage specified in Table 2.
- b) For the secondary battery consisting of series-connected plural secondary cells or series-connected plural cell blocks, the voltages of any one of the secondary cells or cell blocks ~~shall not exceed~~ the upper limit charging voltage, specified in Table 2, by monitoring the voltage of every single secondary cell or the single cell blocks.
- c) For the secondary battery consisting of series-connected plural secondary cells or series-connected plural cell blocks, charging ~~shall be stopped~~ when the upper limit charging voltage is exceeded for any one of the single secondary cells or single cell blocks by measuring the voltage of every single secondary cell or the single cell blocks.
- d) For secondary batteries consisting of series-connected plural secondary cells or cell blocks, nominal charge voltage of the charger shall not be counted as an overcharge protection.
- e) For secondary batteries consisting of series-connected plural secondary cells or cell blocks, secondary cells should have closely matched capacities, be of the same design, be of the same chemistry and be from the same manufacturer.
- f) It is recommended that the secondary cells and cell blocks should not be discharged beyond the cell manufacturer's specified final voltage.
- g) For secondary batteries consisting of series-connected secondary cells or cell blocks, cell balancing circuitry should be incorporated into the battery management system.

5.6.3 Mechanical protection for secondary cells and components of secondary batteries

Mechanical protection for secondary cells, cell connections and control circuits within the secondary battery should be provided to prevent damage as a result of intended use and reasonably foreseeable misuse. The mechanical protection can be provided by the battery case or it can be provided by the end product enclosure for those batteries intended for building into an end product.

The battery case and compartments housing cells should be designed to accommodate cell dimensional tolerances during charging and discharging as recommended by the cell manufacturer.

For secondary batteries intended for building into a portable end product, testing with the secondary battery installed within the end product should be considered when conducting mechanical tests.

5.6.3A Prevention of harm from sharp corners

In the secondary cells and batteries, unless functionally necessary, there shall be no uneven corners or sharp corners which may cause harm on the occasion of intended use. When the corners concerned are functionally necessary for the container, joint, etc. of the secondary cells and batteries, structural protective measures shall be taken so that the user (the consumer) may not touch. However, for the secondary cells, or secondary batteries of special structure in which it is not assumed that the user (the consumer) handles, measures may be taken as agreed between the interested parties. Compliance is checked by visual inspection.

5.7 Quality plan

The cell and battery manufacturers shall prepare and implement a quality plan that defines procedures for the inspection of materials, components, secondary cells and secondary batteries and which covers the whole process of producing each type of secondary cell or battery. The cell and battery manufacturers should understand their process capabilities and should institute the necessary process controls as they relate to product safety.

5.8 Battery safety components

For battery safety components, see Annex F.

6 Test items and sample size

Tests are made with the number of secondary cells or batteries specified in Table 1 using secondary cells or batteries that are not more than six months old. The internal resistance of coin cells shall be measured in accordance with Annex D. Coin cells with internal resistance less than or equal to $3\ \Omega$ shall be tested in accordance with Table 1. No test is required for coin cells with internal resistance greater than $3\ \Omega$. Unless otherwise specified, tests are carried out in an ambient temperature of $20\ ^\circ\text{C} \pm 5\ ^\circ\text{C}$.

NOTE The limit of six months is introduced for consistency in testing and does not imply that safety of secondary cell or battery is reduced after six months.

Table 1 Test items, sample size, charging temperature and ambient temperature

Unit: °C

Test item	Secondary cell			Secondary battery			Applicable sub-clause
	Charging temperature	Ambient temperature during test	Number of samples	Charging temperature	Ambient temperature during test	Number of samples	
Continuous charging at constant voltage (secondary cells)	20 ± 5	Upper limit test temperature	5	—	—	—	7.2.1
Battery case stress at high ambient temperature (secondary batteries)	—	—	—	20 ± 5	70 ± 2	3	7.2.2
Temperature cycling	20 ± 5	—	5	20 ± 5	—	5	7.2.2A
External short-circuit (secondary cells)	Upper limit test temperature	55 ± 5	5	—	—	—	7.3.1
	Lower limit test temperature	55 ± 5	5	—	—	—	
External short-circuit (secondary batteries)	—	—	—	20 ± 5	20 ± 5	5	7.3.2
Free fall	20 ± 5	20 ± 5	3	20 ± 5	20 ± 5	3	7.3.3
Thermal abuse (secondary cells)	Upper limit test temperature	130 ± 2	5	—	—	—	7.3.4
	Lower limit test temperature	130 ± 2	5	—	—	—	
Crush (secondary cells)	Upper limit test temperature	20 ± 5	5	—	—	—	7.3.5
	Lower limit test temperature	20 ± 5	5	—	—	—	
Overcharge (secondary batteries)	—	—	—	—	20 ± 5	5	7.3.6

