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NATIONAL STANDARD OF THE
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ICS 29.220.99

CCS K 82

GB/T 42729-2023

Guidelines for safety use of lithium ion cells and batteries

锂离子电池和电池组安全使用指南

Issued on: August 06, 2023

Implemented on: March 01, 2024

Issued by: State Administration for Market Regulation.

Standardization Administration of PRC.

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Guidelines for safety use of lithium ion cells and batteries

1 Scope

This document provides safety guidance and suggestions during the use of lithium-ion cells and battery packs; provides relevant information about possible dangers that lithium-ion cells and battery pack manufacturers provide to users.

This document applies to the use of lithium-ion cells and battery packs.

2 Normative references

This document does not have normative references.

3 Terms and definitions

The following terms and definitions are applicable to this document.

3.1

Lithium ion cell

A device, that relies on the movement of lithium ions between the positive and negative electrodes, to convert chemical energy into electrical energy; it is designed to be rechargeable.

Note: The device includes electrodes, separators, electrolytes, containers, terminals, etc.

3.2

Module

Configurations with multiple cells connected in series or parallel, which may or may not have protective devices [such as fuses or positive temperature coefficient thermistors (PTC)] and monitoring circuits.

[Source: IEC 62619: 2017, 3.9]

3.3

Battery pack

An energy storage device, which is electrically connected by one or more batteries

or modules.

Note 1: It may include protection and monitoring devices, that provide information (such as battery voltage) to the battery system.

Note 2: It may include a protective cover, which is provided by the terminal or other interconnection device.

[Source: IEC 62619: 2017, 3.10]

3.4

Battery protection circuit module; PCM

Battery management unit; BMU

Battery management system; BMS

A circuit board, circuit module or electronic system, which has the core function of controlling the charging and discharging behavior of the battery pack, to protect battery safety.

Note 1: Usually in simple portable product applications, a separate battery protection circuit module is used to protect the battery. In the component modules in complex battery pack systems, the battery management unit is used to manage the batteries in the module. In complex battery pack systems such as new energy vehicle power battery packs, the battery management system is used to manage and protect the batteries.

Note 2: A complex battery management system may include battery voltage, temperature and current measurement, energy balance, power (SOC) calculation and display, abnormal alarm, charge and discharge management, communication, etc.

3.5

Battery

Battery system

A system consisting of one or more cells, modules or battery packs. It has a battery management system. If overcharge, overcurrent, over-discharge or overheat occur, the battery management system will take action.

Note 1: If the battery manufacturer and the user reach an agreement, over-discharge cut-off is not mandatory.

Note 2: It can include cooling or heating devices; some even include charge and discharge modules and inverter modules.

- Leakage of electrolyte inside the cell due to bulging, deflation, etc.;
- Leakage of electrolyte inside the cell due to extrusion, wear, etc.

4.3 Overheat

4.3.1 Overview

Overheat may directly cause burns to the human body, OR cause the insulation level of equipment to decrease and the performance of safety components to decrease, OR ignite flammable liquids.

4.3.2 Causes

Including but not limited to the following situations:

- The cooling and heat dissipation functions of the cell fail;
- Increased current due to cell failure;
- The ambient temperature of the cell is too high;
- Failure of the protection function causes the cell to heat up abnormally.

4.4 Electric shock

4.4.1 Overview

The physiological response, which is caused by electric shock, depends on the size and duration of the current value, as well as its path through the human body, which directly harms the human body.

Voltages exceeding a DC value of 60 V are considered hazardous voltages.

Note: For products with inverter function that can output AC voltage, see GB 4943.1 for the electric shock hazard.

4.4.2 Causes

Including but not limited to the following situations:

- Contact with exposed parts, that normally carry hazardous voltages;
- The insulation -- between parts with dangerous voltages under normal circumstances and accessible conductive parts -- is broken down;
- Contact current flowing from parts carrying hazardous voltages to accessible parts.

4.5 Fire

4.5.1 Overview

A fire may directly burn the human body, OR cause a fire hazard to the equipment, AND may produce harmful gases that affect human health.

4.5.2 Causes

Including but not limited to the following situations:

- Too much heat energy accumulates inside the cell, meanwhile the temperature reaches the ignition point of internal flammable materials;
- Combustible gas accumulates inside the cell, meanwhile the temperature reaches its ignition point;
- Burning of external parts of the cell may ignite the cell or battery pack.

4.6 Explosion

4.6.1 Overview

When an explosion occurs, the components or parts are ejected, which may directly harm the human body or damage the equipment.

