EXAMINATION REPORT
ON
THE APPROACH TO SAFETY MEASURES CONCERNING LITHIUM ION BATTERIES
IN
DANGEROUS FACILITIES

DECEMBER 2011

DANGEROUS GOODS SAFETY OFFICE,
FIRE AND DISASTER MANAGEMENT AGENCY

INTRODUCTION

Lithium ion storage batteries (generally referred to as lithium ion batteries but legally prescribed as lithium ion storage batteries) are variously used in everyday life in such areas as mobile telephones and personal computers and more recently electric automobiles and household storage batteries.

Meanwhile, the electrolyte that is used in lithium ion batteries is a hazardous substance (flammable liquid) having similar fire risk to petroleum, and facilities that store and handle large quantities of lithium ion batteries are required, as dangerous facilities, under the Fire Service Act to take certain fire safety measures. In the regulatory screening conducted by the Government Revitalization Unit on March 6, 2011, it was requested that the fire risk of lithium ion batteries be reexamined while primarily bearing safety in mind. Accordingly, the approach to safety measures concerning lithium ion batteries in dangerous facilities has been examined based on the findings of demonstration tests.

The approach to safety measures concerning lithium ion batteries in dangerous facilities presented here represents a rational method for securing safety in facilities that that store and handle lithium ion batteries based on the results of reexamining the fire risk.

I would like to express sincere gratitude to all the people who took time out of their busy schedules to positively participate in the examination and give their valuable opinion in the preparation of the report.

December 2011

Examination Committee on the Approach to Safety Measures concerning
Lithium Ion Batteries in Dangerous Facilities

Kyoichi Kobayashi

Chairperson

EXAMINATION REPORT ON THE APPROACH TO SAFETY MEASURES CONCERNING LITHIUM ION BATTERIES IN DANGEROUS FACILITIES

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CHAPTER 1 OUTLINE OF THE EXAMINATION

1.1 Objectives of the Examination

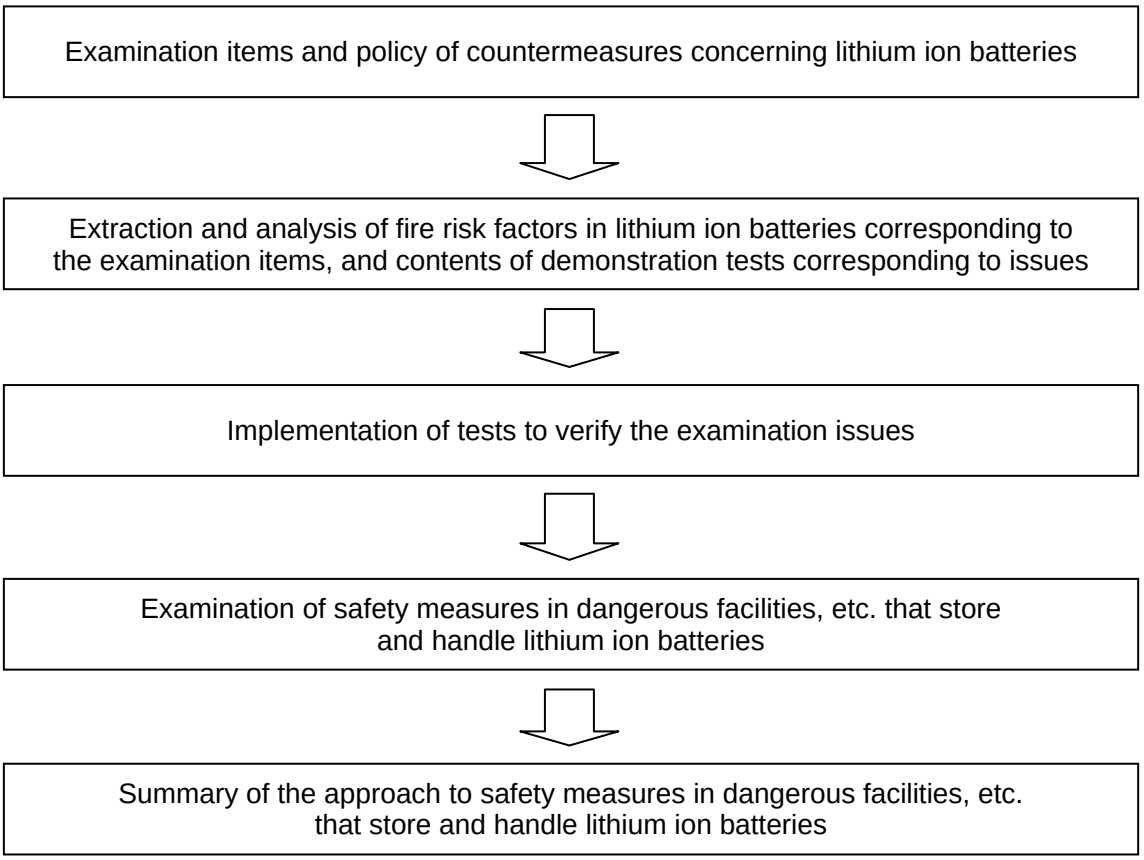
Facilities that store and handle large quantities of lithium ion batteries, which use electrolyte having similar fire risk to petroleum (flammable liquid), are required, as dangerous facilities, under the Fire Service Act to take certain fire safety measures. However, in the regulatory screening conducted by the government revitalization unit on March 6, 2011, it was requested that the fire risk of lithium ion batteries be reexamined while primarily bearing safety in mind.

Accordingly, it is here intended to reexamine the fire risk of lithium ion batteries and examine the approach to safety measures concerning such batteries in dangerous facilities.

1.2 Examination Items

(1) Fire risk of lithium ion batteries
(2) Approach to safety measures concerning lithium ion batteries in dangerous facilities
(3) Other necessary items

Examination Flow



1.3 Examination Setup

Examination Committee on the Approach to Safety Measures concerning Lithium Ion Batteries in Dangerous Facilities

(Japanese alphabetical order, titles omitted)

Chairperson	Kyoichi Kobayashi	Professor, Fire Science Research Center, Research Institute for Science and Technology, Tokyo University of Science
Member	Yoshitaka Asakura	Deputy Chief, Battery WG, Japan Automobile Manufacturers Association, Inc.
	Hidenori Ikeda	Manager, Regulation Section, Prevention Department, Osaka Municipal Fire Department
	Akiyuki Ohtake	Manager, Hazardous Objects Section, Prevention Department, Tokyo Fire Department
	Kei Oda	Deputy Chief, Legislation Working Group, Battery Association of Japan
	Seiichi Koshigaya	Manager, Hazardous Objects Section, Prevention Department, Kawasaki Fire Department
	Yuichi Satoh	Guest professor, University of Kanagawa
	Hiroshi Sugawara	Chief, Battery WG, Japan Automobile Manufacturers Association, Inc.
	Kuniaki Tatsumi	Chief Researcher, Ubiquitous Energy Research Department, National Institute of Advanced Industrial Science and Technology
	Eiichi Tanaka	Chief, Engineering Work Section, Product Safety Center, National Institute of Technology and Evaluation
	Takahiro Tsukame	Chief Researcher, Research and Development Division, National Research Institute of Fire and Disaster
	Takashi Tsuruda	Professor, Faculty of System Science and Technology, Akita Prefectural University
	Masayuki Terada	Chief, Legal Working Group, Battery Association of Japan
	Kazuhiro Nakamitsu	Chairperson of the Next Generation Battery Committee, Battery Association of Japan
	Mitsuzou Nogami	Recommended member, Battery Association of Japan

1.4 Examination Status

The situation regarding examination is as indicated below.

(1) Examination Committee on the Approach to Safety Measures concerning Lithium Ion Batteries in Dangerous Facilities

First committee meeting : August 9, 2011
Second committee meeting : September 14, 2011
Third committee meeting : November 17, 2011
Fourth committee meeting : December 5, 2011

CHAPTER 2 OUTLINE AND ISSUES FOR EXAMINATION IN LITHIUM ION BATTERIES

2.1 Outline of Lithium Ion Batteries

2.1.1 Types of Lithium Ion Batteries

The lithium ion batteries that are currently manufactured comprise cylindrical types, square types and laminated types. Table 1 shows the features of each type of battery via examples. Incidentally, multiple lithium ion batteries (single cells) that are electrically connected are referred to as assembled batteries.

Table 1 Types and Features of Lithium ion batteries (Single Cells)

Type	Features	Amount of electrolyte, etc.	Energy density	Purpose of use
Cylindrical	Size : diameter 18 mm, length 65 mm Armor : metal can	Sealed liquid. There is around 2 ml of electrolyte	Maximum roughly 600 Wh/l	PC batteries, etc.
Square	Size : thickness 5 mm, width 40 mm, height 50 mm Armor : metal can, resin		Roughly 400 Wh/l	Mobile phones, etc.
	Size : 17 cm, width 4 cm, height 11 cm Armor : metal can	Sealed liquid. There is around 100 ml of electrolyte	Roughly 200 Wh/l	Electric vehicles, industrial machines, etc.
Laminated	Size is around the same as the square type, but the armor is made from laminated film.	Gel electrolyte is sealed.	Roughly 400 Wh/l	Mobile phones, etc.
	Size : 250 mm, width 140 mm, height around 9 mm Armor : laminated film	Solid state electrolyte is impregnated and laminated with the electrodes	Around 170Wh/l	Electric automobiles

2.1.2 Electrolyte used in Lithium ion batteries

The electrolyte used in lithium ion batteries uses flammable organic solvents such as dimethyl carbonate (DMC) and diethyl carbonate (DEC) and it comprises complexes of such organic solvents in various blend ratios. Since such mixed liquids have similar ignition points to petroleum products, etc., they are classified as hazardous objects (flammable liquids) under the Fire Service Act.

2.1.3 Structure of Lithium ion batteries

Lithium ion batteries are always equipped with a pressure reducing mechanism (gas release vent) for reducing internal pressure to prevent rupture or explosion of batteries due to the increase of internal pressure in fires and so on.

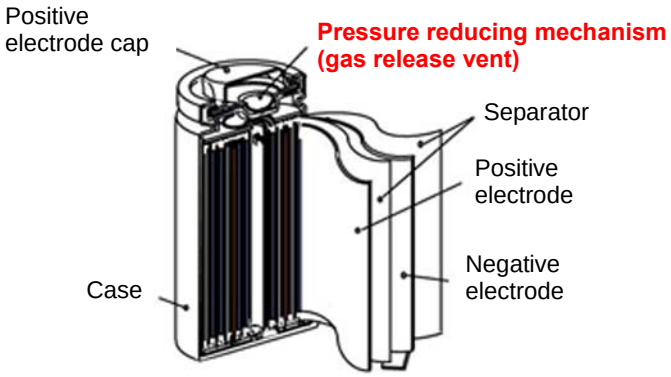


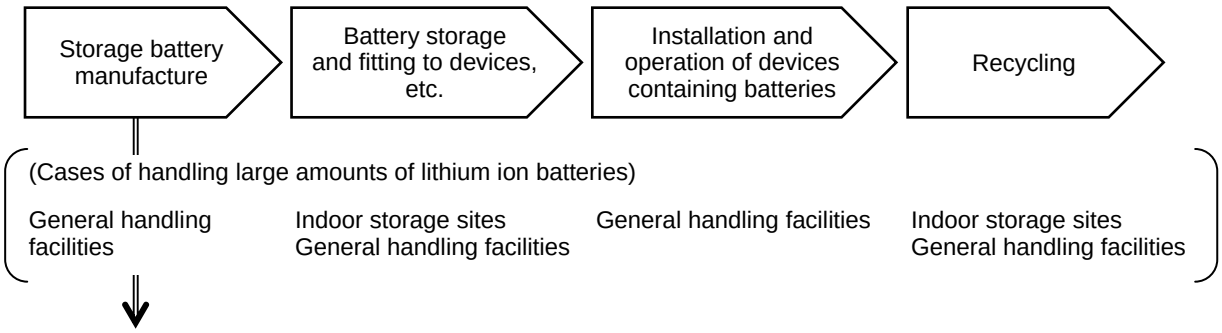
Figure 1 Example of the structure of lithium ion batteries

(Example of a cylindrical lithium ion battery)

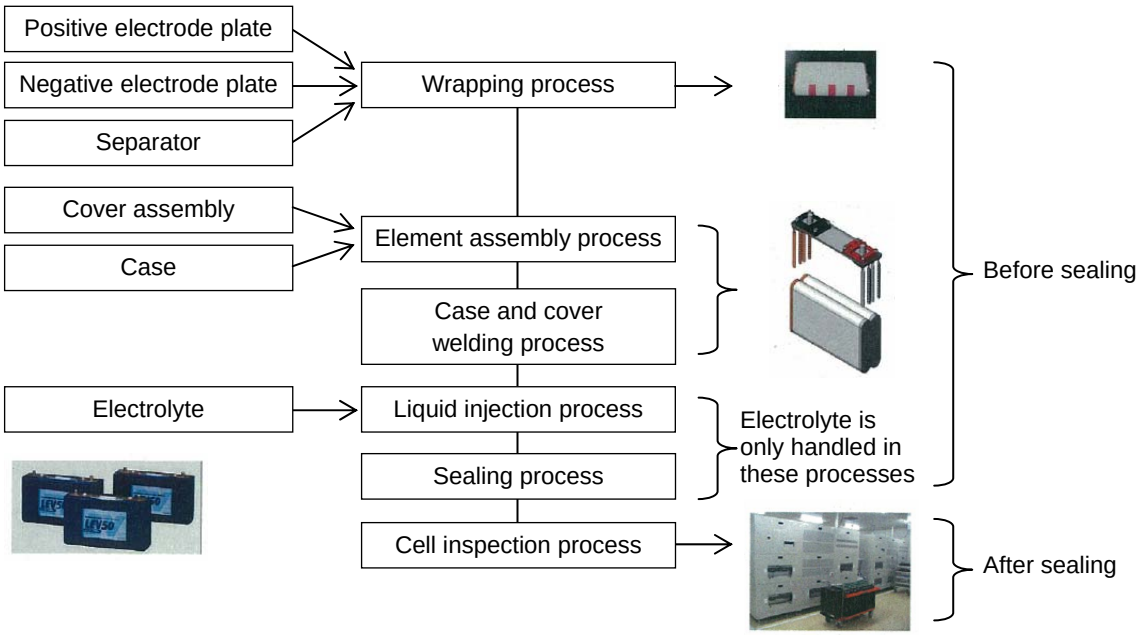
2.1.4 Manufacturing Process, etc. of Lithium Ion Batteries

The manufacturing processing and lifecycle of lithium ion batteries are generally as follows.

<<Lifecycle>>



<<Manufacturing process>>



* Extracted from the materials "Regulatory Sorting" by the Government Revitalization Unit

2.2 Safety Measures for Lithium Ion Batteries

Lithium ion batteries spread to the rest of the world after being developed in Japan in 1990. Safety standards for lithium ion batteries came to be established under the IEC (International Electrotechnical Commission), JIS (Japan Industrial Standards) and the Electrical Appliance and Material Safety Law. The history and contents of safety standards for lithium ion batteries are described below. A feature of these is that the applicable scope is determined and safety measures are stipulated for every kind of possible misuse in the market. Meanwhile, the United Nations recommendations compiled and enforced by the United Nations Committee of Experts on the Transport of Dangerous Goods intend to ensure safety in land, marine and air transportation and are applicable to all lithium ion batteries.

2.2.1 United Nations Recommendations concerning Transportation of Hazardous Substances (UN3090, UN3480)

Following the worldwide spread of lithium ion batteries, these recommendations (UN3090) were compiled and issued in 2001 based on the conventional safety standards for lithium primary batteries. Following subsequent expansion in uses of lithium ion batteries and advances in technology, dedicated recommendations were established apart from those for lithium primary batteries.

Safety tests comprise eight items including vibration, shock, impact, external shorting and so on. Since it is necessary to comply with the requirements of these tests in order to transport batteries, it is essential to incorporate them into design guidelines. To ensure that more certain safety is pursued, a working group on lithium ion batteries has been establishes within the United Nations Committee of Experts on the Transport of Dangerous Goods and this constantly implements review work.

Table 2 shows an overview of the Safety Testing: United Nations Test Standard Manual, Part III, sub-section 38.3 that is prescribed under UN3480.

Table 2 Safety Standards Prescribed in the United Nations Recommendations (UN3480)

Test Item	Test Conditions	Judgment Criteria
T1 : Sophisticated Simulation Test	Store for at least 6 hours in a depressurized environment of 20±5ºC and atmospheric pressure of no more than 11.6kPa.	There shall be no decline in weight, leakage of fluid, operation of vent, rupture, fracture or ignition, and the open-circuit voltage is 90% or more of the pre-test value except for fully discharged batteries.
T2 : Temperature test	Store for 6 hours at 75±2 ºC and 6 hours at - 40±2 ºC, and repeat this cycle at least 10 times.	
T3 : Vibration test	Sweep the frequency of vibration from 7Hz→200Hz→7Hz over 15 minutes. Implement 12 times each in 3 directions.	
T4 : Shock test	Implement half sine shock of peak rate of acceleration 150 gn and pulse hold time 6 ms for a total of 18 times.	
T5 : External shorting test	Create a shorting state in which the total of external resistance is less than 0.1Ω at 55±2 ºC.	External temperature doesn't exceed 170 ºC and there shall be no rupture, fracture or ignition for 6 hours after the test.
T6 : Impact test	Placed a rod of 15.8 mm diameter over the center of a single cell, and drop a weight of 9.1 kg from a height of 61±2.5cm.	External temperature doesn't exceed 170 ºC and there shall be no rupture or ignition for 6 hours after the test.
T7 : Overcharge test	If the recommended charge voltage is no more than 18V, apply either two times the maximum charge voltage or 22V, whichever is lower. If the recommended charge voltage is more than 18V, apply voltage of 1.2 times the maximum charge voltage.	There shall be no rupture or ignition for 7 days after the test.
T8 : Forced discharge test	Conduct 12V forced discharge of a single cell at the maximum discharge current designated by the manufacturer.	There shall be no rupture or ignition for 7 days after the test.

2.2.2 IEC (International Electrotechnical Commission) Standards

In 2000, the IEC standard on safety criteria for lithium ion batteries (IEC61960-1, single cells) was issued, and through this standards were prescribed concerning safety test methods and judgment criteria for drop test, external shorting test, crush test (simulation of internal shorting test) and so on. In the following year (2001), IEC61960-2 (assembled batteries) was issued, and this prescribed the standards for safety test methods pertaining to assembled batteries.

In 2002, the above IEC standards were revised with the formulation of IEC62133, in which the items concerning safety of batteries were extracted from IEC61960. Table 3 shows the contents of safety standards concerning lithium ion batteries according to this.

Table 3 Safety Standards concerning IEC62133

Test Item	Test Conditions	Judgment Criteria
Low voltage test	Hold a charged single cell battery at 20±5 ºC and atmospheric pressure of no more than 11.6kPa (equivalent to 15,240 m altitude) for 6 hours.	There shall be no ignition, rupture or leakage of fluid.
Temperature cycling test	Repeat the cycle of storing at 75±2 ºC for 4 hours→20±5 ºC for 2 hours→-20±2 ºC for 4 hours→20±5 ºC for 2 hours, 5 times, and then leave the battery for 7 days.	
Vibration test	Setting amplitude at 0.76mm (total maximum amplitude 1.52 mm), vary the vibration frequency between 10Hz→55Hz→10Hz and 1Hz/minute. Conduct in 2 directions for cylinders and 3 directions for square batteries.	
Impact test	Starting off with the minimum minimum acceleration of 75 gn for the first 3 ms, add shock with peak acceleration in the range of 125~175 gn. Conduct in 2 direction for cylinders and 3 directions for square batteries.	
External shorting test	Put into the shorted state of less than 100mΩ resistance at 20±5 ºC and 55±5 ºC.	There shall be no ignition or rupture.
Shock test or free fall test	Drop the charged battery 3 times from 1.0 m onto a concrete surface.	
Overcharge test	Using a discharged single cell, using a power supply of 10V or more, charge to 250% (2.5C5/Irec) at the recommended current of Irec.	
Forced discharge test	Conduct reverse charging of a discharged single cell at 1ItA for 90 minutes.	
Continuous uniform charge	Charge a charged single cell for 28 days by the method specified by the manufacturer.	There shall be no ignition, rupture or leakage of fluid.
Deformation of assembled battery container in high temperature	Leave an assembled battery at 70±2 ºC for 7 hours.	There shall be no deformation of the assembled battery container exposing the internal components
Heating test	Heat a charged single cell at 5±2 ºC /min to 130±2 ºC and hold at 130±2 ºC for 10 minutes.	There shall be no ignition or rupture.
Crushing test	Sandwich a charged single cell between flat plates (pressurize to 13±1kN or until pressure drops to 1/3 the initial voltage).	
Battery protection against high rate charging	Charge a discharged single cell with current of 3 times the recommended value Irec until either the cell becomes fully charged or the charging current is cut off by the internal safety element.	

* The test name doesn't necessarily coincide with the test name in the standard.

2.2.3 JIS (Japan Industrial Standards)

The JIS standard JIS C 8712 (Safety of Closed Small Secondary Batteries) was formulated based on similar contents to the IEC standard IEC62133 in 2006.

Around 2006 when JIS C 8712 was formulated, there was a spate of accidents involving the heating and ignition of lithium ion batteries, and since it was thought that these incidents were caused by the heating and ignition of storage batteries, the standard JIS C 8714 (Safety Testing of Single Cell and

Assembled Lithium Ion Batteries for Mobile Devices) was formulated in 2007. Table 4 shows the contents of safety standards for storage batteries that were newly prescribed in JIS C 8714.

Table 4 Safety Standards Prescribed in JIS C 8714

Test Item	Test Conditions	Judgment Criteria
External shorting test	Put into the shorted state with resistance at 80±20mΩ and temperature at 20±5 ºC (assembled battery) and 55±5 ºC (single cell).	There shall be no ignition or rupture.
Crushing test	Sandwich a charged single cell between flat plates (pressurize to 13±1kN and test until pressure drops to 1/3 the initial voltage or until 10% deformation occurs in terms of the battery height). Conduct in 2 directions for square batteries.	
Forced internal shorting test	Remove the electrode assembly from inside the charged single cell and insert a nickel rod, and then pressurize and short inside a testing isothermal bath.	There shall be no ignition.

* The test name doesn't necessarily coincide with the test name in the standard.

* In JIS C 8714, heating test is also prescribed, however, because the contents are the same as in IEC62133, it isn't stated in Table 4.