Table 1 (continued)

Unit: °C

Test item	Secondary cell			Secondary battery			Applicable sub-clause
	Charging temperature	Ambient temperature during test	Number of samples	Charging temperature	Ambient temperature during test	Number of samples	
Forced discharge (secondary cells)		20 ± 5	5	—	—	—	7.3.7
Vibration (secondary batteries)	—	—	—	20 ± 5	20 ± 5	5	7.3.8.1
Mechanical shock (secondary batteries)	—	—	—	20 ± 5	20 ± 5	5	7.3.8.2
Low pressure (secondary cells)	20 ± 5	—	3	—	—	—	7.3.8A
High-rate charge (secondary cells)	—	Upper limit test temperature	5	—	—	—	7.3.8B
	—	Lower limit test temperature	5	—	—	—	
Falling of secondary battery installed in a device (secondary batteries)	—	—	—	20 ± 5	20 ± 5	3	7.3.8C
Overcharge protection (secondary batteries)	—	—	—	—	20 ± 5	1	7.3.8D
Forced internal short-circuit (secondary cells) ^{a)}	Upper limit test temperature	Upper limit test temperature	10, 20 ^{b)}	—	—	—	7.3.9
	Lower limit test temperature	Lower limit test temperature	10, 20 ^{b)}	—	—	—	
Measurement of the internal AC resistance for coin cells	—	20 ± 5	3	—	—	—	D.2

Table 1 (concluded)

Notes ^{a)}	Excludes coin cells and lithium ion polymer cells.
b)	When an exposed positive electrode aluminium foil part does not exist in the facing portion of a positive electrode active material layer, the number of required samples is a maximum of 10. When an exposed positive electrode aluminium foil part exists in the facing portion of a positive electrode active material layer, the number of required samples is a maximum of 20.

The safety analysis of **5.6.1** should identify those components of the protection circuit that are critical for short-circuit, overcharge and overdischarge protection. When conducting the short-circuit test, consideration should be given to the simulation of any single fault condition that is likely to occur in the protecting circuit that would affect the short-circuit test.

7 Specific requirements and tests

7.0A General

Tests shall be made with the number of secondary cells or batteries specified in Table 1. Test temperature conditions shall be in accordance with specifications of each test item in Clause 7. These tests may be performed under severe conditions or by the method whereby severe test results are obtained. For secondary cells and batteries, tests shall be performed on each model. When the structure of the secondary battery is partially modified and the test results before the modification can be substituted, the tests specified in this clause may be omitted

7.1 Charging procedures for test purposes

7.1.0A General

The first and second procedures are specified as charging procedures for tests. These charging procedures, however, do not apply to **7.3.6**, **7.3.7**, **7.3.8B** and **7.3.8D** where the charging process is the purpose of the test.

7.1.1 First procedure

Unless otherwise specified in this Standard, the secondary cells and batteries shall be charged in an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, using the method declared by the manufacturer.

Prior to charging, the secondary cell and battery shall have been discharged at an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ at a constant current of $0.2\text{ }I_t\text{ A}$ down to the designed final voltage specified by the manufacturer.

This charging procedure applies to **7.2.1**, **7.2.2**, **7.2.2A**, **7.3.2**, **7.3.3**, **7.3.8.1**, **7.3.8.2**, **7.3.8A** and **7.3.8C**.

7.1.2 Second procedure

After stabilization for 1 h and 4 h, respectively, at ambient temperature of upper limit test temperature and lower limit test temperature, as specified in Table 2, cells are charged by using the upper limit charging voltage and maximum charging current,

until the charging current at the time of constant voltage charge control is reduced to $0.05 I_t$ A.

This charging procedure applies to **7.3.1**, **7.3.4**, **7.3.5** and **7.3.9**.