4.6.2 Causes

Including but not limited to the following situations:

- Excessive heat energy and gas accumulation inside the cell, meanwhile the internal pressure exceeds the endurance of the casing;
- Overheat of the outside of the cell and other factors cause a large amount of heat or gas to be generated inside the cell, meanwhile the internal pressure exceeds the capacity of the casing.

5 Recommendations for equipment manufacturers

5.1 Protection function management

It should use a battery pack, which is equipped with PCM/BMU/BMS.

When using batteries and battery packs, which are not equipped with battery protection

$$I_1 \geq I_2 \geq I_3 \geq I_4 \quad \dots\dots\dots (5)$$

$$I_5 \leq I_6 \leq I_7 \leq I_8 \quad \dots\dots\dots (6)$$

Where:

I_1 - Maximum charging current of cell, in Ampere (A);

I_2 - Over current for charge protection of battery pack, in Ampere (A);

I_3 - Maximum charging current of battery pack, in Ampere (A);

I_4 - The equipment's continuous charging input current to the cell/battery pack, in Amperes (A);

I_5 - Continuous discharge load current of the cell/battery pack to the equipment, in Amperes (A);

I_6 - Maximum discharge current of battery pack, in Ampere (A);

I_7 - Over current for discharge protection of battery pack, in Ampere (A);

I_8 - Maximum discharge current of cell, in Ampere (A).

Generally, the maximum charging current and maximum discharge current capabilities of lithium-ion cells are closely related to the ambient temperature. The equipment should be able to adjust the charge and discharge current of the cell or battery pack, according to the ambient temperature, to ensure that the cell or battery pack in the equipment does not exceed its maximum charge and discharge current, at the current ambient temperature.

If the charge/discharge current exceeds the normal operating current range of the cell or battery pack, the equipment should take protective action immediately.

5.4 Temperature management

The equipment should have a cell or battery pack temperature monitoring function. It is recommended to monitor the cell or battery pack at multiple points, covering at least the maximum possible temperature point.

Exceptions are made for equipments using battery packs with temperature monitoring capabilities. Equipment is encouraged to add temperature monitoring functions, which can directly measure temperature or read temperature data, through a data interface.

The charging temperature of the cell or battery pack by the equipment should not exceed the operating temperature range of the cell or battery pack, as shown in Figure 3.

T_9 - Lower limited discharging temperature of battery pack, in degrees Celsius ($^{\circ}\text{C}$);

T_{10} - Lower limited discharging temperature of cell, in degrees Celsius ($^{\circ}\text{C}$).

If the cell or battery pack used has different maximum charging current and charging limit voltage, under different ambient temperatures, the charging circuit of the equipment should control the charging current and voltage, according to the temperature of the cell or battery pack, to not exceed the acceptable range at the current temperature.

If the temperature exceeds the working range of the cell or battery pack, the equipment should take protective action immediately.

In general, the lower limit of working temperature of equipment, which has auxiliary heating function, can be lower than the lower limited charging/discharging temperature of the cell or battery pack; however, it must be ensured that the working temperature of the cell or battery pack is within a safe temperature range. For the products which have auxiliary cooling function, the upper limit of working temperature can be higher than the upper limited charge/discharge temperature of the cell or battery pack; however, it must be ensured that the working temperature of the cell or battery pack is within a safe temperature range.

5.5 Series and parallel management of batteries

This Article only applies to equipment, that directly uses multi-stage series and parallel batteries.

Select batteries, whose consistency meets the requirements, for assembly. If the capacities of the assembled batteries are inconsistent, the charging current and discharge current values of each parallel battery must match the values, which are specified by the battery manufacturer; meanwhile it has an "effective charge/discharge current control" function, to ensure that their safe use range is not exceeded.

The equipment should have the function of monitoring the voltage of a single cell. When the voltage of any cell exceeds the specified range, the equipment starts protection.

5.6 Communication management

The equipment should have the function of receiving and processing battery status information, which is reported by the cell or battery pack, including voltage, current, temperature and other related information of the cell or battery pack.

5.7 Battery installation and protection

The equipment needs to provide a secure installation method.

For cells or battery packs without protective shells, the equipment should provide appropriate mechanical protection, fire protection, electrical protection, environmental protection, etc.

For cells or battery packs with protective shells, the equipment should be equipped with additional protective shells.

When selecting protective materials, it is recommended to comprehensively consider the physical and chemical properties of the material. Within the allowable range, priority is given to the use of materials with good flame retardant, insulation and other properties, to reduce the influence on the safety of the battery pack, in abnormal situations such as fire and high temperature.