2.2.4 Revision of the Electric Appliance Safety Law

In line with the 2008 revision of the Electrical Appliance and Material Safety Law (1961, No. 234) aimed at preventing occurrence/reoccurrence of storage battery accidents that was enacted in response to the heating and ignition accidents in lithium ion batteries described above, the Electrical Appliance and Material Safety Law enforcement regulations (Ministry of International Trade and Industry Order No. 84 of 1962) and technical standards for electrical appliances and materials were revised. Under this revision, lithium ion batteries that conform to certain requirements* became targets under the Electrical Appliance and Material Safety Law, and it was made compulsory for storage batteries to comply with the technical standards in cases where they are manufactured or imported. These technical standards for storage batteries comprised the same contents as the standards prescribed in the above IEC62133 (JIS C 8712 prescribes the same safety standards as IEC62133) and JIS C 8714.

* In the Electrical Appliance and Material Safety Law enforcement regulations (Cabinet Order 324 of 1962) Table 2 Item 12, lithium ion batteries are limited to those with a volume energy density of 400 liters per watt-hour per single cell and do not include those affixed by soldering or other methods to mechanical devices in automobiles, motorcycles, medical machinery and appliances and industrial machinery and appliances or those with other special structure.

2.3 Handling of Lithium Ion Batteries under the Current Fire Service Act

2.3.1 Status of Lithium Ion Batteries under the Current Fire Service Act

In the Fire Service Act (No. 186 of 1948) Article 2 Section 7, hazardous objects are defined as "the goods given in product name column of Table 1 that possess the given properties corresponding to the classifications given in the table," and in Table 1 Note 14 under the law, Type 4 (flammable liquids)

Class II petroleums are stipulated as kerosene, light oil and liquids in which the ignition point is between 21~69 degrees at atmospheric pressure of 1.

In the Cabinet Order on regulations for dangerous objects (Cabinet Order 306 of 1959) Table 3, the designated quantity of Type 4 Class II petroleums is prescribed as 1,000 liters, and the storage and handling of more than the designated quantity (1,000 liters) of Class II petroleums needs to be carried out in facilities that conform to the technical standards laid down in the Cabinet Order concerning regulation of hazardous substances. Therefore, in the case of cylindrical lithium ion batteries with a diameter of 18 mm and height of 65 mm (approximately 2 ml of electrolyte), if a facility stores and handles roughly 500,000 such batteries, such a facility will need to be targeted as a dangerous facility under the Fire Service Act. In 1995, a fire broke out at an unlicensed facility storing lithium ion batteries in Koriyama City. Following this, a notification (Fire Service Risk Notification No. 48 (Work Materials) confirming and advertising the status of lithium ion batteries under the Fire Service Act was issued in 1996.

Incidentally, the storage and handling of hazardous substances of less than the designated quantity is conducted based on the fire prevention ordinances of each municipality concerned.

(Reference) Extract from the Fire Service Order

Fire Service Act Table 1

Type	Property	Product
Type 4	Flammable liquid	4, Type II petroleum

Cabinet Order concerning regulation of hazardous objects, Table 3

Type	Product	Designated Quantity
Type 4	Type II petroleum	1000 liters

2.3.2 Current Standards for Facilities that Store and Handle More than the Designated Quantity of Lithium Ion Batteries

Concerning facilities that manufacture or store more than the designated quantity of lithium ion batteries (more than 500,000 cylindrical lithium ion batteries with a diameter of 18 mm and height of 65 mm), it is necessary to regard them as dangerous facilities and take a certain level of safety measures under the Fire Service Act. The contents of the technical standards based on the Fire Service Act are indicated below.

(1) Technical standards concerning facilities that manufacture more than the designated quantity of lithium ion batteries

Facilities that manufacture more than the designated quantity of lithium ion batteries, and facilities that conduct charging and discharging of equipment fitted with more than the designated

quantity of lithium ion batteries (referring to equipment composed of lithium ion batteries and electrical wiring, etc.), are classified as general handling facilities and must comply with the technical standards for general handling facilities.

(Technical standards for general handling facilities)

≪Safety measures concerning location, structure and equipment≫

- The facility shall be located at last 10 meters from houses and 30 meters from schools and hospitals, etc.
- Vacant space of at least 3 meters or 5 meters shall be secured around the facility.
- The facility shall not have a basement.
- The facility walls, pillars, floors, beams and stairs shall be made from noncombustible materials, and exterior walls that are at risk of spreading fire shall comprise fire-resistant walls having no other opening than entrances/exits.
- The facility roof shall be tiled with light and noncombustible materials (explosion-proof structure).
- Fire preventive equipment shall be installed on windows and at entrances/exits, and the entrance/exits fitted into the exterior walls that are at risk of spreading fire shall be automatically closing specific fire prevention system.
- Wire glass shall be used in windows and entrances/exits.
- The floors of facilities that handle liquid hazardous substances shall have a structure and incline that prevents permeation of hazardous substances, and they shall be equipped with holding equipment.
- The facilities shall be equipped with lighting, illumination and ventilation equipment.
- Plants where there is risk of flammable vapor accumulating shall be fitted with exhaust equipment.
- Machinery and appliances that handle dangerous substances shall comprise structure that can prevent leakage, overflow or fly-off of said substances.
- Equipment that heats dangerous substances shall be equipped with temperature measuring devices.
- Equipment that heats dangerous substances shall have a structure that doesn't use direct flame.
- Electrical equipment installed over the scope that flammable vapor accumulates shall comprise explosion-proof structure.
- Facilities that hold more than 10 times the designated quantity shall be equipped with lightning protection system.
- Fire preventive equipment that can appropriately extinguish fires shall be installed. *

* Out of general handling facilities, concerning facilities that handle more than 100 times the designated quantity and facilities with total floor area of 1,000 square meters or more, fixed fire preventive equipment will be installed. In cases where lithium ion battery manufacturing plants are general handling facilities with total area of 1,000 square meters or more, foam and gas fire preventive equipment shall be installed in the parts that handle electrolyte of lithium ion batteries (it is possible to install indoor fire hydrant equipment, etc. in buildings and other work facilities).

(2) Technical standards concerning facilities that store more than the designated quantity of lithium ion batteries

Facilities that store more than the designated quantity of lithium ion batteries are classified as indoor storage facilities and must comply with the technical standards for indoor storage facilities.

(Technical standards for indoor storage facilities)

□Safety measures concerning location, structure and equipment□

1. Case of dedicated buildings with an independent storage area

- ㉮ The facility shall be located at last 10 meters from houses and 30 meters from schools and hospitals, etc.
- ㉯ Vacant space of at 0~15 meters shall be secured around the facility.
- ㉰ The facility shall be a single floor structure with eave height of less than 6 meters, and the floor shall be set above the ground height.
- ㉱ The facility floor area shall be no more than 1,000 square meters.
- ㉲ The facility walls, pillars, floors, beams and stairs shall be made from noncombustible materials, and exterior walls that are at risk of spreading fire shall comprise fire-resistant walls having no other opening than the entrance/exit (facilities with no more than 10 times the designated quantity can be made from noncombustible materials).
- ㉳ The facility roof shall be tiled with light and noncombustible materials (explosion-proof structure).
- ㉴ Fire preventive equipment shall be installed on windows and at entrances/exits, and the entrance/exits fitted into the exterior walls that are at risk of spreading fire shall be automatically closing specific fire prevention system.
- ㉵ Wire glass shall be used in windows and entrances/exits.
- ㉶ The floors of facilities that handle liquid hazardous substances shall have a structure and incline that prevents permeation of hazardous substances, and holding equipment will be installed.
- ㉷ The facilities shall be equipped with lighting, illumination and ventilation equipment.
- ㉸ Electrical equipment installed in areas where flammable vapor accumulates shall be explosion-proof.
- ㉹ Facilities that hold more than 10 times the designated quantity shall be equipped with lightning protection system.

2. Cases where the storage facility is installed as part of a general building

- ㉮ The multiple of stored dangerous substances shall be no more than 20 times.
- ㉯ The facility shall be located on the first or second floor of a building that has noncombustible walls, pillars, floors and beams.
- ㉰ The floor of the facility shall be installed above ground height and the floor height shall be less than 6 meters.
- ㉱ The area of the facility shall be no more than 75 square meters.
- ㉲ The facility walls, pillars, floors, beams and stairs shall be made from noncombustible materials, and it shall be separated from the rest of the general building by a reinforced concrete wall of at least 70 mm that has no opening other than the entrance/exit.
- ㉳ The entrance/exit to the facility shall be a specific be automatically closing specific fire prevention system.
- ㉴ No windows can be fitted in the facility portion.
- ㉵ Dampers and so on shall be installed on the ventilation and exhaust equipment in the facility portion.

㉶~㉹ These are the same as the preceding items ㉶~㉹.

* In the indoor storage facility standard, if the designated multiple of quantity is no more than 50 times, special provisions are stipulated for the above (independent building). According to these, the above items ㉯, ㉰, ㉱, ㉲ and ㉳ will not be applied but will need to be replaced by the following:

- ㉯ Vacant space of 0~2 meters or more shall be provided.
- ㉰ The floor area shall not exceed 150square meters.
- ㉲ The facility walls, pillars, floors, beams and roof shall be made from noncombustible materials.
- ㉳ The entrance/exit to the facility shall be an automatically closing specific fire prevention system.

2.4 Examination Issues

The fire risk of lithium ion batteries has been reduced in line with the successive revision of United Nations recommendations, formulation of IEC standards and JIS standards, and revision of the of the Electrical Appliance and Material Safety Law, etc.

Meanwhile, when lithium ion batteries are exposed to flames, the pressure reduction mechanism (gas release vent) operates, causing the electrolyte to gush out and combust. Accordingly, fires frequently occur in facilities that manufacture or store lithium ion batteries. Moreover, in cases where lithium ion battery-fitted equipment, which is expected to be used more in future for equalization of power demand and as emergency power supply, is installed in buildings and so on, although the fire risk of lithium ion batteries is being reduced as described above, there is still a risk that fire will break out from the electric wiring inside the said equipment or that the equipment will get caught up in fire that breaks out around the installation area of the said equipment.

Concerning the approach to safety measures based on the Fire Service Act in facilities that manufacture or store lithium ion batteries, it is necessary to examine fire properties of lithium ion batteries upon considering the characteristics of batteries and requests from operators and so on.

Examination was carried out on the following two points based on requests from operators, etc. Moreover, concerning transportation of lithium ion batteries, since safety measures are taken under United Nations recommendations and the IMDG code (International Maritime Dangerous Goods Code) and so on, this isn't targeted in the examination here.

2.4.1 Necessary Approach to Safety Measures in Case where Lithium Ion Battery Equipment is Installed in Basements or on Rooftops

(1) Background

There are frequent requests to install lithium ion battery equipment in building basements or on rooftops. In such cases, when installing lithium ion battery equipment in buildings that are already equipped with private generating equipment, if the total amount of kerosene and other fuel for private generator equipment and electrolyte for lithium ion batteries reaches the designated quantity, since it is necessary to designate the building in question as a dangerous facility, it is sometimes difficult to install the said equipment in existing buildings.

(2) Direction and policy of examination

It is necessary to examine the approach to safety measures upon verifying the impact on lithium ion battery equipment in the case where fire breaks out from the private generating equipment (small quantity dangerous facility* or general handling facility) installed in the building basement or rooftop and the impact on private generating equipment in the case where fire breaks out from the said battery equipment. The examination policy will be as follows:

a. Extraction and analysis of fire risk factors in the case where lithium ion battery equipment is installed in the basement or on the rooftop of a building or close to private generating equipment

b. Implementation of demonstration test based on the extraction and analysis of fire risk factors

c. Approach to safety measures concerning installation of storage battery equipment based on the findings of the demonstration test.

* Small quantity dangerous facilities refer to facilities that store or handle less than the designated quantity of dangerous goods and are subject to the fire prevention ordinances of municipalities.

2.4.2 Approach to Storage of Lithium Ion Batteries

(1) Background

In cases of storing lithium ion batteries and lithium ion battery equipment, there have been numerous calls for rationalization concerning the safety measures in storage upon first securing a certain degree of safety through the sealing of batteries and implementation of measures under the Electrical Appliance and Material Safety Law.

(2) Direction and policy of examination

In view of the actual situation regarding storage of lithium ion batteries and so on, it is necessary to examine the approach to the necessary safety measures upon verifying the risk of fire spreading in the case where fire breaks out. The examination policy will be as follows.

a. Extraction and analysis of fire risk factors in the case where large quantities of lithium ion batteries, etc. are stored

b. Implementation of demonstration test based on the extraction and analysis of fire risk factors

c. Approach to safety measures that should be taken as an indoor storage facility based on the findings of the demonstration test.

CHAPTER 3 EXTRACTION AND ANALYSIS OF FIRE RISK AND ISSUES CORRESPONDING TO THE EXAMINATION ISSUES

3.1 Thinking on Fire Risk and Safety concerning Storage and Handling of Hazardous Substances

In facilities that store and handle a certain quantity or more of dangerous substances that entail a high fire risk, once a fire breaks out in such facilities, because there is a high risk that human and physical damage will occur and major impacts will imparted on neighboring facilities, in order to prevent fires and alleviate the damage caused by them, it is necessary to secure safety with respect to the fire outbreak risk, ignition risk and fire spread risk and so on.

Accordingly, in the Fire Service Act, measures are prescribed to counter fires that break out in dangerous substances, measures to mitigate risks of ignition (for example, static electricity) to dangerous substances and measures to prevent spread of fire to surrounding areas.

Because the electrolyte contained in lithium ion batteries is classified as a dangerous substance (flammable liquid) under the Fire Service Act, it is necessary to take a certain degree of safety measures in facilities that manufacture or store large quantities of lithium ion batteries. When examining the approach to safety measures in such facilities, it is necessary to verify the above fire risks upon considering the combustion properties of lithium ion batteries and the situation regarding installation of lithium ion battery equipment.

Moreover, when verifying fire risks, because the risk of fire breaking out from lithium ion batteries has been mitigated due to technical developments in battery safety and enactment of the Electrical Appliance and Material Safety Law and so on, this shall be taken into consideration in the extraction and analysis of fire risk factors.

3.2 Extraction and Analysis of Fire Risk in Cases where Lithium Ion Battery Equipment is Installed in Buildings, etc.

In cases where lithium ion battery equipment is installed in basements or on rooftops of buildings or close to private generating equipment in buildings, fire risk factors are extracted and analyzed as described below.

3.2.1 Outline of Private Generating Equipment

Private generating equipment is broadly divided into general handling facilities that consume the designated amount or more of fuel such as light oil, etc., and small dangerous facilities that consume less than the designated quantity of fuel. Of these, power generating equipments that is small dangerous facilities often consume close to one multiple of the designated quantity.

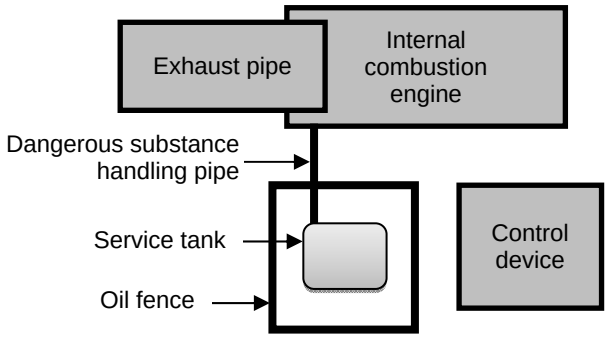


Figure 2 Image of Private Generating Equipment (Top View)

3.2.2 Situation regarding Accidents in Private Generating Equipment (General Handling Facilities)

The situation regarding accidents that have occurred in private generating equipment installed in buildings is described below. Since nationwide information on accidents is gauged for private generating equipment, which is regarded as general handling facilities, analysis was carried out on this.

(1) Fires in private generating equipment from 2000 to 2009

Table 5 shows the number of accidents that have occurred in private generating equipment (restricted to equipment classed as general handling facilities) between 2000 and 2009 (10 years), while Table 6 shows the locations and causes of fires.

According to the Japan Engine Generator Association, 418 private generating equipment units (corresponding to general handling facilities) and 5,713 disaster prevention private electric generators (corresponding to small dangerous facilities) (equivalent to approximately 13.7 times the regular private generating equipment units) were installed in fiscal 2010. Therefore, many private generating equipment units are small dangerous facilities.

Table 5 Number of Fires in Private Generating Equipment installed inside Buildings (General Handling Facilities)

Year	2000	2001	2022	2003	2004	2005	2006	2007	2008	2009	Total
Number of fires	4	2	2	2	1	4	4	3	1	1	24

Table 6 Locations and Causes of Fires in Private Generating Equipment over the Past 10 Years

Location of origin		Cause of fire	
Internal combustion engine	13 (54%)	Overheating	7
		Sparks from impact	2
		Abrasion heat	1
		High temperature surface heat	1
		Sparks from welding and fusing	1
		Unknown	1
Electrical wiring	3 (13%)	High temperature surface heat	1
		Electric sparks	2
Dangerous substance handling pipes	4 (17%)	High surface heat	4
Service tank	2 (8%)	Overheating	1
		Sparks from welding and fusing	1
Other	2 (8%)	Overheating	1
		Unknown	1
Total	24		

* The figures in brackets indicate the ratio out of the total number of fires 824) that have occurred in private generating equipment over the past 10 years.

According to Tables 5 and 6, most cases of fire (13 out of 24 or 54%) in private generating equipment occurred in internal combustion engines, followed next by those occurring in dangerous substance handling pipes (4 cases) and electrical equipment (wiring, circuits, etc.) (3 cases). Out of the fires that broke out in internal combustion engines, 7 (53%) were caused by overheating. In such cases, failure of the internal combustion engine caused leakage of fuel or lubricating oil, which came into contact with the high temperature parts of the engine and caught fire. Moreover, concerning fires that broke out in dangerous substance handling pipes, fuel leaks out due to the corrosion of pipes, comes into contact with the high temperature parts of the engine and catches fire.

Table 7 shows examples of the main causes of fires.

Table 7 Examples of Fires in Private Generating Equipment (General Handling Facilities) (Past 10 Years)

Date	Outline of Incident	Damage
January 15, 2003	Fire broke out due to generator engine trouble in private generating equipment during operation (because lubricating oil was not supplied, abrasion heat caused the bolts to loosen and parts to fly off, thereby damaging the fuel pump).	Approximately 165m^2 of building, 2 power generation units and the power receiving panel, etc. were destroyed by fire, and the total cost of damages was 38.59 million yen.
July 14, 2004	Damage to the fuel injection pipe of private generating equipment for supplying emergency power caused fuel (heavy oil) to gush out, and fire broke out when this came into contact with the engine exhaust high temperature part.	Out of 7 power generating units, 1 was completely burned and 2 were partially burned, and the cost of damages was 40 million yen.
September 10, 2007	Pipe connection with the hydraulic device attached to the private generating equipment became loose, and fire broke out when leaking fuel came into contact with high temperature parts. Due to damage of the fuel pipes, around 1,200 liters of fuel escaped and gathered inside the oil fence, thereby causing the fire to spread.	One power generating unit was burned and the cost of damages was 93.94 million yen.
December 8, 2007	On conducting repeated startup operation for inspection of the private generating equipment, non-vaporized heavy oil mist accumulated inside the exhaust stack and fire broke out when it came into contact with exhaust gases from the private generating equipment.	Two private generating equipment units and exhaust gas stack, etc. were burned.
November 18, 2009	Shorting occurred in the voltage control transformer inside the private generating equipment control panel, and fire broke out when this set fire to the covering of connected wires.	Transformer and cables, etc. were burned.

(2) Situation regarding outflow accidents in private generating equipment from 2005 to 2009

Table 8 shows the number of outflow accidents that occurred in private generating equipment (restricted to those corresponding to general handling facilities) between 2005 and 2009 (five years), and Table 9 shows the main outflow cases.

Table 8 Number of Outflow Accidents Occurring in Private Generating Equipment Installed in Buildings, etc.

Year	2005	2006	2007	2008	2009	Total
Number of cases	2	4	2	2	3	13

Table 9 Main Examples of Outflow Accidents Occurring in Private Generating Equipment (General Handling Facilities) (past 5 years)

Date	Outline of Incident	Damage
March 31, 2006	The valve of the oil feeding pipe of an idle private generating equipment unit became loose, heavy oil was sent to the equipment and it overflowed from the top of the service tank to the oil fence. The oil return pump, which was also idle, failed to operate. Because the rainwater pipe that was fitted inside the oil fence was broken, heavy oil flowed out from the broken part and into the river.	The outflow quantity was unknown.
May 29, 2009	Major vibration occurred in the fuel pipe when the emergency generator was operating, the piping became cracked due to metal fatigue, and 4,000 liters of heavy oil escaped.	Heavy oil escaped from the generator room on the first floor to the first and second basement floors.

As may be gathered from Tables 8 and 9, outflow accidents occur on average 2.6 times a year in private generating equipment and there has been an accident in which 4,000 liters of fuel escaped.

3.2.3 Extraction and Analysis of Fire Risk Factors

Concerning the extraction and analysis of fire risk factors, verification was implemented from the following viewpoints upon considering the fire risks that need to be verified in 3.1 and the conditions of accidents in private generating equipment that were described in 3.2.2.

- In cases of fire outbreak from private generating equipment, what is the effect on lithium ion batteries installed near to the said equipment?
- In cases of fire outbreak from lithium ion batteries, what is the effect on nearby private generating equipment?

(1) Extraction of fire risk factors

a. Cases of fire outbreak from private generating equipment

Table 10 shows the equipment that handles hazardous substances and is at risk of fire based on past cases, and the parts that are impacted by fire.

Table 10 Hazardous Substances Handling Equipment at Risk of Fire and Parts at Risk of Damage

Equipment, etc. (private generating equipment) that handles hazardous substances and is at risk of fire	Lithium ion battery equipment at risk of damage
− Internal combustion engine − Service tank − Hazardous substance pipe − Electrical equipment (including wiring and circuitry, etc.) − Others (exhaust stack, etc.)	− Lithium ion batteries − Electrical equipment (including wiring and circuitry, etc.)

Based on Table 10, Table 11 shows the contents, course and scale of projected disasters in cases where fires occur in equipment that handles hazardous substances, etc.