Table 2 Condition of charging procedure

Upper limit charging voltage	Maximum charging current	Upper limit test temperature	Lower limit test temperature
4.25 V/secondary cell	Specified by the manufacturer of cells	45 °C	10 °C
When the upper limit charging voltage, upper limit test temperature, or lower limit test temperature is newly applied or changed, the cell manufacturer shall keep documents explaining reasons obtained according to the procedure specified in Annex A (see A 3.2.3 and A 4.2.2). The value concerned shall be taken as upper limit charging voltage, upper limit test temperature, or lower limit test temperature.			

WARNING These tests use procedures which may result in harm if adequate precautions are not taken. Tests should only be performed by qualified and experienced technicians using adequate protection. To prevent burns, caution should be taken for those secondary cells or batteries whose casings may exceed 75 °C as a result of testing.

7.2 Intended use

7.2.1 Continuous charging at constant voltage (secondary cells)

- a) **Requirement** A continuous charge at constant voltage shall not cause fire, explosion or leakage.
- b) **Test** Fully charged secondary cells, according to the first procedure in **7.1.1**, are subjected for 28 days to a charge at upper limit charging voltage and upper limit test temperature. After the test, visual inspection shall be performed.
- c) **Acceptance criteria** No fire, no explosion, no leakage.

7.2.2 Battery case stress at high ambient temperature (secondary batteries)

- a) **Requirement** Internal components of batteries shall not be exposed during use at high temperature. This requirement does not apply to secondary batteries with a special structure.
- b) **Test** Fully charged secondary batteries, according to the first procedure in **7.1.1**, are exposed to a high temperature. The secondary battery is placed in an air circulating oven at a temperature of $70\text{ °C} \pm 2\text{ °C}$. The batteries remain in the oven for 7 h, after which they are removed and allowed to return to an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$.
- c) **Acceptance criteria** No physical distortion of the battery case resulting in exposure of internal protective components and secondary cells.

7.2.2A Temperature cycle

The temperature cycle test for secondary cells and batteries shall be as follows.

- a) **Requirements** Repeated exposure to high and low temperatures shall not cause leakage, fire or explosion.
- b) **Test** Fully charged secondary cells or batteries, according to the first procedure in 7.1.1, are subjected to temperature cycling ($-20\text{ }^{\circ}\text{C}$, $+75\text{ }^{\circ}\text{C}$), in forced draught chambers, according to the following procedure and the temperature profile shown in Figure 0A.

Step 1 : Place the secondary cells or batteries in a temperature of $75\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ for 4 h.

Step 2 : Change the temperature to $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ within 30 min and maintain at this temperature for not less than 2 h.

Step 3 : Change the temperature to $-20\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ within 30 min and maintain at this temperature for 4 h.

Step 4 : Change the temperature to $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ within 30 min and maintain at this temperature for not less than 2 h.

Step 5 : Repeat Steps 1 to 4 for a further four cycles. Transition from Step 4 to Step 1 within 30 min.

Step 6 : After the fifth cycle, store the secondary cells or batteries at $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$ for 7 days and then conduct a visual inspection.

NOTE This test can be performed in a single chamber whose temperature is changed or in three separate chambers at three different test temperatures.

- c) **Acceptance criteria** No fire, no explosion, no leakage.