6 Recommendations for end product users

6.1 Charging and discharging

Recommendations for charging and discharging end product users are as follows:

- a) During use, it should follow the charging and discharging conditions specified by the manufacturer; use a charging device, which matches the cell or battery pack, for charging;
- b) During use, it should choose a dry and open environment to charge and discharge the cell or battery pack; avoid charging and discharging in complex environments (except for conditions permitted by the battery manufacturer, such as corresponding IP protection, etc.), such as high temperature, high humidity, etc., to avoid short circuit, corrosion or failure of related protective functions;
- c) Cells and battery packs should be operated, at normal operating temperatures, to avoid cells or battery packs operating outside the temperature range, which is recommended by the manufacturer;
- d) Before charging, it should clean the environment around the cell or battery pack; avoid accumulation of flammable materials around it; stay away from flammable and explosive areas;
- e) The cell or battery pack should be designed with anti-reverse polarity protection. If it does not have this function, pay attention to the polarity of the cell or battery pack, when using it.

6.4 Exception handling

Recommendations for handling abnormal situations for end product users are as follows:

- a) If misuse occurs during use, the user should immediately follow the reasonably foreseeable misuse measures provided by the manufacturer, to avoid battery leakage, high temperature, explosion, fire, or other dangers;
- b) After the cell or battery pack is immersed in water, it should be handled, in accordance with the requirements specified by the manufacturer, unless permitted by the manufacturer. Under normal circumstances, it should not be continued to use;
- c) During use or charging, if the battery is found to be overheated, emit odor, deformed or otherwise abnormal, stop using or charging immediately AND handle it in accordance with the requirements specified by the manufacturer;
- d) If a child accidentally swallows a battery, it is recommended to seek medical attention immediately.

7 Recommendations for maintenance personnel

7.1 General conditions

Recommendations for general situations are as follows:

- a) Maintenance of cells and battery packs should be carried out by designated professionals;
- b) The cell and battery pack should be completely discharged before maintenance. Inspection and maintenance should be carried out, according to the method and cycle recommended by the manufacturer, to avoid damage to the cell and battery pack. If it needs to replace the battery pack, it is recommended to use the original cell or battery pack, which is provided by the cell or battery pack manufacturer.

7.2 Prevention of abnormal situations

Recommendations for preventing abnormal situations are as follows:

- a) The maintenance process should be carried out, in a dry and ventilated environment;
- b) During the maintenance process, the cell or battery pack can be equipped with

necessary cushioning pads, to avoid damage to the cell and battery pack, as caused by collisions, drops, etc.;

- c) Appropriate tools should be used during maintenance, to avoid mechanical damage to the cell, such as breakage, perforation, etc. that may lead to electrolyte leakage and cause battery short circuit, overheat, explosion or fire. It is recommended to replace the battery, if it is found to be damaged;
- d) During the maintenance process, the cell and battery pack should be kept clean and dry. If foreign matter is attached to the terminals of the cell or battery pack, it is recommended to use the method specified by the manufacturer for cleaning;
- e) During the maintenance process, the cell or battery pack should not be exposed to corrosive substances. Keep the workbench clean during maintenance, to prevent corrosion of the cell or battery pack;
- f) Necessary insulation protection should be carried out, during maintenance, to prevent short circuit of the cell or battery pack. The equipment and tools used should be equipped with insulation measures, at the parts that are in contact with the positive and negative electrodes of the battery;
- g) During the maintenance process, it should not forcefully change the battery size, when disassembling or installing batteries or battery packs. It should not hit the cell with hard objects, to prevent sharp objects from puncturing the cell. It should not damage the packaging and appearance of the cell. It should not let the cell in drop or vibration state, to avoid dangers caused by physical factors;
- h) It should not store multiple cells or battery packs randomly on shelves or drawers. Insulation protection should be provided, during the storage process, to prevent them from short-circuiting each other or being short-circuited by other metal objects. It is recommended to set up storage facilities specifically for fixing cells or battery packs;
- i) For battery packs used in special occasions and products, attention should be paid to protecting the battery pack's structural waterproofing, dustproof, insulation and other special designs, during maintenance, to avoid damaging the special functions of the battery pack.

7.3 Exception handling

Recommendations for handling abnormal situations are as follows:

- a) If a danger occurs during maintenance, it should be handled immediately, according to the reasonably foreseeable misuse measures, which are provided by the manufacturer, to avoid the high temperature, leakage, fire, explosion and other

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