Table 11 Contents, Course and Scale of Projected Disasters

Projected Fire Risk Factor	Contents of Disaster	Background, etc. to Accident	Maximum Projected Accident (Scale)
Internal combustion engine	Fire outbreak from the internal combustion engine	Cases where fire occurs due to faulty parts or failure, etc. in the internal combustion engine	Burning of private generating equipment
Service tank	Fire caused by oil outflow from service tank	Cases where fire is caused by hazardous substances leaking from the service tank due to corrosion or poor installation, etc. and coming into contact with high temperature parts	Fire inside the oil fence around the service tank (depending on the area of the oil fence)
Hazardous substance pipe	Fire caused by oil outflow from piping	Cases where hazardous substances gushes out from loose pipe flanges and so on and comes into contact with high temperature parts	Fire in high temperature parts caused by outflow of hazardous substances from pipes (fires also occur inside the oil fence due to oil outflow from pipes).
Electrical equipment (including wiring and circuitry, etc.)	Fire outbreak from wiring, etc.	Cases where fires break out from wiring, etc. caused by shorting over time	Burning of private generating equipment
Others (exhaust stack, etc.)	Fire outbreak from exhaust stack, etc.	Cases where fuel mist inside the exhaust stack catches fire due to heat from exhaust gas	Burning of exhaust stack and other equipment

b. Cases of fire outbreak from lithium ion battery equipment

Table 12 shows the equipment that handles hazardous substances and is at risk of fire based on past cases, and the parts that are impacted by fire.

Table 12 Hazardous Substances Handling Equipment at Risk of Fire and Parts at Risk of Damage

Lithium ion battery equipment where fire occurs	Damaged private generating equipment
− Lithium ion batteries − Electrical equipment (including wiring and circuitry, etc.)	− Internal combustion engine − Service tank − Hazardous substance pipe − Electrical equipment (including wiring and circuitry, etc.)

Based on Table 12, Table 13 shows the contents, course and scale of projected disasters in cases where fires occur in lithium ion battery equipment.

Table 13 Contents, Course and Scale of Projected Disasters

Projected Fire Risk Factor	Contents of Disaster	Background, etc. to Accident	Maximum Projected Accident (Scale)
Lithium ion batteries	Fire outbreak from lithium ion batteries	Fire outbreak from lithium ion batteries caused by faulty products	Burning of lithium ion batteries
Electrical equipment (including wiring and circuitry, etc.)	Fire outbreak from electrical equipment	Cases where fire breaks out from electric equipment due to poor installation or deterioration over time, etc. and spreads to lithium ion batteries	Burning of lithium ion batteries

(2) Analysis and Assessment of Fire Risk Factors

Based on the fire risk factors extracted in (1), the results of analyzing fire risk in cases of fire breaking out from private generating equipment and fire breaking out from lithium ion battery equipment are indicated below.

Moreover, assessment of risk arising from general fire risk factors is generally based on the sum product of the possibility and extent of fire occurrence (degree of fire risk), and the results are as shown in Table 14. In conducting analysis and assessment of fire risk factors, this technique was used.

Table 14 Product of Fire Risk and Fire Extent

		Extent in case where fire occurs		
		Small	Medium	Large
Fire risk	Small	Small	Small	Medium
	Medium	Small	Medium	Large
	Large	Medium	Large	Large

* The yellow parts indicate the product of the fire risk and extent of fire in the event where it occurs.

a. Cases where fire breaks out from private generating equipment

In implementing analysis and assessment of fire risk factors, the possibility of the fire risk factors extracted from accidents in private generating equipment installed inside buildings occurring can be described as follows:

○ **Possibility of fire breaking out from an internal combustion engine: Large**

(Because this type of fire is the most common, accounting for 54% of the total)

○ **Possibility of fire breaking out due to oil outflow from a service tank: Small**

(Although outflow accidents do occur, they only account for 8% of fires).

○ **Possibility of fire breaking out due to oil outflow from dangerous substance handling pipes: Medium**

(Because this type of fire is the second most common, accounting for 17% of the total)

○ **Possibility of fire breaking out from electrical equipment (wiring, etc.): Medium**

(Because this type of fire accounts for 13% of the total)

○ **Possibility of fire breaking out from other areas (exhaust stack, etc.): Small**

(Because such cases only account for 8% of the total)

In consideration of this, Table 15 shows the degree of risk (product of fire risk and extent of fire in the event of occurrence) in cases where fire breaks out from private generating equipment.

Table 15 Degree of Risk in Case where Fire Breaks Out from Private Generating Equipment

Project fire risk factor	Contents of disaster	Possibility of occurrence (A)	Scale of disaster	Extent (B)	Degree of risk (A x B)
Internal combustion engine	Fire from internal combustion engine	Large	Size of the internal combustion engine	Medium	Large
Service tank	Fire caused by outflow from service tank	Small	Fire to the extent of the oil fence area	Large	Medium
Hazardous substance pipe	Fire caused by oil outflow from pipes	Medium	Fire to the extent of the entire private generating equipment area	Large	Large
Electrical equipment (including wiring and circuitry, etc.)	Fire outbreak from wiring, etc.	Medium	Size of internal combustion engine	Medium	Medium
Others (exhaust stack, etc.)	Fire outbreak from exhaust stack, etc.	Small	Size of internal combustion engine	Small	Small

Out of the contents shown in Table 15, cases with the biggest impact (highest degree of risk) are fires that break out from internal combustion engines and those caused by oil outflow from pipes. Judging from the accident cases too, since the extent of damage is large in cases of oil outflow from hazardous substances pipes, it is necessary to verify by demonstration experiment the impact on lithium ion batteries in the case where fire spreads to the private generating equipment overall.

However, since it is extremely dangerous to conduct such an experiment on the scale of real equipment, it is necessary to conduct experiment using a reduced model and to calculate the impact in the case of an actual fire.

b. Cases where fire breaks out from lithium ion batteries

As in cases of fire outbreak from private generating equipment, the possibility of the extracted fire risk factors occurring can be described as follows:

○ **Possibility of fire breaking out from lithium ion batteries: Small**

(Although six fires have occurred in facilities that manufacture or store lithium ion batteries, safety has been secured under the Electrical Appliance and Material Safety Law and so on).

○ **Possibility of fire breaking out from electrical equipment (wiring, circuitry, etc.): Medium**

(Judging from the conditions surrounding the warehouse fire described later on in 3.3, there have been 115 fires that broke out in the wiring of lights and telephones, etc.)

In consideration of this, Table 16 shows the degree of risk in cases where fire breaks out from lithium ion batteries.

Table 16 Degree of Risk in Case where Fire Breaks Out from Lithium Ion Batteries

Project fire risk factor	Contents of disaster	Possibility of occurrence	Scale of disaster	Extent	Degree of risk
Lithium ion batteries	Fire outbreak from lithium ion batteries	Small	Burning of lithium ion batteries	Medium	Small
Electrical equipment (including wiring and circuitry, etc.)	Fire outbreak from electrical equipment	Medium	Burning of lithium ion batteries	Medium	Medium

Since the impact of fires from lithium ion batteries to private generating equipment is thought to be smaller than the impact of fires from private generating equipment to lithium ion battery equipment, we decided to omit the verification of impacts of fires starting in the lithium ion battery equipment.

3.3 Extraction and Analysis of Fire Risk in Cases where Lithium Ion Batteries, etc. are Stored

Regarding cases of bulk storage of lithium ion batteries and so on, assuming that large quantities of lithium ion batteries and so on are stored in a warehouse that isn't a dangerous facility (hereafter referred to as a general warehouse), fire risk factors concerning the storage of lithium ion batteries and so on are extracted and analyzed in light of fires that have occurred in general warehouses.

3.3.1 Conditions regarding Warehouse Fires

Table 17 shows the number of warehouse fires and the burned area per incident. It can be seen that around 670 warehouse fires occur every year and the area burned is around 100 square meters per fire.

Table 17 umber of Warehouse Fires and Area Burned per Incident

Year	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Average
Number of fires	791	809	766	685	724	638	525	609	583	583	601	665
Area burned per incident (m^2)	85.8	107.6	100.7	97.9	90.7	124.7	90.1	84.8	124.7	124.7	82.6	100.9

* The figures for each year are obtained by totaling the number of fires occurring between January and December.

Fires in warehouses have numerous causes such as faulty wiring of electrical instruments and telephones and dropped cigarettes and so on. Table 18 shows the number of fires that are thought to have broken out from objects routinely found in warehouses and analyzes the relationship between fire sources and burned objects. Incidentally, the data shows the total number of fires reported in warehouses (between January and December each year) over the five-year period from 2005 to 2009.

Table 18 Causes (Total) of Warehouse Fires over the Past Five Years (2005~2009)

Cause of fire	Number of cases	Object of ignition											
		Unknown	Buildings, etc.		Objects inside buildings								Others
			Buildings and furniture such as walls and pillars, etc.	Electric wire covering	Gases	Flammable liquids	Fibers (clothes, cloths, etc.)	Wood such as timber and firewood, etc.	Flammable solids (charcoal, rubber products, etc.)	Wastes (paper, wood and metal wastes, etc.)	Other objects in buildings	Automobiles	
Electrical instruments	61	3	4	7	1	3	11	2	13	10	2	3	2
Electrical devices	53	2	5	18	2	9	1	1	7	6	0	0	2
Wiring for lights and telephones, etc.	115	5	25	39	0	1	5	5	15	10	4	5	1
Wiring apparatus	61	0	9	23	0	3	7	1	12	4	0	2	0
Lamp	6	0	2	0	0	1	1	1	0	1	0	0	0
Cigarette	207	5	20	1	0	2	32	4	12	96	3	1	31
Match or lighter	291	15	8	2	4	32	85	8	29	70	4	2	32
Unknown	953	594	39	10	1	12	100	36	43	73	9	6	30
Total	1,747	624	112	100	8	63	242	58	131	270	22	19	98

* In addition to the above, fires have also been caused by gas rings, stoves and arson, etc.

Item definitions are as follows:

Electrical instruments : Domestic electrical appliances, batteries, machine tools, etc.
Electrical devices : Transformers, control panels, etc.
Wiring for lights and telephones, etc. : Distribution lines, extension lines, telephone lines, etc.
Wiring apparatus : Switches, plugs, meters, etc.
Lamp : Votive lamp, candle, etc.

(1) Analysis of fire causes

The relationship between the sources of warehouse fires and burned objects is analyzed as follows according to Table 18.

a. Out of the fires where fires broke out in electrical apparatus, lighting and telephone, etc. wiring, wiring apparatus and lights installed in buildings, 121 cases entailed burning of buildings and 104 cases entailed burning of the stored objects, and there were some cases where the object inside warehouses caught fire from wiring, etc.

b. Concerning fires that broke out in electrical instruments, the number of cases of burning of objects inside buildings (42) was roughly four times higher than the number of cases of burning of buildings, etc. (11), indicating that fires from electrical appliances spread to surrounding flammable objects.

c. Excluding cases of unknown cause, fires originating from cigarettes, matches or lighters were more common than fires that broke out in electrical instruments and electrical devices, etc., and the fire spread to objects inside buildings in almost all such cases.

(2) Extent of burning in warehouse fires

The following table shows the extent of burning in fires caused by the factors indicated in Table 18. Out of the fires indicated here (a total of 1,747 incidents, not including those caused by explosions), Table 19 shows the extent of burning and the number of cases where fire spread to adjoining buildings.

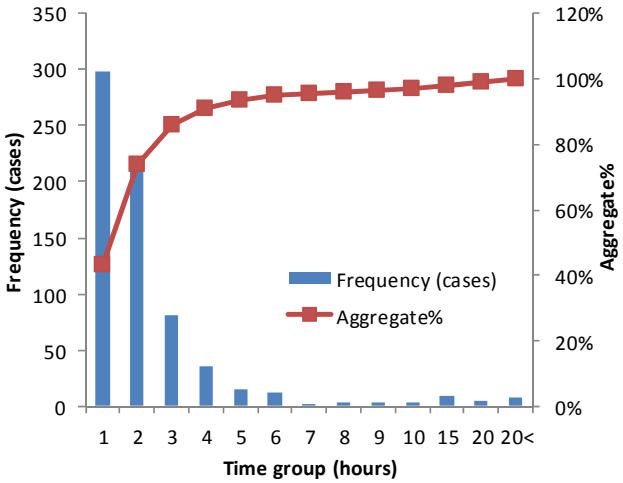
Table 19 Extent of Burning and Number of Cases where Fire Spread to Adjoining Buildings

Extent of burning	Number of cases (a) (ratio of total)		Number of cases of fire spreading to adjoining buildings (b) (b/a)	
Total destruction	743	(43%)	328	(44%)
Semi-destruction	175	(10%)	44	(25%)
Partial burning	437	(25%)	49	(11%)
Small fire	369	(21%)	18	(5%)
Total	1,724		439 (25%)	

According to Table 19, the number of fires that led to total destruction, semi-destruction and partial burning was 1,355, or 78% out of 1,724 cases. The most common were fires that led to total destruction (743), which accounted for 43% of the total number of fires. The number of fires that spread to adjoining buildings was 439 (25%), indicating that one out of every four fires indicated in Table 19 spread to adjoining buildings.

(3) Time required for extinguishing

Out of the fires that broke out due to the causes shown in Table 18, concerning the 743 that led to total destruction, Figure 3 shows the time that was required from outbreak to extinguishment. Fires in which the time of outbreak is unknown (55 cases) are excluded.



Time group (hours)	Frequency (cases)	Aggregate%
1 (X≦1)	298	43.3%
2 (1＜X≦2)	211	74.0%
3 (2＜X≦3)	82	85.90%
4 (3＜X≦4)	36	91.1%
5 (4＜X≦5)	15	93.3%
6 (5＜X≦6)	12	95.1%
7 (6＜X≦7)	2	95.4%
8 (7＜X≦8)	3	95.8%
9 (8＜X≦9)	4	96.4%
10 (9＜X≦10)	3	96.8%
15 (10＜X≦15)	9	98.1%
20 (15＜X≦20)	5	98.8%
Next class (X≦20)	8	100.00%
Total number of cases	**688**	

* Out of the 743 fires that led to total destruction, fires in which the time of outbreak is unknown (55 cases) are excluded.

Figure 3 Time Required from Fire Outbreak to Extinguishment (Fires that Led to Total Destruction)

From Figure 3 it can be seen that fires that caused total destruction were most frequently extinguished in 1 hour or less, and next most frequently in 1 to 2 hours. Concerning warehouse fires, the most common case is fire that leads to total destruction in less than 2 hours from the causes of outbreak shown in Table 18, and this indicates that fires spread very rapidly.

(4) Results of Analysis of Warehouse Fires

The results of analyzing warehouse fires can be summarized as shown below.

a. Warehouse fires have various causes but they often break out in electrical instruments and wiring, etc. and spread to walls, pillars and objects contained inside buildings.

b. Out of fires that originate in electrical wiring and so on, the most common case is fire that leads to total destruction, and the fire spreads to adjoining buildings in one out of four cases.

c. In terms of time from outbreak to extinguishment, fires are mostly extinguished in less than two hours, however, the most common case is fire that lead to total destruction, thus indicating the speed at which fire spreads. (Incidentally, in lithium ion battery fires in 2007, the required time for extinguishing was around 17 hours).

3.3.2 Extraction and Analysis of Fire Risk Factors in Cases where Large Quantities of Lithium Ion Batteries, etc. are Stored in General Warehouses

Judging from the conditions of warehouse fires described in 3.3.1, the following paragraphs describe the contents of extraction and analysis of fire risk assuming cases where a large quantity of lithium ion batteries are stored in a general warehouse, etc.

(1) Extraction of fire risk factors

Similar to the extraction of fire risk factors in 3.2.3, Table 20 shows the contents, course and scale of projected disasters in cases where lithium ion batteries, etc. are stored in general warehouses.

Table 20 Contents, Course and Scale of Projected Disasters

Projected Fire Risk Factor	Contents of Disaster	Background, etc. to Accident	Maximum Projected Accident (Scale)
Electrical instruments	Fire outbreak from electrical instruments	Fire breaks out from electrical instruments due to faulty products, etc. and spreads to other stored objects.	Total destruction of warehouse
Electrical devices	Fire outbreak from electrical devices	Fire breaks out from electrical devices due to faulty products, etc. and spreads to other stored objects.	Total destruction of warehouse
Wiring of lights and telephones, etc.	Fire outbreak from wiring of lights and telephones, etc.	Fire breaks out from wiring of lights and telephones, etc. due to deterioration over time, etc. and spreads to other stored objects.	Total destruction of warehouse
Wiring apparatus	Fire outbreak from wiring appliances	Fire breaks out from wiring appliances due to faulty products, etc. and spreads to other stored objects.	Total destruction of warehouse

(2) Analysis of fire risk factors

In conducting analysis and assessment of fire risk factors, judging from the conditions of warehouse fires described in 3.3.1, the possibility of fires arising from the extracted factors are as indicated below.

○ **Possibility of fire breaking out from electrical instruments: Medium**

(Because there were 61 such cases over five years).

○ **Possibility of fire breaking out from electrical devices: Medium**

(Because there were 53 such cases over five years)

○ **Possibility of fire breaking out from wiring of lights and telephones, etc.: Large**

(Because there were 115 such cases over five years)

○ **Possibility of fire breaking out from wiring apparatus: Medium**

(Because there were 61 such cases over five years)

(1) Based on the fire risk factors extracted in (1), the results of analyzing the degree of fire risk using the risk assessment technique shown in Table 14 are as shown in Table 21.

Table 21 Degree of Risk in Cases where Lithium Ion Batteries, etc. are Stored in General Warehouses

Project fire risk factor	Contents of disaster	Possibility of occurrence	Scale of disaster	Extent	Degree of risk
Electrical instruments	Fire outbreak from electrical instruments	Medium	Stored objects or the entire warehouse	Large	Large
Electrical devices	Fire outbreak from electrical devices	Medium	Stored objects or the entire warehouse	Large	Large
Wiring of lights and telephones, etc.	Fire outbreak from wiring of lights and telephones, etc.	Large	Stored objects or the entire warehouse	Large	Large
Wiring apparatus	Fire outbreak from wiring appliances	Medium	Stored objects or the entire warehouse	Large	Large

Judging from Table 21, since safety measures in general warehouses are not necessarily taken according to the contents of dangerous substances, the degree of risk once fire breaks out is high. Considering that fires break out from various causes and spread to the objects contained in the warehouse, it is necessary to conduct assessment of safety and so on with respect to fires in lithium ion batteries.

CHAPTER 4 TESTS FOR VERIFYING THE EXAMINATION ISSUES, AND RESULTS

Demonstration tests were carried out in order to confirm the following three points in lithium ion batteries (also referred to as batteries in this and the following chapter): 1) Fire risk before and after sealing, 2) Safety measures for batteries, and 3) Safety during storage.

When conducting the demonstration tests, the following preconditions were assumed: 1) lithium ion battery equipment that uses batteries (also referred to as battery equipment in this and the following chapter) is charged to 100% ready for charge and discharge, 2) the charge factor during storage is a maximum of 50%, 3) the single cell type battery (18650), which is widely available on the market, is used in the tests, and 4) a reduced scale model is used because texting on the actual equipment scale would be very dangerous.

Cooperation was sought from the Battery Association of Japan concerning the batteries used in tests, and the empty batteries and electrolyte used in pre-sealing tests.

4.1 Fire Risk Evaluation Test Before and After Sealing

4.1.1 Objective of Tests

There is a risk that batteries stored close to private generating equipment or in warehouses will get caught up in fires and be exposed to naked flames. In this testing, in addition to confirming combustibility characteristics assuming the extreme case where extremely large thermal energy is supplied to a single cell battery in a short time, combustibility of a battery before sealing is confirmed under the same conditions. (Comparison is conducted between combustibility characteristics in the pre-sealing state, in the 50% charged state and in the 100% charged state).

4.1.2 Test Conditions and Test Method

(1) Batteries, etc. used in testing

In order to assess fire risk in cases where batteries are installed close to private generating equipment and cases where they are stored in warehouses, Type 18650 batteries (containing around 2 cc of electrolyte) were used in the fully charged state (100% charged) and with the maximum charge rate adopted during the distribution stage (50% charged).

Moreover, in order to confirm combustion characteristics before sealing, the same container (or substitute container) and electrolyte (or substitute) as used in batteries were used.

(2) Burner used in testing

A conventional gas burner (the type used in cooking experiments) was used to heat up the batteries.

(3) Time exposed to flames

According to fire statistics, since the average time required to extinguish fires in buildings is approximately 57 minutes, this time should be adopted, however, considering that the force of fires tends to die down, it was decided to check combustion characteristics for around 20 minutes (one-third of the time required to extinguish fires). Moreover, since burner flame is similar to the state of flames in the initial stages of fire, it is necessary to consider that fire will quickly spread from this state in a short time. (If combustion ends before 20 minutes elapse, only that time will be assumed).

(4) Number of tests

Considering disparities between individual batteries, tests were implemented at least three times.

(5) Test method

Concerning batteries before sealing, the battery and a similar amount of electrolyte were inserted into the same container (an open container with no contents) as used for sealed batteries, heating was directly carried out under the aforementioned conditions using the burner as shown in Figure 4, and the combustion characteristics were confirmed.

Concerning sealed batteries, heating was directly carried out under the aforementioned conditions using the burner as shown in Figure 5, and the combustion characteristics were confirmed.

Figure 4 Lithium ion battery (after sealing)

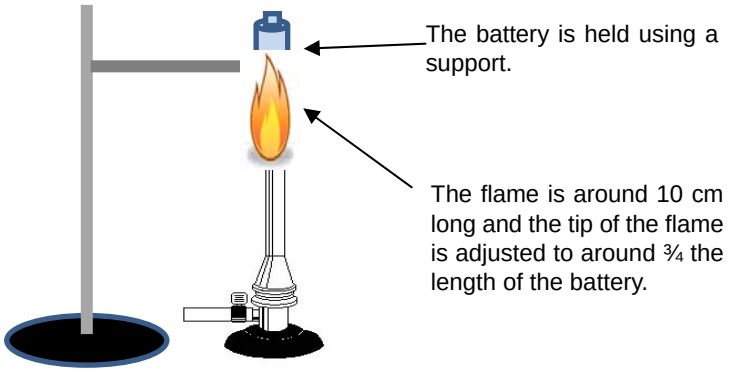
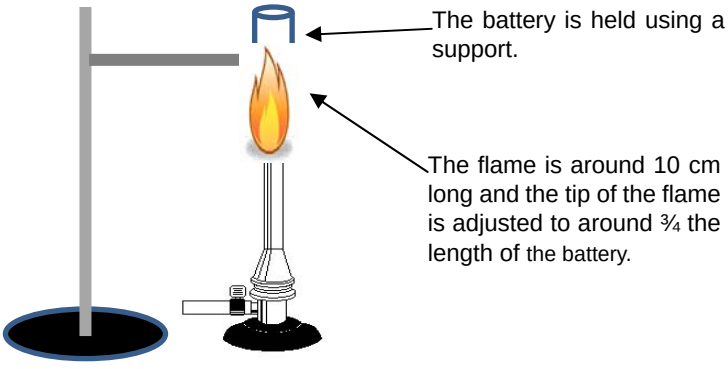


Figure 5 Lithium ion battery (before sealing)



4.1.3 Verification Items

Batteries before and after sealing were heated under the same conditions and the following items were confirmed:

- Time required to catch fire
- Combustion characteristics after catching fire (height of flames, continuous burning time, etc.)
- Condition of battery following combustion

4.1.4 Test Results

(1) Battery before sealing

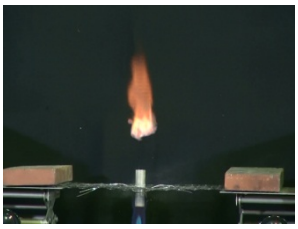
The results of carrying out the same experiment three times are indicated below. The first test was conducted on November 17 while the second and third tests were conducted on November 24.