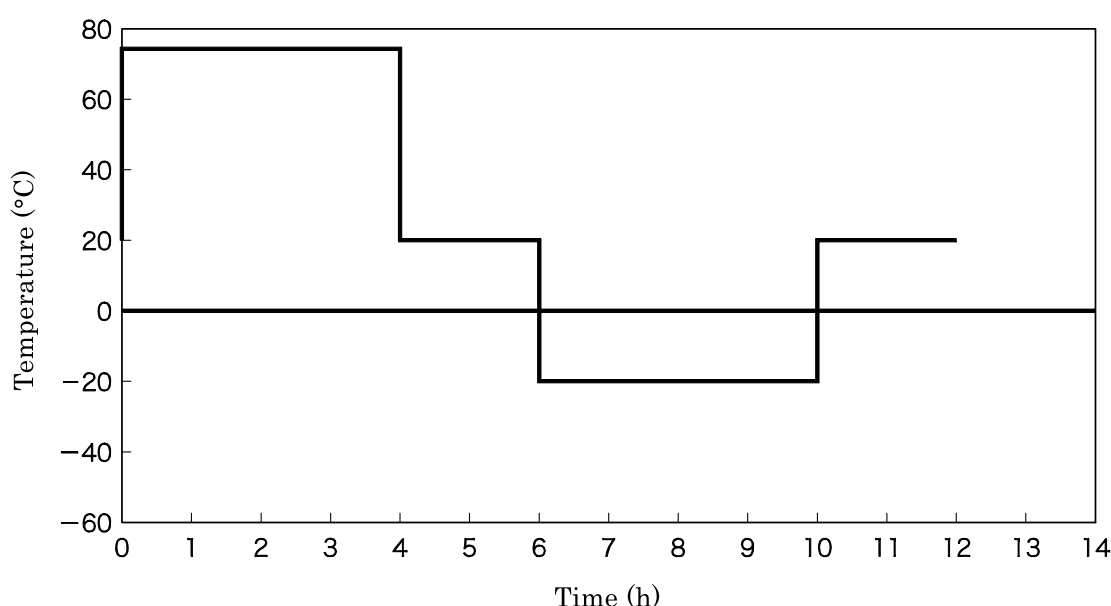


Figure 0A Temperature profile for temperature cycling test (1 cycle)

7.3 Reasonably foreseeable misuse

7.3.1 External short-circuit (secondary cells)

- a) **Requirements** Short-circuiting of the positive and negative terminals shall not cause fire or explosion.
- b) **Test** Fully charged secondary cells, according to the second procedure in 7.1.2, are stored in an ambient temperature of $55\text{ °C} \pm 5\text{ °C}$ for 1 h to 4 h. Each secondary cell is then short-circuited by connecting the positive and negative terminals with a total external resistance of $80\text{ m}\Omega \pm 20\text{ m}\Omega$. The secondary cell remains on test for 24 h or until the surface temperature declines from the maximum temperature by 80 % (down to 20 %) of the maximum temperature rise (difference between the maximum temperature and ambient temperature), whichever is the sooner.
- c) **Acceptance criteria** No fire, no explosion.

7.3.2 External short-circuit (secondary batteries)

- a) **Requirements** Short-circuiting of the positive and negative terminals shall not cause fire or explosion. This requirement does not apply to secondary batteries with a special structure.
- b) **Test** Fully charged secondary batteries, according to the first procedure in 7.1.1, are stored in an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$. Each secondary battery is then short-circuited by connecting the positive and negative terminals with a total external resistance of $80\text{ m}\Omega \pm 20\text{ m}\Omega$. The secondary battery remains on test for 24 h or until the surface temperature declines from the maximum temperature by 80 % (down to 20 %) of the maximum temperature rise (difference between the maximum temperature and ambient temperature), whichever is the sooner. However, in case of a rapid decline in the short-circuit current, the battery should remain on test for an additional one hour after the current reaches a low end steady state condition. This typically refers to a condition where the voltage per series-connected cell or cell block of the battery is below 0.8 V and is decreasing by less than 0.1 V in a 30-min period. A single fault in the discharge protection circuit should be conducted on one to four (depending upon the protection circuit) of the five samples before conducting the short-circuit test. A single fault applies to protective component parts such as MOSFET (metal oxide semiconductor field-effect transistor), fuse, thermostat or positive temperature coefficient (PTC) thermistor.

NOTE Examples of single fault conditions in the discharge protection circuit can include shorting over a discharge MOSFET or over a fuse or other protection elements. Protection elements found to meet the requirements of applicable component standards such as those outlined in Annex F or electronics circuits of which the safe operation is certain to be secured (electronics circuits evaluated for functional safety) are not subject to single fault conditions.

- c) **Acceptance criteria** No fire, no explosion.

7.3.3 Free fall

- a) **Requirements** Dropping a secondary cell or battery (for example, from a bench top) shall not cause fire or explosion. This requirement does not apply to secondary batteries with a mass of more than 7 kg or those with a special structure.
- b) **Test** Fully charged secondary cells or batteries, according to the first procedure in 7.1.1, are stored in an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. Each secondary cell or battery is dropped three times from a height of $1.0\text{ m} \pm 0.01\text{ m}$ onto a flat concrete floor or metal floor. The cells or batteries are dropped so as to obtain impacts in random orientations. After the test, the secondary cell or battery shall be put on rest for a minimum of 1 h and then a visual inspection shall be performed.
- c) **Acceptance criteria** No fire, no explosion.