Concerning the conditions of change, after the start of heating, the battery caught fire, it burned continuously for a certain time, the fire was extinguished, white smoke was emitted immediately after extinguishing, and finally the white smoke stopped being emitted. Table 22 shows the test results, while Figure 6 shows the conditions during the test. Incidentally, the photograph in Figure 6 is from the first test conducted on November 17.

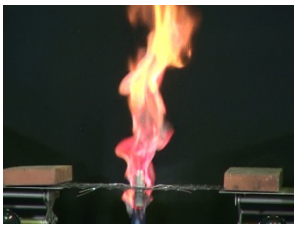
Table 22 Test Results for Battery before Sealing

	Time from start of heating to ignition	Time from start of heating to extinguishing	Time from start of heating to when white smoke stops appearing	Height of the biggest flame during combustion
1st	6 sec	18 sec	26 sec	Around 40 cm
2nd	4 sec	17 sec	32 sec	Around 40 cm
3rd	6 sec	21 sec	35 sec	Around 65 cm
Average	4.7 sec	18.7 sec	31 sec	Around 48 cm

Start of heating

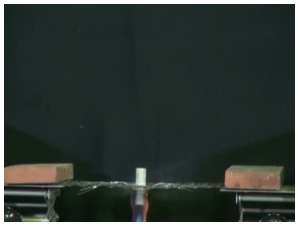


After 6 sec



After 7 sec

After 18 sec



After 26 sec

Figure 6 Course of Test (battery before sealing) (implemented on November 17) (1st test)

(2) Battery after sealing (charging rate 50%)

The results of conducting the test three times were as follows. The first test was conducted on November 17 while the second and third tests were conducted on November 24.

Concerning the conditions of change, after the start of heating, the battery caught fire, it burned continuously for a certain time while emitting a blowing sound, flames and sparks, then it combusted with flame only, and finally it went out. Table 23 shows the test results, while Figure 7 shows the conditions during the test. Incidentally, the photograph in Figure 7 is from the first test conducted on November 17.

Table 23 Test Results for Battery After Sealing (charging rate 50%)

	Time from start of heating to ignition	Time from start of heating to extinguishment of sparks	Time from start of heating to extinguishment of flame	Height of the biggest flame during combustion
1st	23 sec	30 sec	53 sec	Left/right around 35 cm
2nd	19 sec	26 sec	46 sec	Left/right around 40cm
3rd	22 sec	30 sec	55 sec	Left/right around 40cm
Average	21.3 sec	28.7 sec	51.3 sec	Left/right around 38 cm

(Note) Sparks fly over a larger range than the largest flame during combustion.

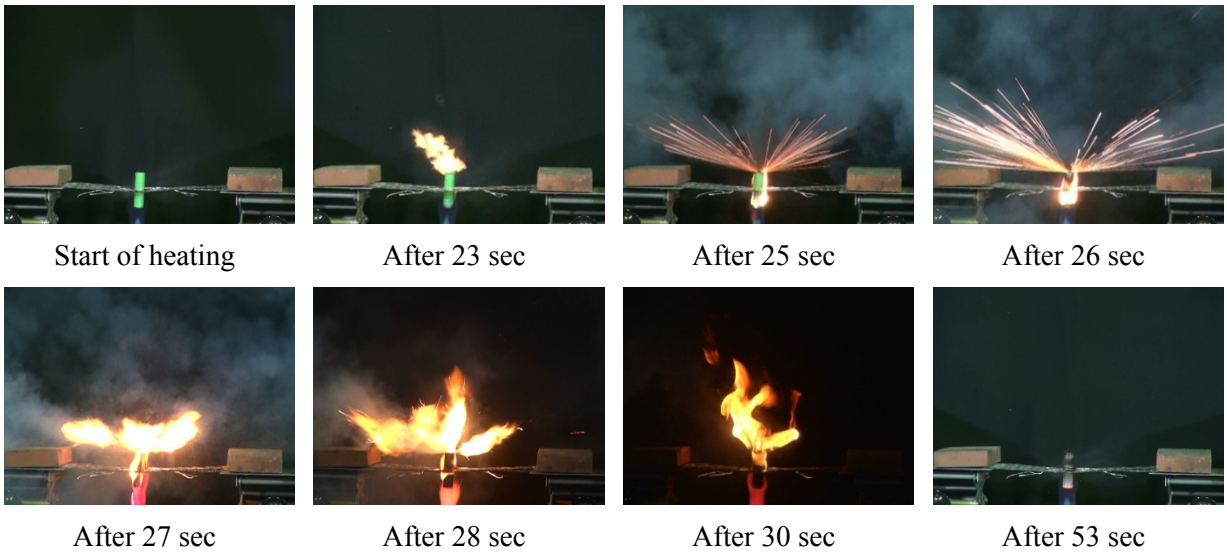


Figure 7 Course of Test (battery after sealing) (charging rate 50%) (Implemented on November 17) (1st test)

(3) Battery after sealing (charging rate 100%)

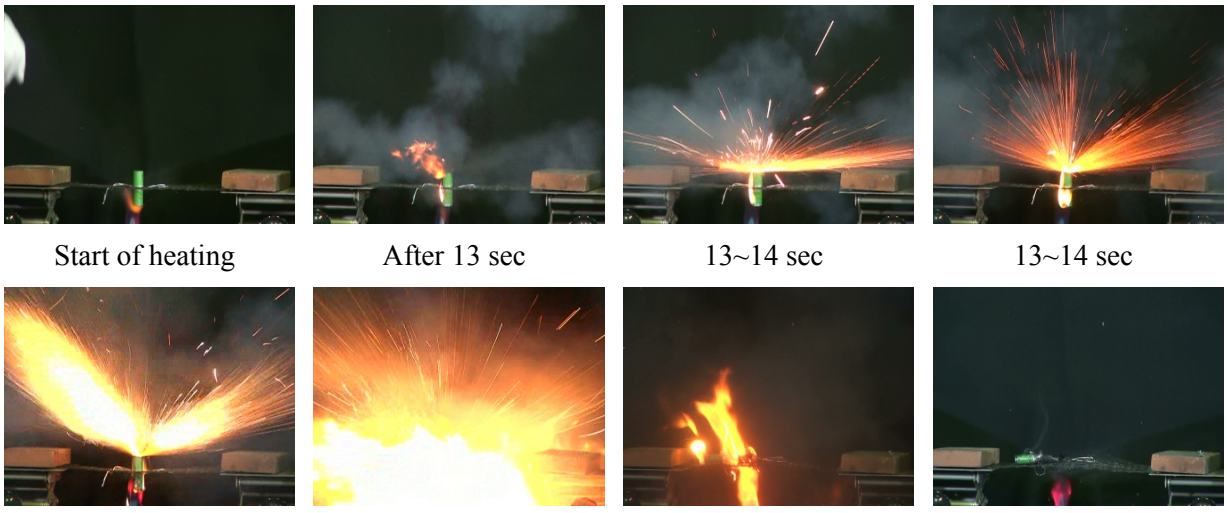
The results of conducting the test three times were as follows. The first test was conducted on November 17 while the second and third tests were conducted on November 24.

Concerning the conditions of change, after the start of heating, the battery caught fire, it burned continuously for a certain time while emitting a blowing sound, flames and sparks, then it combusted with flame only, and finally it went out. Table 24 shows the test results, while Figure 8 shows the conditions during the test. Incidentally, the photograph in Figure 8 is from the first test conducted on November 17.

Table 24 Test Results for Battery after Sealing (charging rate 100%)

	Time from start of heating to ignition	Time from start of heating to extinguishment of sparks	Time from start of heating to extinguishment of flame	Height of the biggest spark during combustion
1st	13 sec	14 sec	24 sec	Around 1m
2nd	17 sec	23 sec	34 sec	1m or more
3rd	12 sec	15 sec	25 sec	1m or more
Average	14 sec	17.3 sec	27.7 sec	Around 1m

(Note) Flames also appeared in line with the flying of sparks.



Start of heating | After 13 sec | 13~14 sec | 13~14 sec

After 14 sec | Immediately after 14 sec | Immediately after 14 sec | After 24 sec

Figure 8 Course of Test (battery after sealing) (charging rate 100%) (implemented on November 17) (1st test)

4.1.5 Observations

Although the risk of batteries catching fire has been largely reduced, since there is still possibility that they will be caught up in fires for some reason or other, combustion characteristics were ascertained through directly exposing batteries before sealing and after sealing (with charging rate of 50% and 100%) to flame. As a result, as is shown in the test results described in 4.1.4, there was found to be no mitigation in combustion in the sealed batteries compared to the batteries before sealing.

4.2 Evaluation Test for Battery Safety Measures

4.2.1 Test Objective

The test intends to verify whether or not certain safety measures taken for batteries are effective during fires.

4.2.2 Test Conditions and Test Method

(1) Batteries, etc. used in testing

In order to assess the effectiveness of certain safety measures taken for batteries in cases where batteries are installed close to private generating equipment and cases where they are stored in warehouses, Type 18650 batteries (containing around 2 cc of electrolyte) were used in the fully charged state (100% charged) and with the maximum charge rate adopted during the distribution stage (50% charged).

(2) Burner used in testing

A conventional gas burner (the type used in cooking experiments) was used to heat up the batteries.

(3) Time exposed to flames

The time exposed to flames was 20 minutes as in the case of exposure to direct flames.

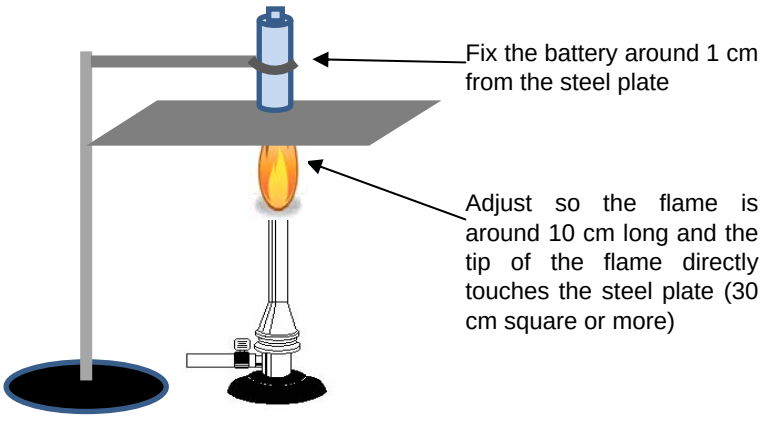
(4) Number of tests

Considering disparities between individual batteries, tests were implemented at least three times.

(5) Test method

Through inserting a steel plate of certain thickness (1.6 mm or more) between the flame and battery, changes in the state of combustion were confirmed.

Figure 9 Confirmation of effectiveness of safety measures



4.2.3 Verification Items

Through inserting a steel plate of certain thickness (1.6 mm or more) between the flame and battery, changes in the state of combustion were confirmed. (Effectiveness of the steel plate in blocking the flame was ascertained).

4.2.4 Test Results

As a result of conducting tests three times each for batteries charged to a factor of 50% and 100% respectively, flames didn't reach the batteries in any cases. The first test on batteries with a charging rate of 100% was implemented on November 17, while the remaining tests were implemented on November 24. Table 25 shows the changes in the surface temperature of batteries in each test, while Figure 10 shows the test conditions. Incidentally, the photograph in Figure 10 is from the first test conducted on November 17.

Table 25 Surface Temperature of Battery during Each Test

		Surface temperature just before ignition	Surface temperature at the end (after 20 minutes)
Charging rate 100%	1st	17.8 ºC	43.1 ºC
	2nd	16.8 ºC	51.5 ºC
	3rd	25.5 ºC	56.8 ºC
Charging rate 50%	1st	21.8 ºC	48.9 ºC
	2nd	26.8 ºC	52.8 ºC
	3rd	23.3 ºC	51.9 ºC

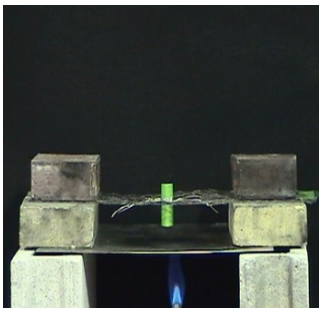


Figure 10 Test Conditions
(First test implemented on November 17)
No change was observed in the battery after 20 minutes of heating by flame.

4.2.5 Observations

Through inserting a steel plate of 1.6 mm thickness between the flame and battery, it was confirmed that fire doesn't spread to the battery for 20 minutes.

4.3 Test to Confirm Safety during Storage

4.3.1 Test Objective

In cases where large quantities of batteries are stored in warehouses, it is possible that batteries stored on mounts will fall in the event of earthquake and so on. Tests were conducted in order to confirm the risk of leakage and the risk of flammable vapor retention when batteries fall.

4.3.2 Test Conditions and Test Method

(1) Batteries, etc. used in testing

In view of the preconditions in the case for warehouse storage, Type 18650 batteries (containing around 2 cc of electrolyte) were used with the maximum charge rate adopted during the distribution stage (50% charged).

(2) Drop height

The actual maximum stored height was adopted.

(3) Dropped surface

The battery was dropped onto a flat concrete surface.

(4) Dropped angle of battery

The angle that is deemed to generate the greatest impact

(5) Number of dropped batteries

The same type of battery was dropped at least three times.

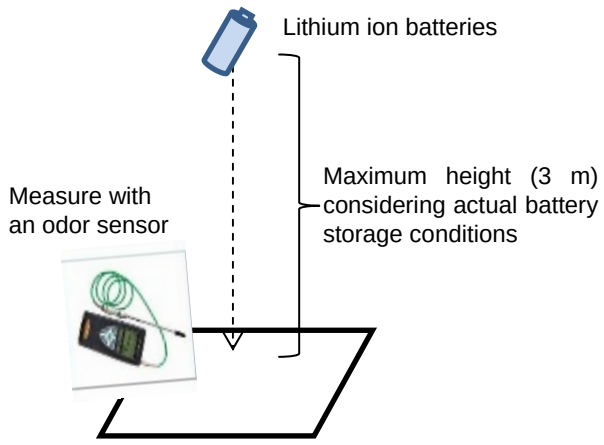
(6) Method for confirming leakage and flammable vapor

First, visual confirmation was carried out, and in cases where leakage and flammable vapor couldn't be confirmed visually, a portable device for measuring flammable vapor was used.

(7) Test method

Based on the abovementioned test conditions, batteries were dropped in the manner shown in Figure 11, visual checking for cracks and so on in the batteries was conducted and a flammable vapor measuring device was used in cases where conditions couldn't be ascertained visually.

Figure 11 Drop Test



4.3.3 Verification Items

Confirmation was carried out on battery deformation, damage and leakage in the case where it is dropped from the maximum height reflecting the actual storage conditions of batteries.

In cases where leakage couldn't be visually confirmed by eye, a flammable vapor measuring device was used to check.

4.3.4 Test Results

The drop test was conducted three times using a 50% charged battery. The first test was conducted on November 17 while the second and third tests were conducted on November 24. In all cases, there were no traces of leakage in the vicinity. Table 26 shows the test results, while Figures 12 and 13 show the equipment and materials used in the drop test.

Table 26 Drop Test Measurement Results

	Background measurement value	Measurement value after dropping
1st	16	300
2nd	33	45
3rd	27	49

(Note) An odor sensor was used for detecting.

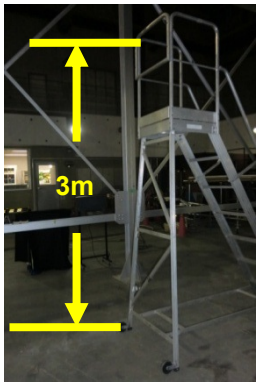


Figure 12 Platform for dropping samples

Figure 13 Odor sensor used for confirming leakage

4.3.5 Observations

As a result of the first test, the value increased to 300, however, on sealing the battery in a plastic bag and detecting once again with the sensor, the value initially increased to the said level but soon fell back to the background value. From this, it is possible that a minor deviation occurs in the pressure reduction mechanism, however, even assuming that the detected substance is all dimethyl carbonate, it is only in the order of a few ppm, which is far lower than the percentage order that is the lower explosive limit of ordinary substances (see Figure 14).

Moreover, in the second and third tests, figures remained almost in the same order.

In view of these findings, it was confirmed that there is not enough leakage of flammable gas to justify the adoption of an explosion-proof structure, etc.

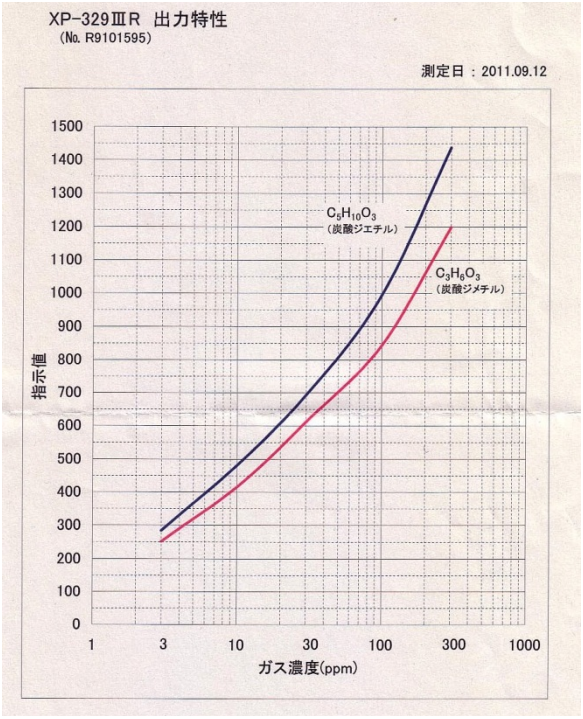


Figure 14 Output Characteristics of the Odor Sensor (dimethyl carbonate and diethyl carbonate)

* The vertical axis shows the sensor measurement and the horizontal axis shows gas concentration (ppm). The figure thus shows the correlation between dimethyl carbonate and diethyl carbonate measurements and gas concentration.

CHAPTER 5 APPROACH TO SAFETY MEASURES CONCERNING DANGEROUS FACILITIES THAT STORE AND HANDLE LITHIUM ION BATTERIES, ETC.

Since it is forecast that batteries will be increasingly used in future for the equalization of power demand and as emergency power supply, it will be necessary to ensure safety in storage and handling from now on.

Meanwhile, concerning batteries, since fire risk has been greatly reduced thanks to the Electrical Appliance and Material Safety Law and IMDG code and so on, and a certain degree of know-how has been acquired through demonstration tests, safety measures concerning the storage and handling of batteries have been compiled as follows.

5.1 Approach to Safety Measures Common to the Installation and Storage of Storage Battery Equipment

In cases where battery safety regarding externally applied force has been secured under the shock test prescribed in United Nations recommendation (UN3480) paragraph 38.3, T4 (restricted to batteries not targeted by the Electrical Appliance and Material Safety Law), which is applied in the IMDG code, and the crushing test that is prescribed in the Electrical Appliance and Material Safety Law, and there is confirmed to be no leakage of flammable vapor from the battery in the 3 meter drop test, the following measures are deemed to be appropriate.

The following conditions, which are required in dangerous facilities or small dangerous facilities that store and handle liquid hazardous substances shall not be required:

- In places where there is risk of flammable vapor accumulating, explosion-proof structure will be adopted for electrical equipment, etc.
- Floor structures will be such that hazardous substances cannot permeate.
- The floor shall be inclined and equipment (collection drain) for temporarily storing leaked hazardous substances shall be provided.

Moreover, in the testing here, batteries (single cell type 18650) were confirmed to possess the above performance, and it will be possible to handle other batteries in the same manner providing that they are confirmed to possess similar performance.

5.2 Approach to Safety Measures concerning the Installation of Storage Battery Equipment

5.2.1 Cases where only the Battery Electrolyte is Greater than the Designated Quantity

Considering the combustion characteristics of batteries before and after sealing, in cases where only the quantity of electrolyte is greater than the designated quantity, it is necessary to handle in dangerous facilities (general handling facility). Specifically, if similar safety measures as those adopted for private generating equipment in general handling facilities are adopted (for example, partitioning with fireproof structure (reinforced concrete structure with thickness of at least 70 mm and so on), it is appropriate to allow installation in building basements.

Out of the safety measures required for private generating equipment (general handling facility) installed in part of a building, the following measures are required for installing battery equipment.

[When installing in part of a building other than the rooftop]

- The designated quantity shall be less than 30 times.
- Signs and noticeboards shall be provided in conspicuous places. (Note 1)
- Electrical equipment shall be in accordance with legal stipulations for electric facilities. (Note 2)
- If the multiple of the designated quantity is more than 10 times, lightning conducting equipment shall be installed.
- Windows shall not be installed in areas used as general handling facilities in buildings.
- Special fire preventive equipment shall be installed at entrances/exits of areas used as general handling facilities in buildings. (Automatically closing equipment shall be adopted on exterior walls at risk of fire spreading and partition walls with other parts of the building).
- Floors that are used for general handling facilities of buildings that handle liquid hazardous substances shall have structure that doesn't allow hazardous substances to permeate, and the floor shall be inclined and fitted with equipment for temporarily storing leaked hazardous substances. (Note 2)
- The general handling facilities of buildings shall be equipped with lighting, illumination and ventilation equipment necessary for handling hazardous substances.
- General handling facilities in buildings where there is risk of flammable vapor or particulates accumulating shall be fitted with equipment for discharging the said vapor and particulates outside. (Note 2)
- Dampers that are effective for fire proofing shall be fitted to ventilation equipment and exhaust equipment. (Note 2)
- The facility walls, pillars, floors, beams and stairs shall comprise fireproof structure, and the area in question shall be partitioned from the rest of the building by floors and walls made from reinforced concrete structure with thickness of at least 70 mm, or a structure of equivalent strength, that has no openings other than the entrance/exit.
- In cases where the part used as a general handling facility has an upper floor, the floor shall be a fireproof structure, and in cases where there is no upper floor, the ceiling shall be made from noncombustible materials.

[When installing on a building rooftop]

- The designated quantity shall be less than 10 times.
- Signs and noticeboards shall be provided in conspicuous places. (Note 1)
- Electrical equipment shall be in accordance with legal stipulations for electric facilities. (Note 2)
- The equipment shall be installed on the roof of a building that has fireproof structure walls, pillars, floors, beams and ceilings.
- The equipment that handles hazardous substances shall be fixed on the rooftop.
- The equipment that handles hazardous substances shall be a cubicle structure.
- An enclosure of at least 0.15 meters in height shall be provided around the equipment that handles hazardous substances. (Note 2)
- Vacant space of at least 3 meters in width shall be secured around the equipment that handles hazardous substances. However, in cases where building walls (restricted to those that do not have openings except for the entrance/exit equipped with automatically closing special fire preventive equipment) and pillars within less than 3 meters from the equipment are fireproof structures, that distance shall be sufficient.
- The area inside the enclosure placed around the equipment that handles hazardous substances shall have structure that doesn't allow hazardous substances to permeate, and it shall be inclined and fitted with equipment for temporarily storing leaked hazardous substances. (Note 2)
- An oil separator shall be installed on the storage equipment. (Note 2)

(Note 1) Signs and noticeboards shall also indicate that batteries are contained.

(Note 2) If it is confirmed that the requirements stated in 5.1 are satisfied, it will be appropriate not to require countermeasures regarding the accumulation of flammable vapor and leakage of hazardous substances.

5.2.2 Cases where the Quantity of Battery Electrolyte is Less than the Designated Quantity, and Adjacent Private Generating Equipment is also Less than the Designated Quantity

As a result of the tests to evaluate safety measures for batteries, in light of the properties and structure, etc. of battery equipment, in cases where less than the designated quantity is contained in a container made from steel plate or material with similar performance of 1.6 mm or greater thickness that has no openings other than the entrance/exit, it is appropriate to treat that as a small dangerous facility rather than combining it with private generating equipment. Moreover, in cases where the total quantity of electrolyte is less than the designated quantity, it shall be possible to install multiple containers (if the total quantity of electrolyte is more than the designated quantity, it will be necessary to take the safety measures described in 5.2.1). In either case, it is appropriate to not require separating distance with private generating equipment.

As a rule, it is not permitted to fit openings other than the entrance/exit in containers, however, it is appropriate to allow exceptions to this in cases where there is a functional need to install openings and the minimum required opening is fitted with fireproof device for certainly preventing spread of fire from inside and outside the battery equipment and preventing inflow of flammable vapor from outside.

Safety measures for small dangerous facilities required under fire prevention ordinance in addition to the abovementioned safety measures

- Signs and noticeboards shall be provided in conspicuous places. (Note 1)
- Electrical equipment shall be in accordance with legal stipulations for electric facilities. (Note 2)
- Container entrances/exits shall be equipped with fire preventive equipment made from made from steel plate or material with similar performance of 1.6 mm or greater thickness.
- Floors in areas that store and handle liquid hazardous substances shall have structure that doesn't allow hazardous substances to permeate, and the floor shall be inclined and fitted with a collection drain. (Note 2)
- In cases where there is risk of flammable vapor or particulates accumulating, equipment shall be installed for discharging the said vapor and particulates outside. (Note 2)

(Note 1) Signs and noticeboards shall also indicate that batteries are contained.
(Note 2) If it is confirmed that the requirements stated in 5.1 are satisfied, it will be appropriate not to require countermeasures regarding the accumulation of flammable vapor and leakage of hazardous substances.

5.3 Approach to Safety Measures concerning Storage

As a result of testing to evaluate safety measures for batteries, in light of actual conditions during storage, in cases where batteries are stored in warehouses and less than the designated quantity is contained in containers made from steel plate or material with similar performance of 1.6 mm or greater thickness that have no openings other than the entrances/exits, it is appropriate to treat those as small dangerous facilities rather than adding the contents of each container. Also, it is appropriate to not require separating distance between containers.

In such cases, it is appropriate not to permit openings other than the entrances/exit.

Safety measures for small dangerous facilities required under fire prevention ordinance in addition to the abovementioned safety measures

- The piled height of containers shall be no more than 3 m.
- Signs and noticeboards shall be provided in conspicuous places. (Note 1)
- Electrical equipment shall be in accordance with legal stipulations for electric facilities. (Note 2)
- Container entrances/exits shall be equipped with fire preventive equipment made from made from steel plate or material with similar performance of 1.6 mm or greater thickness.
- Floors in areas that store and handle liquid hazardous substances shall have structure that doesn't allow hazardous substances to permeate, and the floor shall be inclined and fitted with a collection drain. (Note 2)
- In cases where there is risk of flammable vapor or particulates accumulating, equipment shall be installed for discharging the said vapor and particulates outside. (Note 2)

(Note 1) Signs and noticeboards shall also indicate that batteries are contained.
(Note 2) If it is confirmed that the requirements stated in 5.1 are satisfied, it will be appropriate not to require countermeasures regarding the accumulation of flammable vapor and leakage of hazardous substances.

CHAPTER 6 CONCLUSION

Concerning lithium ion batteries, based on the assumption that fire risk has been greatly reduced through the Electrical Appliance and Material Safety Law and so on, demonstration tests were carried out in order to confirm fire risk before sealing and to ascertain the fire spread prevention effect of certain safety measures, structural strength at times of dropping and so on. In light of the findings, in Chapter 5, rational safety measures were presented concerning the installation of lithium ion battery equipment and storage of lithium ion batteries, etc.

In future it is forecast that lithium ion batteries will become more and more widespread and it is anticipated that the safety measures described in this report will contribute to the safer use of lithium ion batteries.

ANNEX 1

EXTRACTS FROM RELATED LEGISLATION AND REVIEW OF ACCIDENT CONDITIONS, ETC.

1. Extracts from Related Legislation

Fire Service Act (Law No. 86 of July 24, 1948)

Article 2 Terms used in this legislation are as indicated on the left.

(2)~(6) Abbreviated

(7) Dangerous substances refer to the substances shown in the list of items in Table 1 that have the properties indicated in the properties column according to the classifications prescribed in the table.

(8)~(9) Abbreviated

Article 10 More than the designated quantity of hazardous substances must not be stored in locations other than storage facilities (including storage facilities where dangerous substances are stored and handled in a tank fixed onto a vehicle (hereafter referred to as mobile tank storage facilities); hereafter the same), and they must not be handled in locations other than manufacturing facilities, storage facilities and handling facilities. However, special provisions shall be permitted in cases where approval is obtained from the local fire chief or fire station chief to temporarily store or handle more than the designated quantity of hazardous substances for a period no longer than 10 days.

(2) In cases where the products indicated in Table 1 (simply referred to as "products" in Article 11-4, paragraph (1) or two or more of dangerous substances of differing designated quantities are stored or handled in the same location, if the sum of quotients when the stored or handled quantities of each hazardous substance is divided by the designated quantity comes to 1 or more, the location in question shall be viewed as storing or handling more than the designated quantity.

(3) The storage and handling of hazardous substances in manufacturing facilities, storage facilities and handling facilities must be carried out in accordance with the technical standards prescribed by Cabinet Orders.

(4) The location, structure and technical standards of equipment in manufacturing facilities, storage facilities and handling facilities shall be stipulated by Cabinet Order.

Cabinet Order concerning regulation of hazardous substances (Cabinet Order No. 306 of September 26, 1959)

(Manufacturing facility standards)

Article 9 Technical standards regarding the location, structure and equipment (excluding firefighting equipment, warning equipment and evacuation equipment; the same shall also apply in parts 1 through 3 in this chapter) of the manufacturing facilities described in Article 10 (4) shall be as follows.

(i) Concerning location of the manufacturing facility, the distances prescribed for each of the following buildings, etc. shall be maintained between the buildings and the exterior wall or exterior side of a work piece that corresponds to the exterior wall of the manufacturing facility. However, concerning the buildings, etc. prescribed below in (a) through (c), in

cases where the municipal head deems it to be safe through adopting a fireproof fence made from non-combustible materials (referring to those materials prescribed by the Ministry of Internal Affairs and Communications out of the non-combustible materials indicated in the Building Standard Law (Law No. 201 of 1950) Article 2, item (ix); hereafter the same) and so on, it shall be possible to adopt the distance that is prescribed by the municipal head.

(a) Buildings and work pieces other than those indicated in (b) through (d) that are used for residential purposes (excluding those that are situated on the same grounds as a manufacturing facility): 10 meters or more

(b) Schools, hospitals, theaters and other facilities that hold large numbers of people and are prescribed under ministerial ordinance of the Ministry of Internal Affairs and Communications: 30 meters or more

(c) Buildings that are designated as important cultural assets, important tangible folk cultural assets, historical remains or important cultural assets under the Law for the Protection of Cultural Properties (Law No. 214 of 1950) or buildings that are recognized as art treasures under the former Law for the Preservation of Art Treasures, etc. (Law No. 43 of 1933): 50 meters or more

(d) Facilities that store and handle high-pressure gas and other substances that carry risk of causing disaster and are prescribed under ministerial ordinance of the Ministry of Internal Affairs and Communications: Distance prescribed under ministerial ordinance of the Ministry of Internal Affairs and Communications

(e) Special high voltage overhead power lines with voltage of more than 7,000 V and less than 35,000 V: 3 meters or more in terms of horizontal distance

(f) Special high voltage overhead power lines with voltage of more than 35,000 V: 5 meters or more in terms of horizontal distance

(ii) Vacant space of width according to the categories indicated in the following table shall be secured around buildings and work pieces that handle hazardous substances (excluding pipes or equivalent work pieces for transferring hazardous substances). However, this shall not apply in cases where an effective fireproof wall is provided according to ministerial ordinance of the Ministry of Internal Affairs and Communications.

Category	Width of vacant space
Manufacturing facilities where the multiple of the designated quantity is less than 10	3 m or more
Manufacturing facilities where the multiple of the designated quantity is more than 10	5 m or more

(iii) Manufacturing facilities shall have signs in conspicuous locations indicating that the facility is a manufacturing facility and a noticeboard displaying the necessary items related to fire prevention according to ministerial ordinance of the Ministry of Internal Affairs and

Communications.

(iv) Buildings that handle hazardous substances shall not have basement floors (referring to basement floors as prescribed in the Building Standard Law enforcement orders (Cabinet Order 338 of 1950) Article 1, item (ii)).

(v) Buildings that handle hazardous substances shall have walls, pillars, floors, beams and stairs that are made from noncombustible materials, and exterior walls that are at risk of spreading fire shall comprise fireproof structures (referring to fireproof structures in the Building Standard Law Article 2, item (vii); hereafter the same) having no other opening than the entrance/exit.

(vi) Buildings that handle hazardous substances shall have a roof that is made from noncombustible materials and be tiled with metal or other light and noncombustible materials. However, in buildings that handle only Type II hazardous substances (excluding powder substances and combustible solids), the roof may be a fireproof structure.

(vii) Fire preventive equipment (out of the fire preventive equipment stipulated in the Building Standard Law Article 2, item (ix-2) (b), fire-retarding doors and other items designated under ministerial ordinance of the Ministry of Internal Affairs and Communications), shall be installed on windows and at entrances/exits of buildings that handle hazardous substances; moreover, the entrance/exits fitted into exterior walls that are at risk of spreading fire shall be fitted with automatically closing specific fire prevention system that can be opened at all times (out of the specific fire prevention system stipulated in the Building Standard Law enforcement ordinances Article 112, paragraph (1)), fire-retarding doors and other items designated under ministerial ordinance of the Ministry of Internal Affairs and Communications; hereafter the same).

(viii) If glass is used in windows and entrances/exits of buildings that handle hazardous substances, wire glass shall be used.

(ix) The floors of facilities that handle liquid hazardous substances shall have a structure and incline that prevent permeation of hazardous substances, and equipment for temporarily holding spilled hazardous substances (hereafter referred to as holding equipment) will be installed.

(x) Buildings that handle hazardous substances shall be equipped with lighting, illumination and ventilation equipment necessary for handling hazardous substances.

(xi) Buildings where there is risk of flammable vapor or particulates accumulating shall be fitted with equipment for discharging the said vapor and particulates outside at a high point.

(xii) An enclosure of at least 0.15 meters in height shall be provided around the ground directly underneath outdoor equipment that handles liquid hazardous substances; alternatively, hazardous substance outflow prevention measures prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications that are equally or more effective

than this shall be taken; moreover, the ground shall be covered in concrete or other material that cannot be permeated by the hazardous substances, and appropriate incline and holding equipment shall be provided. In such cases, concerning equipment that handles Class IV hazardous substances (restricted to substances that don't dissolve in water) shall have holding equipment equipped with an oil separator to prevent the hazardous substance in question from directly entering drainage ditches.

(xiii) Machinery and appliances that handle dangerous substances shall comprise structure that can prevent leakage, overflow or fly-off of said substances. However, this shall not apply in cases where incidental equipment for preventing accidents caused by the leakage, overflow or fly-off of hazardous substances is installed.

(xiv) Equipment that heats up hazardous substances, and equipment that undergoes temperature changes in line with the handling of hazardous substances, shall be equipped with a temperature measuring device.

(xv) Equipment that heats or dries dangerous substances shall have a structure that doesn't use direct flame. However, this shall not be so if the said equipment is installed in an area that is safe in terms of fire protection or incidental equipment for preventing fires is fitted to the equipment in question.

(xvi) Equipment that pressurizes hazardous substances, or equipment in which there is risk that pressure of handled hazardous substances will increase, shall be fitted with a pressure gauge or a safety device prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications.

(xvii) Electrical equipment shall be in accordance with the stipulations of legislation concerning electrical work pieces.

(xviii) Equipment where there is risk of static electricity being generated when handling hazardous substances shall be fitted with a device for effectively removing the static electricity that builds in the equipment.

(xix) Manufacturing facilities that hold more than 10 times the designated quantity shall be equipped with a lightning protection system prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications. However, this shall not be so in cases where surrounding conditions are safe.

(xx) The location, structure and equipment of tanks that handle hazardous substances (excluding outdoor tanks and indoor tanks with less than one-fifth of the designated capacity) shall be as follows.

(a) The structure and equipment of outdoor tanks shall be according to the structural and equipment examples (including special cases prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications according to Article 11 paragraph (5)) of tanks that store and handle hazardous substances at outdoor tank storage facilities cited in Article 11 paragraph (1), item (iv) (excluding parts pertaining to specific outdoor storage

tanks and quasi-specific outdoor storage tanks) items (v) through (x) and items (xi) and (xii). Also, tanks holding liquid hazardous substances shall be fitted with an oil fence as prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications for preventing outflow in the case where hazardous substances overflow.

(b) The structure and equipment of indoor tanks shall be according to the structural and equipment examples of tanks that store and handle hazardous substances at indoor tank storage facilities cited in Article 12 paragraph (1), items (v) through (ix) and items (x) and (xi).

(c) The structure and equipment of underground tanks shall be according to the structural and equipment examples of tanks that store and handle hazardous substances at underground tank storage facilities cited in Article 13, paragraph (1) (excluding items (v), (ix-2) and (xii)), paragraph (2) (excluding Article 13, paragraph (1) items (v), (ix-2) and (xii) given as examples) and Article 13, paragraph (3) (excluding paragraph (1) items (v), (ix-2) and (xii)).

(xxi) The location, structure and equipment of pipes that handle hazardous substances shall be as follows.

(a) Pipes shall possess sufficient strength in light of their installation situation and conditions of use; moreover, no leaks or other abnormalities shall be observed when the pipes are subjected to hydraulic test (including tests conducted using noncombustible liquids apart from water or noncombustible gases) at pressure of 1.5 times or more greater than the maximum working pressure.

(b) Pipes shall be such that they are not easily degraded by the hazardous substances they handle.

(c) Pipes shall be such that they are not easily deformed by heat from fires and so on. However, this shall not be so in cases where the pipes are installed underground or in places that are not prone to adverse impacts from heat caused by fires and so on.

(d) Pipes shall receive measures for preventing corrosion of the outer surface according to ministerial ordinance of the Ministry of Internal Affairs and Communications. However, this shall not be so in cases where there is no risk of corrosion under the conditions in which the pipes are installed.

(e) In cases where pipes are installed underground, steps shall be taken to enable inspection for leakage of hazardous substances from pipe joints (except in cases where pipes are joined by welding or other methods that are deemed to entail no risk of leakage).

(f) In cases where equipment for heating or insulating pipes is installed, it shall entail structure that is safe in terms of fire prevention.

(g) In addition to the items cited in (a) through (f), pipes shall comply with standards prescribed by the Ministry of Internal Affairs and Communications.

(xxii) Motors and the pumps, valves and joints, etc. of equipment that handles hazardous substances shall be attached in positions that do not impede fire prevention.

(2) Concerning manufacturing facilities that handle only Class IV hazardous substances with an ignition point of 100 degree or higher (referred to as high ignition point hazardous substances) according to ministerial ordinance of the Ministry of Internal Affairs and Communications, special provisions to the preceding standards can be established by ministerial ordinance of the Ministry of Internal Affairs and Communications.

(3) Concerning manufacturing facilities that handle alkyl aluminum, alkyl lithium, acetaldehyde, propylene oxide and other hazardous substances prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications, special provisions exceeding the standards stated in paragraph (1) can be prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications according to the properties of the hazardous substance concerned.

Part 2 Standards for Location, Structure and Equipment of Storage Facilities

(Standards for indoor storage facilities)

Article 10 Technical standards regarding the location, structure and equipment of indoor storage facilities (excluding those prescribed in the next paragraph and paragraph (3)) shall be as follows.

(i) The location of indoor storage facilities shall be according to the examples for location of manufacturing facilities cited in the preceding Article, paragraph (1), item (i).

(ii) Vacant space of width according to the categories indicated in the following table shall be secured around buildings and work pieces that store and handle hazardous substances (hereafter referred to as storage warehouses in this article). However, when installing two or more indoor storage facilities next to each other, the width of said vacant space can be reduced according to ministerial ordinance of the Ministry of Internal Affairs and Communications.

Category	Width of vacant space	
	Cases where the building walls, pillars and floors are fireproof structure	Other cases
Indoor storage facilities where the multiple of the designated quantity is less than 5.		0.5 m or more
Indoor storage facilities where the multiple of the designated quantity is more than 5 and less than 10.	1 m or more	1.5 m or more
Indoor storage facilities where the multiple of the designated quantity is more than 10 and less than 20	2 m or more	3 m or more
Indoor storage facilities where the multiple of the designated quantity is more than 20 and less than 50.	3 m or more	5 m or more
Indoor storage facilities where the multiple of the designated quantity is more than 50 and less than 200.	5 m or more	10 m or more
Indoor storage facilities where the multiple of the designated quantity is more than 200	10 m or more	15 m or more

(iii) Indoor storage facilities shall have signs in conspicuous locations indicating that the facility is an indoor storage facility and a noticeboard displaying the necessary items related to fire prevention according to ministerial ordinance of the Ministry of Internal Affairs and Communications.

(iii-2) Storage warehouses shall be independent dedicated buildings.

(iv) Storage warehouses shall be single floor structures with height of less than 6 meters from ground to eaves (hereafter referred to as eave height), and the floor shall be set above the ground height. However, in cases of storage warehouses storing only Class II or Class IV hazardous substances and prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications, it shall be possible to adopt an eave height of less than 20 meters.

(v) The floor area of a single storage warehouse shall not exceed 1,000 square meters.

(vi) Storage warehouses shall have fireproof structure walls, pillars and floors as well as beams made from noncombustible materials, and exterior walls that are at risk of spreading fire shall be walls having no other opening than the entrance/exit. However, in storage warehouses that hold less than 10 times the designated quantity and storage warehouses that store only Type II or Type IV hazardous substances (excluding combustible solids and Type IV hazardous substances with an ignition point of less than 70 degrees), it shall be possible to adopt noncombustible materials for exterior walls, pillars and floors that have no risk of fire spreading.

(vii) Storage warehouses shall have a roof that is made from noncombustible materials and be tiled with metal or other light and noncombustible materials; moreover, they shall have no ceiling. However, in storage warehouses that handle only Type II hazardous substances (excluding powder substances and combustible solids), the roof may be a fireproof structure; while in storage warehouses that handle only Type V hazardous substances, it shall be possible to install a ceiling made from flame-retardant materials or noncombustible materials in order to maintain temperature inside the warehouse at an appropriate level.

(viii) Fire preventive equipment shall be installed on windows and at entrances/exits of storage warehouses; moreover, the entrance/exits fitted into exterior walls that are at risk of spreading fire shall be fitted with automatically closing specific fire prevention system that can be opened at all times.

(ix) If glass is used in windows and entrances/exits of storage warehouses, wire glass shall be used.

(x) The floors of storage warehouses that store Type I hazardous substances, specifically alkali metal oxides or other substances that contain this, Type II hazardous substances, specifically iron dust, metal dust, magnesium and substances that contain these, Type III hazardous substances, specifically substances that display the properties described in

Article 1-5, paragraph (6) in the water reactivity test described in paragraph (5) of that Article (including potassium, natrium, alkyl aluminum and alkyl lithium; hereafter referred to as water-reactive substances), or Type IV hazardous substances, shall have a structure that prevents water infiltration and permeation.

(xi) The floors of storage warehouses that store liquid hazardous substances shall have a structure and incline that prevent permeation of hazardous substances, and shall be equipped with temporary holding equipment.

(xi-2) When installing frames in storage warehouses, the structure and equipment of frames shall be as prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications.

(xii) Storage warehouses shall be equipped with lighting, illumination and ventilation equipment necessary for storing and handling hazardous substances, and in storage warehouses that store hazardous substances with an ignition point of less than 70 degrees, equipment for discharging accumulated flammable vapor to outside shall be installed.

(xiii) Electrical equipment shall be according to the examples for electrical equipment in manufacturing facilities that were cited in the previous Article, paragraph (1), item (xvii).

(xiv) Storage warehouses that store more than 10 times the designated quantity of hazardous materials shall be equipped with a lightning protection system prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications. However, this shall not be so in cases where surrounding conditions are safe.

(xv) Storage warehouses that store Type V hazardous substances, specifically celluloid and substances that carry risk of decomposing and catching fire when temperature rises and are prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications, shall comprise structure that maintains temperature inside the warehouse to a level that doesn't cause the hazardous substances in question to ignite, and they shall be fitted with ventilation apparatus and air conditioning, etc.