7.3.4 Thermal abuse (secondary cells)

- a) **Requirements** An extremely high temperature shall not cause fire or explosion.
- b) **Test** Each fully charged secondary cell, according to the second procedure in 7.1.2, is placed in a gravity or circulating air-convection oven, in an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$, for 1 h. The oven temperature is raised at a rate of $5\text{ }^{\circ}\text{C}/\text{min} \pm 2\text{ }^{\circ}\text{C}/\text{min}$ to a temperature of $130\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$. The secondary cell remains at this temperature for 30 min before the test is terminated.
- c) **Acceptance criteria** No fire, no explosion.

7.3.5 Crush (secondary cells)

- a) **Requirements** Severe crushing of a secondary cell shall not cause fire or explosion.
- b) **Test** Each fully charged secondary cell, according to the second procedure in 7.1.2, is crushed between two flat surfaces. The force for the crushing is applied by a crushing apparatus exerting a force of $13\text{ kN} \pm 0.78\text{ kN}$. Once the maximum force has been applied, or an abrupt voltage drop of one-third of the original voltage has been obtained, the force is released. A cylindrical or prismatic secondary lithium cell is crushed with its longitudinal axis parallel to the flat surfaces of the crushing apparatus. Test only the wide side of prismatic secondary lithium cells. A coin cell shall be crushed by applying the force on its flat surface.
- c) **Acceptance criteria** No fire, no explosion.

7.3.6 Overcharge (secondary batteries)

- a) **Requirements** Charging for longer periods than specified by the manufacturer shall not cause fire or explosion. This requirement does not apply to secondary batteries with a special structure.
- b) **Test** The test shall be carried out in an ambient temperature of $20\text{ }^{\circ}\text{C} \pm 5\text{ }^{\circ}\text{C}$. Each secondary battery shall be discharged at a constant current of $0.2\text{ }I_A$ A, to the designed final voltage specified by the manufacturer. Secondary batteries shall then be charged at a constant current of $2.0\text{ }I_t$ A. The supply voltage and power supply shall be as follows.

NOTE Although only “supply voltage” is described in the corresponding International Standard, since the description of “power supply” is included in the third subdivision, “and power supply” is added.

- Use the value of 1.4 times the upper limit charging voltage presented in Table 2 (but not to exceed 6.0 V) for single secondary cell/cell block batteries.
- Use the value of 1.2 times the product of the number of series by the upper limit charging voltage presented in Table 2 for series connected multi-cell batteries.
- Use the power supply sufficient to maintain a constant current of $2.0 I_t$ A throughout the duration of the test or until the supply voltage is reached.

A thermocouple shall be attached to each secondary battery to measure the battery case temperature. The test shall be continued until the temperature of the outer case reaches steady state conditions (less than 10 °C change in a 30-min period) or returns to an ambient temperature of $20\text{ °C} \pm 5\text{ °C}$.

- c) **Acceptance criteria** No fire, no explosion.

7.3.7 Forced discharge (secondary cells)

- a) **Requirements** A secondary cell shall withstand polarity reversal during charging without causing fire or explosion.

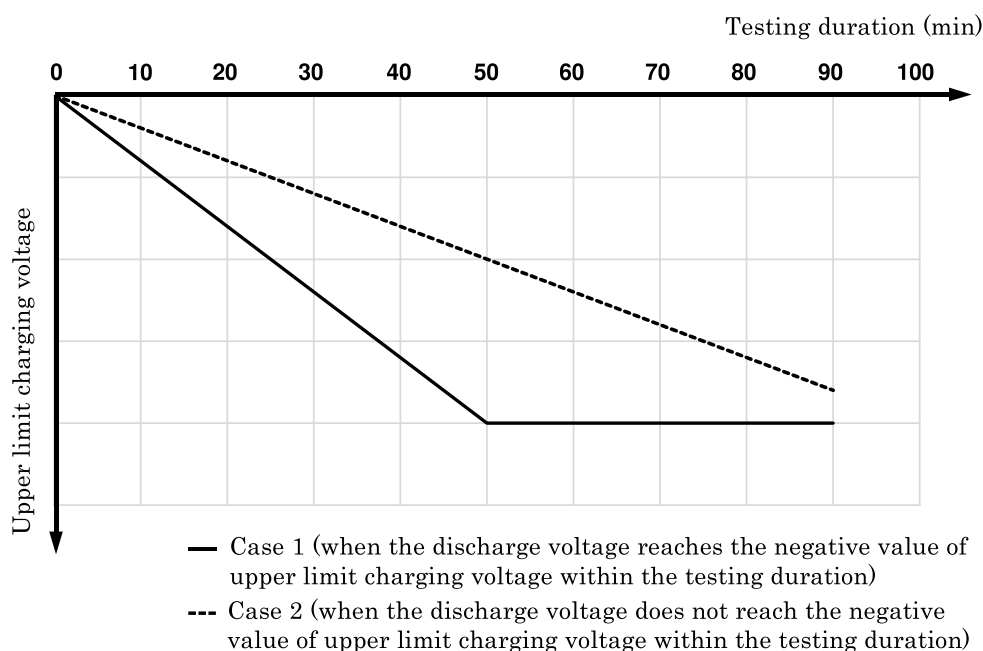
When an electronic device or secondary battery which uses secondary cells has a protection element, it is possible to perform the test in which the protection element concerned is mounted to the secondary cells.