(2) Technical standards regarding the location, structure and equipment of indoor storage facilities (restricted to buildings in which the storage warehouse is other than a single floor structure) that store only Type II or Type IV hazardous substances (excluding combustible solids and Type IV hazardous substances with an ignition point of less than 70 degrees) shall be according to the preceding paragraph items (i) through (iii-2) and items (vii) through (xiv) and as follows.

(i) Each floor in storage warehouses shall be provided above the ground, and the height (floor height) from floor surface to the bottom of the floor on an upper level (eaves if there is no upper level) shall be less than 6 meters.

(ii) The floor area of a single storage warehouse shall not exceed 1,000 square meters.

(iii) Storage warehouses shall have fireproof structure walls, pillars and floors as well as beams made from noncombustible materials, and exterior walls that are at risk of spreading fire

shall be fire-resistant walls having no other opening than the entrance/exit.

(iv) The floors of storage warehouses from the second level upwards shall not have openings. However, this shall not be so concerning stairwells that are partitioned by fireproof structure walls or fire preventive equipment.

(3) Technical standards regarding the location, structure and equipment of indoor storage facilities that store less than 20 times the designated quantity (limited to buildings that have parts not used for indoor storage) shall be according to paragraph (1), item (iii) and items (x) through (xv).

(i) The indoor storage facility shall be located on either the first floor or second floor of buildings in which walls, pillars, floors and beams are fireproof structures.

(ii) The floor in the part of the building used as indoor storage facility shall be raised above the ground, and the floor height shall be less than 6 meters.

(iii) The floor area in the part of the building used as indoor storage facility shall not exceed 75 square meters.

(iv) The part of the building used as indoor storage facility shall have fireproof structure walls, pillars, floors beams and roof (if there is an upper story, the floor of the upper story), and it shall be partitioned from the rest of the building by floor and walls made from reinforced concrete of 70 mm or greater thickness or similar strength structure that has no other openings than the entrances/exits.

(v) The entrances/exits of the part of the building used as indoor storage facility shall be fitted with automatically closing specific fire prevention system that can be opened at all times.

(vi) Windows shall not be provided in the part of the building used as indoor storage facility.

(vii) Dampers that are effective for fire proofing must be fitted to ventilation equipment and exhaust equipment in the part of the building used as indoor storage facility.

(4) In indoor storage facilities that store up to 50 times the designated quantity, special provisions to the standards prescribed in paragraph (1) can be stipulated under ministerial ordinance of the Ministry of Internal Affairs and Communications.

(5) Concerning indoor storage facilities that that store only hazardous substances with a high ignition point, special provisions to the standards prescribed in paragraph (1), paragraph (2) and the preceding paragraph can be stipulated under ministerial ordinance of the Ministry of Internal Affairs and Communications.

(6) Concerning indoor storage facilities that that store and handle organic peroxide and substances that contain this, specifically hazardous substances prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications, alkyl aluminum, alkyl lithium and other hazardous substances prescribed by ministerial ordinance of the Ministry of Internal Affairs, special provisions exceeding the standards prescribed in paragraphs (1) through (4) can be stipulated according to the properties of the hazardous substances concerned under ministerial ordinance of the Ministry of Internal Affairs and Communications.

(Standards for general handling facilities)

Article 19 The provisions of Article 9, paragraph (1) shall be applicable to the technical standards regarding the location, structure and equipment of general handling facilities.

(2) Out of the general handling facilities indicated below, the facilities that are prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications may be subject to the special provisions of the standards based on ministerial ordinance of the Ministry of Internal Affairs and Communications that were indicated in the preceding paragraph.

(i) General handling facilities that conduct spray coating work, and other general handling facilities of this type

(i-2) General handling facilities that conduct washing work, and other general handling facilities of this type

(ii) General handling facilities that conduct quenching work, and other general handling facilities of this type

(iii) General handling facilities that consume hazardous substances in boilers or burners, and other general handling facilities of this type

(iv) General handling facilities that insert hazardous substances into fixed tanks in vehicles, and other general handling facilities of this type

(v) General handling facilities that refill hazardous materials into containers

(vi) General handling facilities that install hydraulic equipment that uses hazardous substances or lubricating oil circulating equipment, and other general handling facilities of this type

(vii) General handling facilities that install cutting equipment or grinding equipment that uses hazardous substances as cutting oil, and other general handling facilities of this

(viii) General handling facilities that install heat medium oil circulating equipment that uses hazardous substances for heating substances other than hazardous substances, and other general handling facilities of this type

(3) Concerning general handling facilities that handle only high ignition point hazardous substances according to ministerial ordinance of the Ministry of Internal Affairs and Communications, it shall be possible to stipulate special provisions of the standards described in paragraph (2) above based on ministerial ordinance of the Ministry of Internal Affairs and Communications.

(4) Concerning general handling facilities that handle alkyl aluminum, alkyl lithium, acetaldehyde, propylene oxide and other hazardous substances prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications, special provisions exceeding the standards stated in paragraph (1) can be prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications according to the properties of the hazardous substance concerned.

Rules concerning Regulation of Hazardous Substances (Prime Minister's Office Order No. 55 of September 29, 1959)

(Special provisions for specific indoor storage facilities)

Article 16-2-3 Special provisions of the standards stated in Article 10, paragraph (1) based on the provisions of paragraph (4) concerning indoor storage facilities that store less than 50 times the designated quantity shall be as prescribed in this Article.

(2) Out of the indoor storage facilities described in the previous paragraph (excluding those stipulated in the next paragraph), the provisions stated in Article 10, paragraph (1), item (i), item (ii) and items (v) through (viii) shall not be applied.

(i) Vacant space of width according to the categories indicated in the following table shall be secured around storage warehouses.

Category	Width of vacant space
Indoor storage facilities where the multiple of the designated quantity is less than 5.	
Indoor storage facilities where the multiple of the designated quantity is more than 10 and less than 20	1 m or more
Indoor storage facilities where the multiple of the designated quantity is more than 20 and less than 50.	2 m or more

(ii) The floor area of a single storage warehouse shall not exceed 150 square meters.

(iii) Storage warehouses shall have fireproof structure walls, pillars, floors, beams and roofs.

(iv) Automatically closing specific fire prevention system that can be opened at all times shall be installed at the entrances/exits of storage warehouses.

(v) Windows shall not be installed in storage warehouses.

(3) Out of the indoor storage facilities described in paragraph (1) (restricted to facilities in which the eave height (referring to the eave height prescribed in Article 10, paragraph (1), item (iv)) is more than 6 meters and less than 20 meters), concerning the facilities that comply with the standards prescribed in the preceding paragraph items (ii) to (v), the provisions described in Article 10, paragraph (1), items (i) and items (v) through (viii) shall not be applicable.

(General handling facilities in which special provisions can be prescribed)

Article 28-54 The general handling facilities prescribed by ministerial ordinance of the Ministry of Internal Affairs and Communications in Article 19, paragraph (2) shall be subject to the provisions stated in each item according to the following categories of general handling facilities.

(i) General handling facilities stated in Article 19, paragraph (2), item (i): general handling facilities that use hazardous substances (restricted to Type II hazardous substances or Type IV hazardous substances (excluding special flammable substances)) for coating, printing or application, and the quantities used are less than 30 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(i-2) General handling facilities stated in Article 19, paragraph (2), item (i-2): general handling

facilities that use hazardous substances (restricted to Type IV hazardous substances with an ignition point of more than 40 degrees) for washing, and the quantities used are less than 30 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(ii) General handling facilities stated in Article 19, paragraph (2), item (ii): general handling facilities that use hazardous substances (restricted to Type IV hazardous substances with an ignition point of more than 40 degrees) for quenching or electrical discharge, and the quantities used are less than 30 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(iii) General handling facilities stated in Article 19, paragraph (2), item (iii): general handling facilities that consume hazardous substances (restricted to Type IV hazardous substances with an ignition point of more than 40 degrees) in boilers, burners and similar devices, and the quantities used are less than 30 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(iv) General handling facilities stated in Article 19, paragraph (2), item (iv): general handling facilities that insert liquid hazardous substances (excluding alkyl aluminum, etc., acetaldehyde, etc., and hydroxylamine, etc.) into fixed tanks in vehicles (this includes handling facilities that refill liquid hazardous substances into containers)

(v) General handling facilities stated in Article 19, paragraph (2), item (v): general handling facilities that use fixed lubricating equipment to refill hazardous substances (restricted to Type IV hazardous substances with an ignition point of more than 40 degrees) into containers in boilers, and general handling facilities that insert hazardous substances into fixed tanks in vehicles (concerning tanks with capacity of more than 2,000 liters, this is restricted to tanks that are partitioned into sections of less than 2,000 liters), and the quantities used are less than 30 times the designated quantity

(vi) General handling facilities stated in Article 19, paragraph (2), item (vi): general handling facilities that install hydraulic equipment that uses hazardous substances or lubricating oil circulating equipment (restricted to cases where only high ignition point hazardous substances are handled at temperatures of less than 100 degrees), and the quantities used are less than 50 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(vii) General handling facilities stated in Article 19, paragraph (2), item (vii): general handling facilities that install cutting equipment or grinding equipment or similar equipment of this type that uses hazardous substances as cutting oil (restricted to cases where only high ignition point hazardous substances are handled at temperatures of less than 100 degrees), and the quantities used are less than 30 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(viii) General handling facilities stated in Article 19, paragraph (2), item (viii): general handling

facilities that install heat medium oil circulating equipment that uses hazardous substances (restricted to high ignition point hazardous substances) for heating substances other than hazardous substances, and the quantities used are less than 30 times the designated quantity (restricted to cases where equipment that handles hazardous substances is fitted to buildings)

(Special provisions for general handling facilities that conduct spray coating work, etc.)

Article 28-55 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in the preceding Article item (i) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities described in item (i) of the preceding Article, concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The part of a building used as general handling facility shall have no basement floors.

(ii) The part of the building used as general handling facility shall have fireproof structure walls, pillars, floors beams and roof (if there is an upper story, the floor of the upper story), and it shall be partitioned from the rest of the building by floor and walls made from reinforced concrete of 70 mm or greater thickness or similar strength structure that has no other openings than the entrances/exits.

(iii) Windows shall not be provided in the part of the building used as general handling facility.

(iv) The entrances/exits of the part of the building used as general handling facility shall be fitted with specific fire prevention system, and the entrances/exits provided in exterior walls that are at risk of spreading fire and partition walls that separate the facility from the rest of the building shall be fitted with automatically closing specific fire prevention systems that can be opened at all times.

(v) The floor in part of a building used as general handling facility that handles liquid hazardous substances shall have a structure and incline that prevent permeation of hazardous substances, and shall be fitted with temporary holding equipment.

(vi) The part of the building used as general handling facility shall be equipped with lighting, illumination and ventilation equipment necessary for storing and handling hazardous substances.

(vii) The part of the building used as general handling facility where there is risk of flammable vapor or particulates accumulating shall be fitted with equipment for discharging the said vapor and particulates outside at a high point.

(viii) Dampers that are effective for fire proofing shall be fitted to ventilation equipment and the equipment described in the preceding item.

(Special provisions for general handling facilities that conduct washing work, etc.)

Article 28-55-2 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in the preceding Article 28-54, item (i) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (i-2), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied

(i) An enclosure based on the examples prescribed in Article 13-3 paragraph (2), item (i) shall be provided around tanks that handle hazardous substances (excluding those that hold less than one-fifth the designated quantity).

(ii) Equipment for heating hazardous substances shall be equipped with a device for preventing overheating.

(iii) The standards prescribed in each item of the preceding article paragraph (2) shall be complied with.

(3) Out of the general handling facilities stated in Article 28-54, item (i-2) (restricted to those handling less than 10 times the designated quantity), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The general handling facility shall have walls, pillars, floors beams and roof made from noncombustible materials, and it is attached to a single story building that has no ceiling.

(ii) Equipment that handles hazardous substances (excluding pipes for transferring hazardous substances) shall be fixed to the floor, and vacant space of at least 3 meters in width shall be secured around the equipment. However, in cases where building walls (restricted to walls that have no openings other than the entrance/exit (restricted to entrances/exits fitted with automatically closing specific fire prevention system that can be opened at all times)) and pillars that are less than 3 meters away from the equipment are fireproof structures, the distance of vacant space between the equipment and said walls and pillars shall be deemed sufficient.

(iii) The floor in part of a building used as general handling facility (including the vacant space mentioned in the preceding item; and the same in item (vi)) shall have a structure and incline that prevent permeation of hazardous substances, and it shall be fitted with temporary holding equipment and drainage channel around the perimeter.

(iv) Equipment that handles hazardous substances shall have a structure that does not permit flammable vapor and particulates generated in the equipment to spread beyond the equipment. However, this shall not be applicable in cases where equipment for directly

discharging vapor and particulates outside at a high point is installed.

(v) Dampers that are effective for fire proofing shall be fitted to the equipment mentioned in the proviso in the preceding item.

(vi) The facility shall comply with the standards prescribed in the preceding Article paragraph (2), items (vi) to (viii) and the preceding paragraph items (i) and (ii).

(Special provisions for general handling facilities that conduct quenching work, etc.)

Article 28-56 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (ii) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (ii), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The part of the building used as general handling facility shall have fireproof structure walls, pillars, floors and beams, and it shall be partitioned from the rest of the building by floor and walls made from reinforced concrete of 70 mm or greater thickness or similar strength structure that has no other openings than the entrances/exits.

(ii) In cases where the part of the building used as general handling facility has an upper story, the floor of the upper story shall be fireproof structure, and if there is no upper story, the roof shall be made from noncombustible materials.

(iii) The part of the building used as general handling facility shall be equipped with a device that can give a warning when the temperature of hazardous substances reaches a dangerous level.

(iv) The facility shall comply with the standards prescribed in the Article 28-55, paragraph (2) (excluding item (ii)).

(3) Out of the general handling facilities stated in Article 28-54, item (ii) (restricted to those handling less than 10 times the designated quantity), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) Equipment that handles hazardous substances (excluding pipes for transferring hazardous substances) shall be fixed to the floor, and vacant space of at least 3 meters in width shall be secured around the equipment. However, in cases where building walls (restricted to walls that have no openings other than the entrance/exit (restricted to entrances/exits fitted with automatically closing specific fire prevention systems that can be opened at all times)) and pillars that are less than 3 meters away from the equipment are fireproof structures, the distance of vacant space between the equipment and said walls and pillars shall be deemed

sufficient.

(ii) The floor in part of a building used as general handling facility (including the vacant space mentioned in the preceding item; and the same in next item) shall have a structure and incline that prevent permeation of hazardous substances, and it shall be fitted with temporary holding equipment and drainage channel around the perimeter.

(iii) The facility shall comply with the standards prescribed in Article 28-55, paragraph (2), items (vi) to (viii) and the preceding Articled paragraph (3), item (i) and the preceding paragraph item (iii).

(Special provisions for general handling facilities that consume hazardous substances in boilers, etc.)

Article 28-57 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (iii) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (iii), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The facility shall comply with the standards prescribed in the Article 28-55, paragraph (2), items (iii) to (viii) and the preceding Article paragraph (2), items (i) and (ii).

(ii) The part of the building used as general handling facility shall be equipped with a device for automatically stopping the supply of hazardous substances to boilers, burners or similar apparatus (excluding apparatus concerned with emergency power supply) at times of earthquake or power outage.

(iii) Tanks that handle hazardous substances shall have total capacity of less than the designated quantity, and an enclosure based on the examples prescribed in Article 13-3 paragraph (2), item (i) shall be provided around the tanks (excluding those that hold less than one-fifth the designated quantity).

(3) Out of the general handling facilities stated in Article 28-54, item (iii) (restricted to those handling less than 10 times the designated quantity), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) Equipment that handles hazardous substances (excluding pipes for transferring hazardous substances) shall be fixed to the floor, and vacant space of at least 3 meters in width shall be secured around the equipment. However, in cases where building walls (restricted to walls that have no openings other than the entrance/exit (restricted to entrances/exits fitted with automatically closing specific fire prevention system that can be opened at all times))

and pillars that are less than 3 meters away from the equipment are fireproof structures, the distance of vacant space between the equipment and said walls and pillars shall be deemed sufficient.

(ii) The floor in part of a building used as general handling facility (including the vacant space mentioned in the preceding item; and the same in next item) shall have a structure and incline that prevent permeation of hazardous substances, and it shall be fitted with temporary holding equipment and drainage channel around the perimeter.

(iii) The facility shall comply with the standards prescribed in the Article 28-54 paragraph (2), items (vi) to (viii) and Article 28-55-2, paragraph (3), item (i) and the preceding paragraph items (ii) and (iii).

(4) Out of the general handling facilities stated in the preceding Article 28-54, item (iii) (restricted to those handling less than 10 times the designated quantity), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xii) and item (xx) (a)) (restricted to the part concerning oil fence) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied

(i) The general handling facility shall be installed on the rooftop of a building that has fireproof structure walls, pillars, floors, beams and roof.

(ii) Equipment that handles hazardous substances (excluding pipes for transferring hazardous substances) shall be fixed on the rooftop.

(iii) Equipment that handles hazardous substances (excluding tanks that handle hazardous substances and pipes for transferring hazardous substances) shall comprise a cubicle structure (referring to equipment housed in a steel plate outer box), and an enclosure of at least 0.15 meters in height shall be provided around it.

(iv) The interior of the equipment mentioned in the preceding item shall be equipped with lighting, illumination and ventilation equipment necessary for handling hazardous substances.

(v) Tanks that handle hazardous substances shall have total capacity less than the designated quantity.

(vi) An enclosure of at least 0.15 meters in height based on the examples prescribed in Article 13-3 paragraph (2), item (i) shall be provided around outside tanks that handle hazardous substances (excluding those that hold less than one-fifth the designated quantity).

(vii) Vacant space of at least 3 meters shall be secured around the enclosures mentioned in item (iii) and the preceding item. However, in cases where building walls (restricted to walls that have no openings other than the entrance/exit (restricted to entrances/exits fitted with automatically closing specific fire prevention system that can be opened at all times)) and pillars that are less than 3 meters away from the enclosures mentioned in item (iii) and the preceding item are fireproof structures, the distance of vacant space between the enclosures

and said walls and pillars shall be deemed sufficient.

(viii) The interior of the enclosures mentioned in items (iii) and (vi) shall have a structure and incline that prevent permeation of hazardous substances, and it shall be fitted with temporary holding equipment. In such cases, an oil separator must be fitted to the holding equipment to prevent the hazardous substances in question from directly entering drainage ditches.

(ix) Indoor tanks that handle hazardous substances shall be installed inside dedicated tank rooms that comply with the following standards:

(a) The facility shall conform to the standard examples given in Article 12 paragraph (1), item (xiii) through (xvi).

(b) The tank room floor shall be a fireproof structure, and the walls, pillars and beams shall be made from noncombustible materials.

(c) The tank room floor shall be equipped with lighting, illumination and ventilation equipment necessary for handling hazardous substances.

(d) Tank rooms where there is risk of flammable vapor or particulates accumulating shall be fitted with equipment for discharging the said vapor and particulates outside at a high point.

(e) An enclosure based on the examples prescribed in Article 13-3 paragraph (2), item (i) shall be provided around tanks that handle hazardous substances, and the threshold of the entrance/exit to tank rooms shall be raised.

(x) Dampers that are effective for fire proofing shall be fitted to ventilation equipment and the equipment described in the preceding item (ix) (d).

(xi) The facility shall conform to the standards given in paragraph (2), item (ii).

(Special provisions for general handling facilities that conduct filling work, etc.)

Article 28-58 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (iv) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (iv), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) items (v) through (xii) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) When establishing a building, the building shall have walls, pillars, floors, beams and roof that are either fireproof structures or are made from noncombustible materials, and fire preventive equipment shall be fitted on windows and entrances/exits.

(ii) If glass is used in the windows and entrances/exits of the buildings mentioned in the preceding item, wire glass shall be used.

(iii) The buildings mentioned in item (i) shall have no walls in at least two directions with a view to enabling ventilation.

(iv) The general handling facility shall have vacant space around equipment for inserting hazardous substances into tanks fixed to vehicles (excluding pipes for transferring hazardous substances) and this shall be enough to ensure that the said vehicles don't protrude from the space and it is possible to safely and smoothly insert hazardous substances into the said tanks

(v) In cases where equipment for refilling hazardous substances into containers is installed in the general handling facility, apart from the vacant space mentioned in the preceding item, there shall be vacant space around equipment for injecting hazardous substances into tanks fixed to vehicles (excluding pipes for transferring hazardous substances) and this shall be enough to safely place containers and safely and smoothly refill hazardous substances into the said containers.

(vi) The vacant spaces mentioned in the preceding item (ii) shall have paving based on the examples cited in Article 24-16 to ensure that leaked hazardous substances don't permeate.

(vii) The vacant spaces mentioned in items (iv) and (v) shall be subject to the measures described in Article 24-17 to ensure that leaked hazardous substances don't accumulate and the said hazardous substances and other liquids shall not flow out of the vacant spaces to other areas.

(Special provisions for general handling facilities that conduct refilling work, etc.)

Article 28-59 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (v) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (v), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) (excluding items (iii), (xvii) and (xxi)) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The general handling facilities shall have vacant space for refilling containers and inserting into tanks around hose apparatus of fixed lubricating equipment (below the hose apparatus in cases of suspended fixed lubricating equipment), and this shall have the area specified in (a) and (b) below according to the categories of fixed lubricating equipment indicated in (a) and (b).

(a) Fixed lubricating equipment for refilling hazardous substances into containers: enough space to safely place containers and safely and smoothly refill hazardous substances into the said containers.

(b) Fixed lubricating equipment for inserting hazardous substances into tanks fixed to vehicles: enough space enough to ensure that the said vehicles don't protrude from the space and it is possible to safely and smoothly insert hazardous substances into the said tanks.

(ii) The vacant spaces mentioned in the preceding item shall have paving based on the

examples cited in Article 24-16 to ensure that leaked hazardous substances don't permeate.

(iii) The vacant spaces mentioned in item (i) shall be subject to the measures described in Article 24-17 to ensure that leaked hazardous substances and flammable vapors don't accumulate and the said hazardous substances and other liquids shall not flow out of the vacant spaces to other areas.

(iv) General handling facilities shall not be equipped with tanks for handling hazardous substances, except in cases where an underground dedicated tank with capacity of no more than 30,000 liters that connects to fixed lubricating equipment (hereafter referred to as an underground dedicated tank) is installed under the ground.

(v) The location, structure and equipment of the underground dedicated tank shall be based on the examples of location, structure and equipment of underground dedicated tanks stated in Article 13, paragraph (1) (excluding items (v), (ix) (restricted to the parts on noticeboards), (ix-2) and (xii) that are deemed to be based on such examples), Article 13, paragraph (2) (excluding paragraph (1), items (v), (ix) (restricted to the parts on noticeboards), (ix-2) and (xii)), and Article 13, paragraph (3) (excluding paragraph (1), items (v), (ix) (restricted to the parts on noticeboards), (ix-2) and (xii) that are deemed to be based on such examples).

(vi) Piping for inserting hazardous substances into fixed lubricating equipment shall comprise only the pipes from the underground dedicated tank that connects to the fixed lubricating equipment in question.

(vii) Fixed lubricating equipment shall be based on the examples of fixed lubricating equipment in the filling handling facilities prescribed in Article 17, paragraph (1), item (x).

(viii) Fixed lubricating equipment shall be separated from road perimeters by the distances stipulated in the following table according to the given categories of fixed lubricating equipment, from building walls by at least 2 meters (1 meter in cases where the general handling facility building wall has no entrance/exit), and at least 1 meter from the site perimeter. However, this shall not apply to pump equipment or oil pump equipment that is separated from hose apparatus and is installed in a pump room that conforms to each item in Article 25-3-2.

Category of fixed lubricating equipment		Distance
Suspended fixed lubricating equipment		4 meters
Other fixed lubricating equipment	The total length of the longest hose attached to the fixed lubricating equipment (hereafter referred to as the total length of the longest lubricating hose) is no longer than 3 meters	4 meters
	The total length of the longest lubricating hose is more than 3 meters and no longer than 4 meters.	5 meters
	The total length of the longest lubricating hose is more than4 meters and no longer than 5 meters.	6 meters

(ix) General handling facilities equipped with suspended fixed lubricating equipment shall be equipped with a device that can suddenly stop transfer of hazardous substances from the underground dedicated tank through stopping the pump apparatus, etc. of the fixed lubricating equipment.

(x) A fence or wall that is 2 meters or more in height, comprises a fireproof structure or is made from noncombustible materials, and conforms to the following requirements shall be provided around the general handling facilities:

(a) It shall have no openings (excluding fixed sash windows (restricted to wire glass windows if glass is used) in the case of fire preventive equipment).

(b) In cases where fire stipulated in notices occurs in the general handling facilities, radiation heat on exterior walls and other notified parts of buildings on adjacent land shall satisfy the formula prescribed by notice.

(xi) The entrances/exits of the general handling facilities shall be fitted with specific fire prevention system.

(xii) Pump rooms and other rooms that handle hazardous substances shall be based on the examples of oil lubrication handling facility pump rooms and other rooms that handle hazardous substances stipulated in Article 17, paragraph (1), item (xx).

(xiii) In cases where roof, shed or other building necessary for refilling (hereafter referred to as roof, etc.) is built onto general handling facilities, the roof, etc. shall be made from noncombustible materials.

(xiv) The horizontal projected area of the roof, etc. shall be no more than one-third the site area of the general handling facilities.

(Special provisions for general handling facilities that install hydraulic systems, etc.)

Article 28-60 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (vi) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (vi), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii), items (iv) through (xi), and items (xviii) and (xix) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The general handling facility shall be installed in a single story building that shall have walls, pillars, floors beams and roof made from noncombustible materials.

(ii) The part of the building used as general handling facility shall have walls, pillars, floors beams and roof made from noncombustible materials, and exterior walls that are at risk of spreading fire comprise fire-resistant walls having no other opening than the entrance/exit.

(iii) The windows and entrances/exits of the part of the building used as general handling facility shall be fitted with fire preventive equipment, and the entrances/exits of exterior

walls that are at risk of spreading fire are fitted with fitted with automatically closing specific fire prevention system that can be opened at all times.

(iv) If glass is used in windows and entrances/exits of the part of the building used as general handling facility, wire glass shall be used.

(v) Equipment that handles hazardous substances (excluding pipes for transferring hazardous substances; also the same in paragraph (4)) shall be firmly fixed to the floor in the part of the building used as general handling facility.

(vi) Either an enclosure based on the example given in Article 13-3 paragraph (2), item (i) shall be provided directly underneath tanks that handle hazardous substances (excluding those that hold less than one-fifth the designated quantity), or the threshold of the part of the building used as general handling facility shall be raised.

(vii) The facility shall conform to the standards given Article 28-55, paragraph (2), items (v) through (viii).

(3) Out of the general handling facilities stated in the preceding Article 28-54, item (vi), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii), items (iv) through (xi) and items (xviii) and (xix) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) The part of the building used as general handling facility shall have fireproof structure walls, pillars, floors and beams.

(ii) The facility shall comply with the standards prescribed in the Article 28-55, paragraph (2), items (iii) to (viii), Article 28-56, paragraph (2), item (ii), and the preceding paragraph item (vi).

(4) Out of the general handling facilities stated in the Article 28-54, item (vi) (restricted to facilities that handle less than 30 times the designated quantity), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii), items (iv) through (xi) and items (xviii) and (xix) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) Equipment that handles hazardous substances shall be fixed to the floor, and vacant space of at least 3 meters in width shall be secured around the equipment. However, in cases where building walls (restricted to walls that have no openings other than the entrance/exit (restricted to entrances/exits fitted with automatically closing specific fire prevention system that can be opened at all times)) and pillars that are less than 3 meters away from the equipment are fireproof structures, the distance of vacant space between the equipment and said walls and pillars shall be deemed sufficient.

(ii) The floor in part of a building used as general handling facility (including the vacant space mentioned in the preceding item; and the same in item (iv)) shall have a structure and incline that prevent permeation of hazardous substances, and it shall be fitted with

temporary holding equipment and drainage channel around the perimeter.

(iii) An enclosure based on the example given in Article 13-3 paragraph (2), item (i) shall be provided directly underneath tanks that handle hazardous substances (excluding those that hold less than one-fifth the designated quantity).

(iv) The facility shall comply with the standards prescribed in the Article 28-55, paragraph (2), items (vi) to (viii) and Article 28-55-2, paragraph (3), item (i).

(Special provisions for general handling facilities that install cutting apparatus, etc.)

Article 28-60-2 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (vii) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in the preceding Article 28-54, item (vii), concerning those in which location, structure and equipment comply with the standards prescribed in Article 28-55, paragraph (2), item (i) and items (iii) through (viii), Article 28-56, paragraph (2), item (ii) and the preceding Article paragraph (2), item (vi) and paragraph (3), item (i), the provisions stipulated in Article 9, paragraph (1) item (i), item (ii), items (iv) through (xi), and items (xviii) and (xix) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(3) Out of the general handling facilities (restricted to those that handle less than 10 times the designated quantity) stated in the preceding Article 28-54, item (vii), concerning those in which location, structure and equipment comply with the standards prescribed below, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii), items (iv) through (xi), and items (xviii) and (xix) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied

(i) Equipment that handles hazardous substances (excluding pipes for transferring hazardous substances) shall be fixed to the floor, and vacant space of at least 3 meters in width shall be secured around the equipment. However, in cases where building walls (restricted to walls that have no openings other than the entrance/exit (restricted to entrances/exits fitted with automatically closing specific fire prevention system that can be opened at all times)) and pillars that are less than 3 meters away from the equipment are fireproof structures, the distance of vacant space between the equipment and said walls and pillars shall be deemed sufficient.

(ii) The floor in part of a building used as general handling facility (including the vacant space mentioned in the preceding item; and the same in the next item) shall have a structure and incline that prevent permeation of hazardous substances, and it shall be fitted with temporary holding equipment and drainage channel around the perimeter.

(iii) The facility shall comply with the standards prescribed in the Article 28-55, paragraph (2), items (vi) to (viii) and Article 28-55-2, paragraph (3), item (i) and the previous Article paragraph (4), item (iii).

(Special provisions for general handling facilities that install heat medium oil circulating equipment, etc.)

Article 28-60-3 The special provisions for the standards stated in Article 19, paragraph (1) based on the provisions of Article 19, paragraph (2) concerning the general handling facilities stated in Article 28-54, item (viii) shall be based on the provisions stated in this Article.

(2) Out of the general handling facilities stated in Article 28-54, item (viii), concerning those in which location, structure and equipment comply with the following standards, the provisions stipulated in Article 9, paragraph (1) item (i), item (ii) and items (iv) through (xi) that are applicable mutatis mutandis in Article 19, paragraph (1) shall not be applied.

(i) Equipment that handles hazardous substances shall have a structure that can prevent leakage of hazardous substances due to the volumetric expansion of said substances.

(ii) The facility shall comply with the standards prescribed in the Article 28-55, paragraph (2), item (i) and items (iii) to (viii), Article 28-55-2, paragraph (2), items (i) and (ii), and Article 28-56, paragraph (2), items (i) and (ii).

2 Related Notification

(Fire Risk Notification No. 48 of 1996 (Work Materials)

Fire Risk No. 48
April 2, 1996

To all Prefectural Fire Department Chiefs

Manager, Hazardous Substances Regulatory Section,
Fire and Disaster Management Agency

Re: Sending of work materials concerning regulatory clerical affairs for hazardous substances

Please refer to the enclosed work materials concerning regulatory clerical affairs for hazardous substances.

You are also requested to notify these materials to your municipality to ensure the smooth operation of hazardous substance administration.

Incidentally, the following abbreviated title for legislation is used in these materials:

Fire Service Act (Law No. 186 of 1951).....Law

1. Law-separate tables

Q: Is it acceptable to consider that lithium ion batteries contain hazardous substances based on the understanding that electrolyte is a Class IV hazardous substance.

A: Yes, it is.

Abbreviated

3. Review of Past Accidents

3.1 Accidents in Facilities for Manufacturing or Storing Lithium Ion Batteries

(1) Fires in facilities that did not take safety measures based on the Fire Service Act, irrespective of the fact that they manufacture or store large quantities of lithium ion batteries: 2 cases

(2) Fires in facilities that manufacture or store large quantities of lithium ion batteries for which safety measures based on the Fire Service Act were taken: 4 cases

3.2 Number of fires caused by lithium ion batteries in products such as mobile phones and so on from manufacturers that handle lithium ion batteries

- 1998 to 2008: ..... 80 cases
- 2009: ..... 5 cases
- 2010: ..... 4 cases

(According to the homepage of the National Institute of Technology and Evaluation (NITE))

3.3 Number of fires involving lithium ion batteries in targets of fire protection other than communal housing

In order to gauge conditions regarding occurrence of fires involving lithium ion batteries, inquiries were made with fire headquarters throughout the country concerning fires in facilities that are require fire protection other than communal housing in which lithium ion batteries were burned. As a result, 18 such fires were reported.

Review of Past Fires (Accident Cases)

Examples of extremely major accidents in facilities that did not take safety measures based on the Fire Service Act, irrespective of the fact that they store or handle large quantities of lithium ion batteries

Example of an extremely large fire (1995, Koriyama City, Fukushima Prefecture)

Approximately 7,000 m^2 burned
Persons injured: 2
Time required for extinguishing: Approximately 7 hours

Conditions of damage in the warehouse area

* In this warehouse, where large quantities of charged lithium ion batteries were stored at room temperature on 4-level shelves, fire broke out from the batteries and spread to approximately 3 million of them.
Extinguishing the fire was extremely difficult and two people were injured. The fire was eventually extinguished in around seven hours after it had burned approximately 7,000 square meters.

Accident that caused extensive damage outside of facilities (1997, Moriguchi City, Osaka Prefecture)

Damage occurred among houses and so on over a radius of 175 meters.
The building of fire outbreak, covering 1,230 square meters, was totally destroyed, while 486 square meters of adjoining buildings were partially destroyed.
Persons injured: 2
Time required for extinguishing: Approximately 8 hours

Roof blown off by the fire

Condition of burned facilities

Damage occurred among houses and so on over a radius of 175 meters

* Fire broke out from lithium ion batteries in the warehouse area that was storing a large quantity of charged lithium ion batteries in 13 piled layers, and approximately 1,220,000 batteries were burned.
This fire also caused damage to houses and so on over a scope of 175 meters. Extinguishing the fire was extremely difficult and two people were injured. The fire was eventually extinguished in around eight hours after it had entirely burned the building of outbreak, covering approximately 1,230 square meters, as well as partially destroying 486 square meters of adjoining buildings.

Examples of fires in facilities that store and handle large quantities of lithium ion batteries for which safety measures based on the Fire Service Act were taken

[2000, Oyamazaki-cho, Otokunigun,, Kyoto Prefecture]

Fire broke out while lithium ion batteries were being stored in a steam thermostatic chamber in order to stabilize quality, and based on the statements given by facilities personnel and the site investigation, it was found that the fire originated from the lithium ion batteries. Moreover, the fire was caused by internal shorting of the batteries in the manufacturing process. The fire resulted in the burning of the stored lithium ion batteries and the steam thermostatic chamber.

[2006, Moriguchi City, Osaka Prefecture]

The fire broke out in charge/discharge equipment in the area for conducting the finishing charge/discharge of lithium ion batteries, and based on the statements given by facilities personnel and the site investigation, it was found that the fire originated from the lithium ion batteries. Moreover, the fire was caused by passing excessive current through the lithium ion batteries. The fire resulted in the burning of the lithium ion batteries that were placed in the charge/discharge equipment and the equipment itself.

[2007, Moriguchi City, Osaka Prefecture]

The fire broke out in the area for conducting the finishing charge/discharge of lithium ion batteries, and based on the statements given by facilities personnel and the site investigation, it was found that the fire originated from the lithium ion batteries. Moreover, the fire was caused by passing excessive current through the lithium ion batteries.
The fire resulted in the burning of the charge/discharge area covering some 1,500 square meters and it took approximately 17 hours to extinguish. Further spread of the fire was only prevented thanks to determined firefighting efforts and partitioning of the building interior and so on.

[2008, Moriguchi City, Osaka Prefecture]

The fire broke out in the electrolyte injection process on the lithium ion battery assembly line, and based on the statements given by facilities personnel and the site investigation, it was found that the fire started when the electrolyte waste oil hose detached and the electrolyte leaked out. Moreover, the fire was caused by electric sparks.
The fire resulted in the burning of the lithium ion batteries that were placed ion the conveyor belt as well as the charge/discharge equipment.

Examples of accidents involving lithium ion batteries occurring after the day on which safety standards for lithium ion batteries were added to the Electrical Appliance and Material Safety Law

[2009, Kyoto City, Kyoto Prefecture]

The fire broke out during storage at room temperature on steel shelves in a research laboratory, and based on the statements given by facilities personnel and the site investigation, it was found that the fire originated from the lithium ion batteries. Moreover, the fire was caused by internal shorting in the lithium ion batteries. The fire resulted in the burning of the lithium ion batteries, air conditioners and lighting fixtures.

[2010, Hachioji City, Tokyo]

This fire burned four vehicles including solar vehicles powered by lithium ion batteries in a building rooftop parking area. It is possible the fire broke out in the solar vehicles, however, the cause of the fire is currently under investigation.

4. Previous Test Results

The National Research Institute of Fire and Disaster conducted combustion tests on lithium ion batteries in 1999 and 2011. The following paragraphs describe the contents of these tests and the combustion properties of lithium ion batteries that have so far been revealed.

4.1 Combustion Tests of 1999

(1) Outline of test

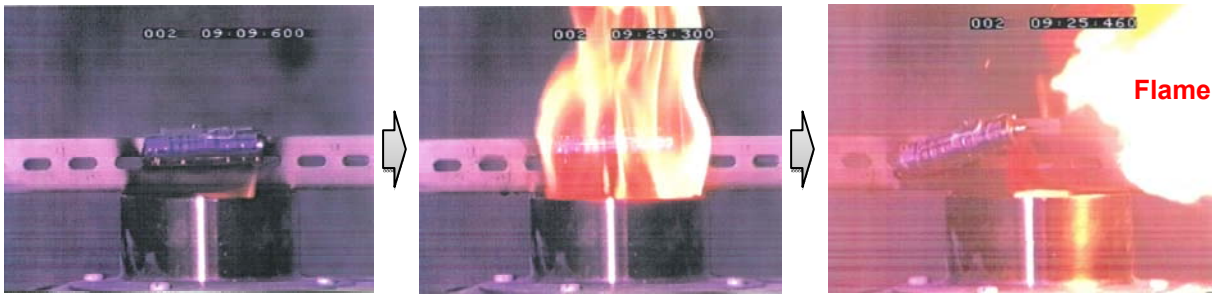
One lithium ion battery was exposed to burner flame and the combustion properties of the battery were verified.

The test was carried out on a cylindrical lithium ion battery that was taken from an electrical device that was on sale at the time (1999). (The outer casing was metal, the battery measured 18 mm across by 65 mm long, and it contained about 2 ml of electrolyte).

(2) Test Results

The pressure reduction mechanism (safety vent) of the battery was activated within a few minutes of the battery being exposed to the flame, and the electrolyte gushed out and burned fiercely. The surface temperature of the battery when the pressure reduction mechanism was operated was around 200 °C.

≪Test conditions≫



4.2 Combustion Test of 2011

4.2.1 Combustion Test on Single Cell Battery (cylindrical)

(1) Outline of Test

In order to compare combustion conditions of lithium ion batteries with the results from 1999, the test was carried out by exposing one lithium battery of the type currently on sale (2011) for use in PCs and video cameras and so on, and the battery combustion conditions were verified.

As was also the case in 1999, the test was carried out on a cylindrical lithium ion battery. (The outer casing was metal, the battery measured 18 mm across by 65 mm long, and it contained about 2 ml of electrolyte).

(2) Test Results

The pressure reduction mechanism (safety vent) of the battery was activated within a few minutes of the battery being exposed to the flame, and the electrolyte gushed out. After that, the flame grew in size and the container ruptured with a large sound.

The surface temperature of the battery when the pressure reduction mechanism was operated was around 300 ºC, and it was around 330 ºC when the battery ruptured.

As was also the case in 1999, electrolyte gushed out and burned fiercely.

≪Test conditions≫

4.2.2 Combustion Test of Single Cell Batteries (square batteries) (see Annex 1)

(1) Outline of Test

Among the lithium ion batteries that are currently on sale, since square types are used in video cameras and so on, a square lithium ion battery (metal outer casing, measuring 37 mm long, 35 mm across, 8 mm high and containing 8 ml of electrolyte) was exposed to burner flame and the battery combustion properties were verified.

(2) Test Results

The pressure reduction mechanism (safety vent) of the battery was activated within a few minutes of the battery being exposed to the flame, and the electrolyte gushed out. After that, the flame grew in size and the container ruptured with a large sound.

The surface temperature of the battery when the pressure reduction mechanism was operated and the battery ruptured was around 240 ºC.

4.2.3 Combustion Test on Multiple Single Cell Batteries (see Annex 2)

(1) Outline of Test

In order to verify combustion conditions in the case where a fire breaks out in the immediate vicinity of a large quantity of lithium ion batteries being stored and handled in a general plant or warehouse (at least 500,000 batteries if converted to cylindrical single cell batteries of similar size to Type 3 batteries, i.e. 18 mm diameter and 65 mm height), the combustion test was implemented on 480 single cell batteries (equivalent to roughly one-thousandth of 500,000 batteries).

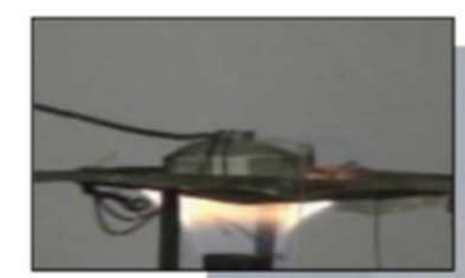
Combustion conditions were verified assuming fire burning in the immediate vicinity of 95 lithium ion battery packs (480 single cell batteries).

(2) Test Results

When fire was started close to the lithium ion batteries, the flames spread to the batteries, leading to intense combustion and explosions. Flame radiation combustion was observed and the electrolyte that gushed out from the batteries burned furiously.

Attach 1

1. Combustion Test of Lithium Ion Batteries (Square Single Cell)



- When the area around the battery is heated to 235 ºC
- Condition where no major change is seen

- When the area around the battery is heated to 240 ºC
- The battery bursts into flames with a loud noise.

- When the area around the battery is heated to 240 ºC
- The battery ruptures and flies apart.

Status before the start of the test

Commercially available lithium ion battery
(left side): 2 single cells are contained.

Battery following the test

- When the lithium ion battery (square type) was heated by burner, it burst into flames with a loud noise.
- After that, the battery ruptured and blew apart.

2. Combustion Test of Lithium Ion Batteries (480 batteries of similar size to Type 3 batteries)

In order to verify combustion conditions when a fire breaks out in the immediate vicinity of a large quantity of lithium ion batteries being stored and handled in a general plant or warehouse (at least 500,000 batteries if converted to cylindrical single cell batteries of similar size to Type 3 batteries), the combustion test was implemented on 480 single cell batteries (equivalent to roughly one-thousandth of 500,000 batteries).

The lithium ion batteries used in the test
95 lithium ion battery packs (480 cylindrical cell batteries of 18 mm diameter and 65 mm length) of the type used in video cameras and so on

Fire in immediate vicinity

The flames spread due to the gushing of electrolyte from the batteries

Explosive spread of the flames

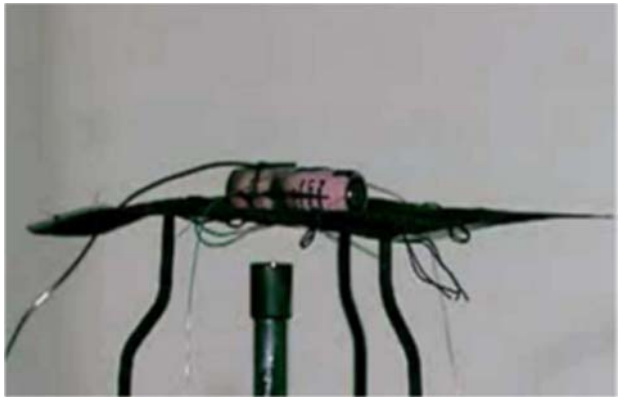
Flame radiation combustion was observed

Test conducted inside a steel tank for safety purposes Flames jumped out of the tank

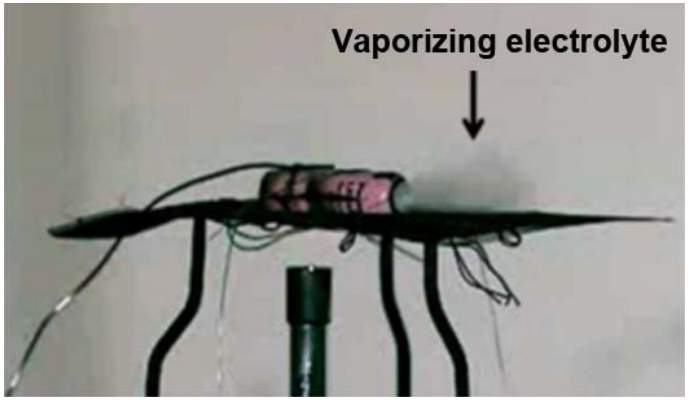
When fire breaks out in the immediate vicinity of 95 lithium ion battery packs (480 cylindrical single cell batteries of18 mm diameter and 65 mm height of similar shape to Type 3 batteries), the batteries burned fiercely with accompanying explosions. Flame radiation combustion was observed and the electrolyte that gushed out from the batteries burned furiously.