- b) **Test** A secondary cell is discharged to the designed final voltage specified by the cell manufacturer. The discharged cell is then subjected to a reverse charge at $1 I_t$ A for 90 min.

If the discharge voltage reaches the negative value of upper limit charging voltage within the testing duration, the voltage shall be maintained at the negative value of the upper limit charging voltage by reducing the current for the remainder of the testing duration (Case 1 of Figure 1).

If the discharge voltage does not reach the negative value of upper limit charging voltage within the testing duration, the test shall be terminated in 90 min (Case 2 of Figure 1).

- c) **Acceptance criteria** No fire, no explosion.



NOTE The curves shown in Figure 1 are examples of voltage transition.

Figure 1 Example of voltage transition during forced discharge test

7.3.8 Mechanical test (secondary batteries)

7.3.8.1 Vibration (secondary batteries)

- a) **Requirements** Vibration encountered during transportation shall not cause leakage, fire or explosion. This requirement does not apply to secondary batteries with a special structure.
- b) **Test** Fully charged secondary batteries, according to the first procedure in 7.1.1, shall be firmly secured to the platform of the vibration machine without distorting them in such a manner as to faithfully transmit the vibration.

Secondary batteries shall be subjected to sinusoidal vibration according to Table 3. This cycle shall be repeated 12 times for a total of approximately 3 h for each of three mutually perpendicular mounting positions. One of the directions shall be perpendicular to the terminal face.

- c) **Acceptance criteria** No fire, no explosion, no leakage.

Table 3 Conditions for vibration test

Frequency range (Hz)		Ampli- tudes	Duration of logarith- mic sweep cycle (7 Hz – 200 Hz – 7 Hz) (min)	Axis	Number of cycles
from	to				
$f_1 = 7$	f_2	$A_1 = 1\ g_n$	Approximately 15	X	12
f_2	f_3	$S = 0.8\ \text{mm}$		Y	12
f_3	$f_4 = 200$	A_2		Z	12
and back to $f_1 = 7\ \text{Hz}$				Total	36
NOTE Vibration amplitude is the maximum absolute value of displacement or ac- celeration. For example, a displacement amplitude of 0.8 mm corresponds to a peak-to-peak displacement of 1.6 mm.					
Key					
f_1, f_4 : lower or upper frequency					
f_2, f_3 : cross-over frequencies					
— $f_2 \approx 17.62\ \text{Hz}$					
— $f_3 \approx 49.84\ \text{Hz}$					
A_1, A_2 : acceleration amplitude					
— $A_2 = 8\ g_n$					
S : displacement amplitude					
g_n : gravitational acceleration (= 9.806 65 m/s ²)					

7.3.8.2 Mechanical shock (secondary batteries)

- Requirements** Shocks encountered during transportation and use shall not cause fire, explosion or leakage. This requirement does not apply to secondary batteries with a special structure.
- Test** Fully charged secondary batteries, according to the first procedure in 7.1.1, shall be secured to the testing machine by means of a rigid mount which will support all mounting surfaces of each test battery. Each test battery shall be subjected to three shocks in each direction of three mutually perpendicular mounting positions of the battery for a total of 18 shocks. For each shock, the parameters given in Table 4 shall be applied. Waveform, peak acceleration and pulse duration shall be as specified in JIS C 60068-2-27.
- Acceptance criteria** There shall be no leakage, no explosion and no fire during this test.

Table 4 Shock parameters

	Waveform	Peak acceleration	Pulse duration	Number of shocks per half axis
Secondary battery	Half sine	150 g_n	6 ms	3

7.3.8A Low pressure (secondary cells)

- Requirements** Low pressure (for example, during transportation in an aircraft