<Reference> Gushing of electrolyte from lithium ion batteries

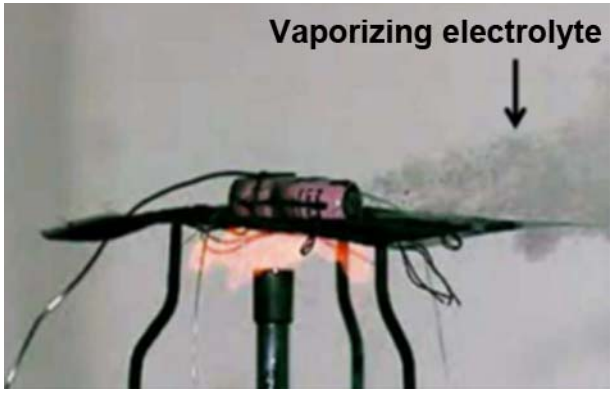
Test date: February 2011
Location: National Research Institute of Fire and Disaster
The lithium ion batteries used in the test were manufactured in 1998.
The batteries were exposed to burner flames and the gushing of electrolyte was observed by high-speed camera.



Heating of battery by burner



The moment that electrolyte gushes out (the pressure reduction mechanism operates when the battery surface temperature reaches around 230 ^{o}C.



Condition of rapid gushing of electrolyte

After the electrolyte has gushed out, it catches fire in the burner flames and burns violently.
(The above photograph was taken with a normal camera).

ANNEX 2

CONCERNING REVIEW OF HANDLING REGULATIONS FOR LITHIUM ION BATTERIES

(MATERIALS PROVIDED BY THE BATTERY ASSOCIATION OF JAPAN)

Concerning the Immediate Review of Handling Regulations for Lithium Ion Batteries: Explanatory Materials

1. Safety technology for batteries in general and lithium ion batteries
2. Safety improvement initiatives for lithium ion batteries and their results
3. Points at issue in the examination workshop and proposals of the Battery Association of Japan

September 14 2011

Battery Association of Japan

Next Generation Storage Battery Committee

Legal Working Group

Members

These materials were prepared based on the discussions and examination of the Legal Working Group members.

Kazuhiro Nakamitsu	GS Yuasa Co., Ltd.
Keiji Ogino	Panasonic Corporation
Kazumasa Ooya	NEC Energy Devices, Ltd.
Kei Oda	ELIIY Power CO., Ltd.
Akio Furukawa	SANYO Electric Co., Ltd.
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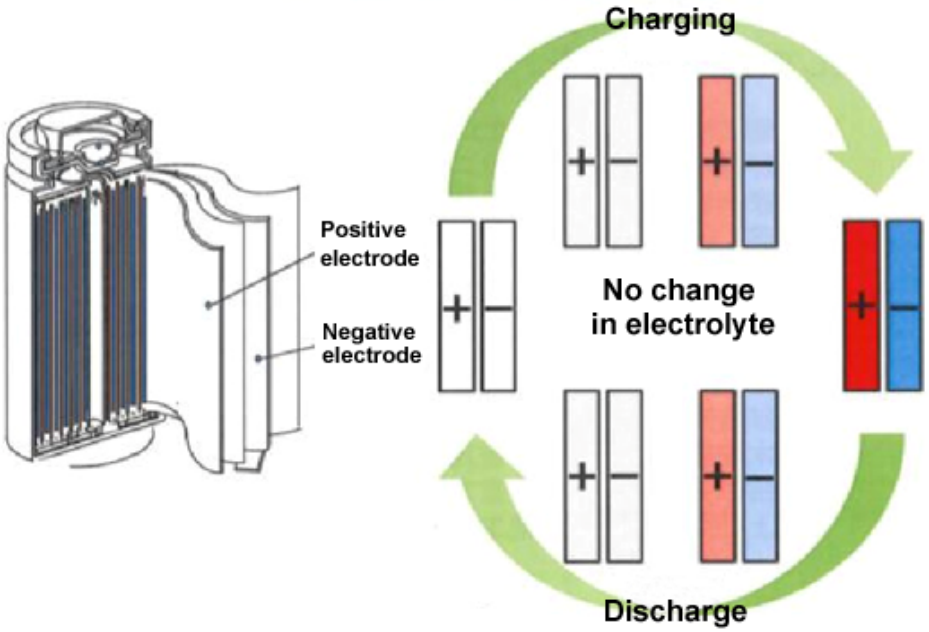
Mitsuzou Nogami	The Battery Association of Japan, Secretariat

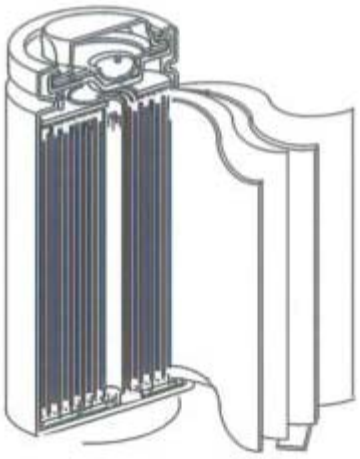
Concerning the Immediate Review of Handling Regulations for Lithium Ion Batteries: Explanatory Materials

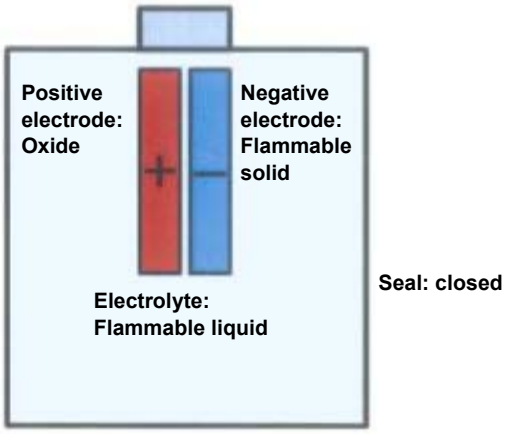
1. **Safety technology for batteries in general and lithium ion batteries**
2. Safety improvement initiatives for lithium ion batteries and their results
3. Points at issue in the examination workshop and proposals of the Battery Association of Japan

Principles of energy storage in lithium ion batteries



Safety standards for energy storage media (batteries): Global thinking





Rather than focusing on the individual component substances, safety is secured and safety standards are established for the entire energy storage media.

United Nations recommendations, IEC standards, JIS standards, SBA standards, etc.

5

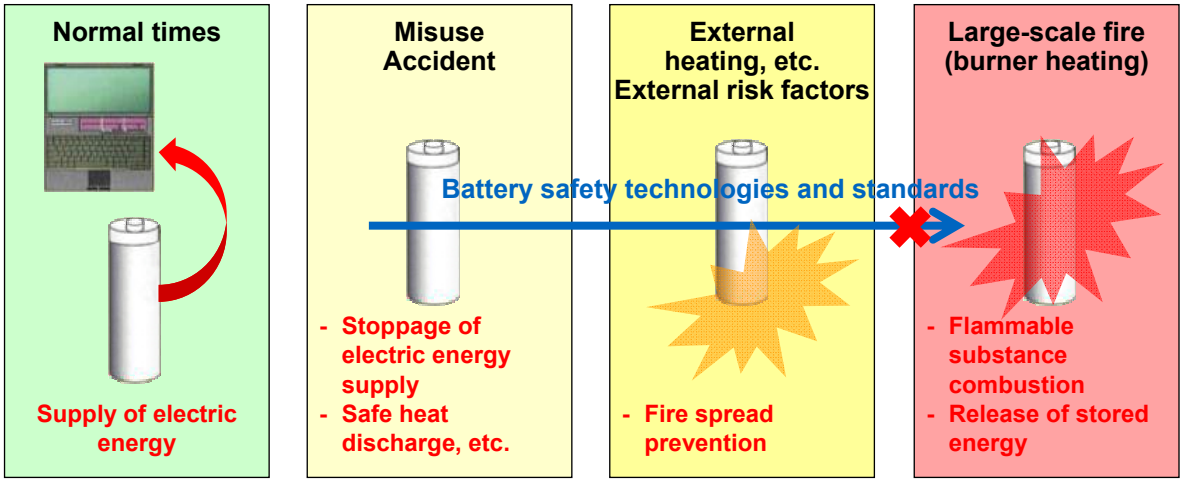
Categories of Hazardous Substances According to United Nations Classifications

1. **Explosives**
2. **Gases**
3. **Flammable liquids**
   Class IV Type 2 petroleum
4. **Flammable solids**
5. **Oxidizing substances**
6. **Toxic & infectious substances**
7. **Radioactive materials**
8. **Corrosives**
9. **Miscellaneous dangerous goods**
   Lithium ion batteries

6

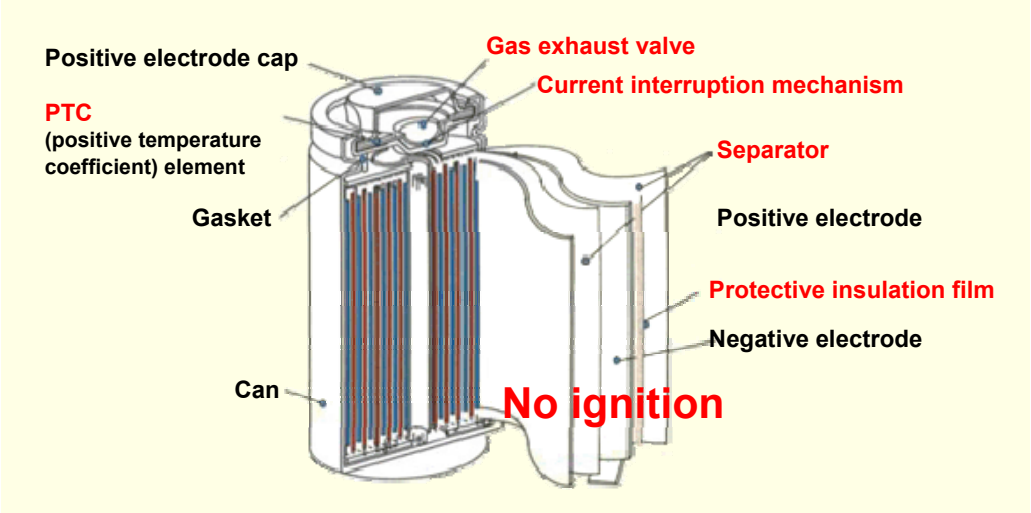
Release of Battery Energy

Common to dry cell batteries, alkaline manganese batteries, silver storage batteries, nickel-cadmium batteries, nickel-hydrogen batteries, and lithium ion batteries



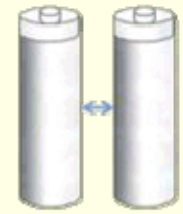
Safety Mechanism in Lithium Ion Batteries

Misuse and Accident Countermeasures

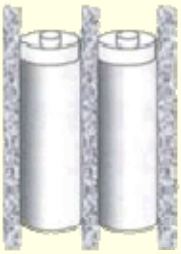


Rule: UN3840, IEC62133, Electrical Appliance and Material Safety Law

Measures to Counter Fire Spreading in Lithium Ion Batteries

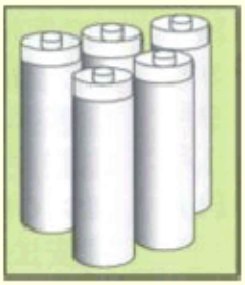


Appropriate spacing
Appropriate arrangement



Battery system design

Fire spread prevention material



Packing method

Do not let fire spread

Rules: UN3840, SBAS1101, etc.

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Concerning the Immediate Review of Handling Regulations for Lithium Ion Batteries: Explanatory Materials

1. Safety technology for batteries in general and lithium ion batteries
2. **Safety improvement initiatives for lithium ion batteries and their results**
3. Points at issue in the examination workshop and proposals of the Battery Association of Japan

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Safety improvement initiatives for lithium ion batteries and their results

History of Safety Improvement Initiatives

1996	Revision of the Fire Service Act, notification from the Fire and Disaster Management Agency
November 2000	Issue of IEC standards first edition (IEC61960-1, single cell batteries)
September 2001	Issue of IEC standards first edition (IEC61960-2, single cell batteries)
September 2001	Issue of UN recommendations: Towards compulsory enforcement of a World Standard
January 2003	Enforcement of international civil aviation rules and international maritime transportation rules
November 2007	Issue of JIS C8714
	Enforcement of the Electrical Appliance and Material Safety Law: Initiatives for realizing zero major market accidents
	Revision of IEC62133 (including items in the Electrical Appliance and Material Safety Law)
	Proposal of the contents of SBA standards to IEC Japan as Project Leader

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United Nations Recommendations Safety Test Standards

United Nations test standard manual, Part III, Sub-section 38.3

T1: Sophisticated simulation
T2: Temperature test
T3: Vibration
T4: Shock
T5: External shorting
T6: Impact
T7: Overcharging
T8: Forced discharge

<Outline of standards>
- Harsh testing in consideration of the hazards of storage and transportation
- Test methods and criteria are finely set according to each item.
- Batteries cannot be transported if they fail even one item.
- No total quantity regulations

Worldwide compliance

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Effect of United Nations Recommendations UN3840

There has not been one reported case of an accident occurring during transportation following compliance with UN3840.

More than 10 billion units transported over 10 years

Analysis of lithium ion battery stacking accidents by PRBA

44 accidents since 1991

- **Accidents caused by infringement of rules: 16 cases**
- **Accidents caused by customer's goods: 16 cases**
- **Accident caused when battery was cut open in inspection room: 1 case**
- **Accident caused when a forklift pierced battery packing at an airport: 1 case**
- **Accidents where the role of lithium ion batteries is uncertain: 10 cases**

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Continuous Revision of UN Rules

→Activities for constantly maintaining high-level safety

United Nations Transportation Rules: Battery Working Group

Chairperson: **Dr. Charles Ke (US Department of Transport)**
Mr. Clause Pfauvadel (Chairperson of the UN Conference, French Ministry of Transport)

Government representatives:
US, Canada, UK, Germany, France, Spain, Belgium, Netherlands, Switzerland, China, South Korea, etc.

Industry groups: **Battery associations and pilot associations of Europe, US, China, South Korea and Japan, international organizations for marine and land transport, Japan Automobile Research Institute, etc.**

November 2008: Washington
April 2009: Paris
November 2009: Kyoto
June 2010: Washington
December 2010: Proposal of outputs to the United Nations Conference

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Lively Debate on Revision of the UN Rules

The 3rd U.N. Lithium Batteries Informal WG
Kyoto Research Park Nov. 9-Nov.11 2009

9th

1. **Generals**
   U.S. Proposal on Clarifying Cell and Battery Testing
2. **Definitions**

2-1 U.S. Proposal on Battery Definition
2-2 China Proposal on Thermal Cycling and Mass Loss
2-3 China Proposal on T1-T4 Open Circuit Voltage Requirement
2-4 PRBA Proposal on Related Capacity Definitions
2-5 **BAJ Proposal on state of change of Lithium ion batteries**

3. **Battery assembly**

10th

4. **T2-T5 test**

4-1 Industry Proposal on T2 and Mass Loss
4-2 Germany Proposal on Observation of Cells and Batteries (T3)
4-3 COSTHA T3 proposal
4-4 Germany Proposal on Observation of Cells and Batteries (T5)

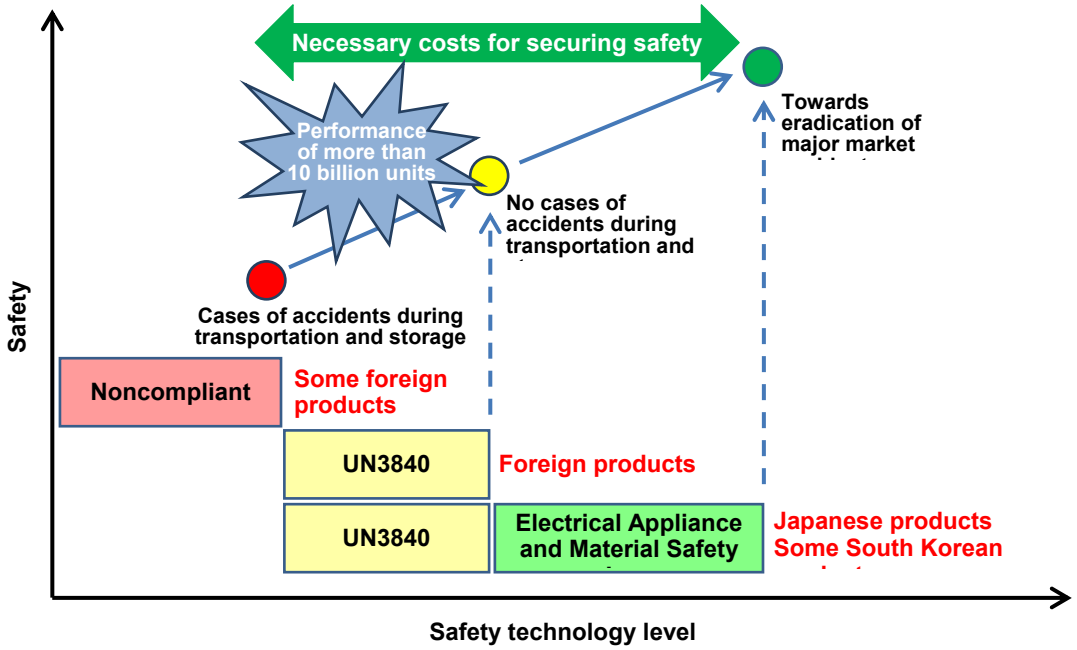
5. **T6 test**

5-1 Industry Proposal on T6
5-2 U.S. Proposal on T6
France Proposal on the Crush test, internal short circuits and other related safety issues
5-4 Germany Proposal on Observation of Cells and Batteries (T6)
5-5 China Proposal on T6

11th

6. **T7-T8 test**
   Germany Proposal on Observation of Cells and Batteries, (T7-T8)
7. **Miscellaneous and future work**

Japan's Approach for an even safer level
→ Electrical Appliance and Material Safety Law



Concerning the Immediate Review of Handling Regulations for Lithium Ion Batteries: Explanatory Materials

1. Safety technology for batteries in general and lithium ion batteries
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3. **Points at issue in the examination workshop and proposals of the Battery Association of Japan**

Point of issue 1: Concerning verification of safety

Why is it necessary to conduct burner heating tests to ascertain the safety of lithium ion batteries?

Response from the Fire and Disaster Management Agency

Question 2: Concerning heating tests from 800 ºC to 1200 ºC

[Response]

Because lithium ion batteries use flammable liquid as electrolyte, facilities that store large quantities of batteries (facilities that store or handle more than the designated quantity of electrolyte) are required to take fire prevention safety measures as dangerous facilities.
In order to once more verify the fire risk of batteries before and after sealing, it is necessary to ascertain combustion properties and risk of fire spread, etc. in cases where batteries are exposed to flames. Therefore, your association is requested to provide data on tests entailing exposure of batteries to flames (such verification can also be implemented using NAS batteries).
In normal fires (warehouse fires and so on), temperature inside the fire room quickly rises from 800 ºC to around 1200 ºC and batteries are thus exposed to high temperature conditions. In order to confirm the combustion properties and fire properties of batteries, since it is necessary to verify what kind of properties batteries display when they are placed in an environment in which temperature rises from room temperature to 800 ºC to 1200 ºC, it is necessary to implement tests entailing exposure of entire batteries to flames. Moreover, in such cases, since it is important to confirm the combustion properties of batteries (fire spread properties), there is not so much need to test fire extinguishing.
Incidentally, it should be mentioned that paper and wood and so on burn and heat up due to oxidation when they are exposed to flames, and these properties are very different from the combustion properties displayed by hazardous substances such as flammable liquids and the like.

Burner heating is required

Confirmation of point at issue (from the course of discussion)

Battery Association of Japan →Government Revitalization Unit

Concerning sealed lithium ion batteries, please cancel handling as objects that contain Class IV hazardous substances.

Regulatory sorting conclusion: Interpretation

Reexamine (whether or not there is enough risk to view as containing Class IV hazardous substances) according to status before and after sealing

Fire risk of Class IV petroleums

Class IV petroleum classification	Designated quantity (L)	Name of substance	Chemical formula	Ignition point (°C)	Combustion energy (kJ/mol)
Class I petroleum	200	Pentane	C_6H_{14}	-22	3509
Alcohol	400	Methanol	CH_3OH	11	725
		Ethanol	C_2H_5OH	13	1367
Class II petroleum	1000	Decane	$C_{10}H_{22}$	46	6788
Class III petroleum	2000	Dodecane	$C_{12}H_{26}$	71	8089
Paper, wood, plastic					

Flammability ↑

Evaluate what through burner heating? Combustion energy?

Methanol: 22.6 Kj/g Dodecane: 47.6 kJ/g

Test Method and Dominating Factors

Liquid only

No sealing

Battery

Flammability	Large ∴No sealed	
Combustion energy	Which is the dominating factor?	Large ∴ In addition to electrolyte, ① combustion energy of separators, etc. and ② stored energy of battery are added.

Extreme Example

Powerful burner heating

Forecast result

The intensity of burning is determined by the sum of energy possessed by the battery, irrespective of whether or not it is sealed.

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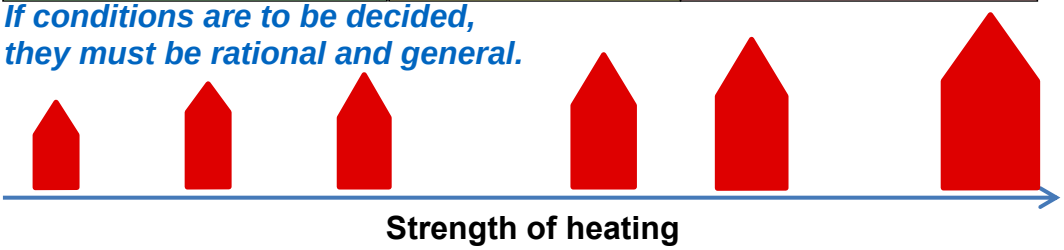
Dominating factor differs according to the test conditions

Ease of ignition is dominant	Either	Combustion energy is dominant

There is no standard manual.
If conditions are to be decided, they must be rational and general.



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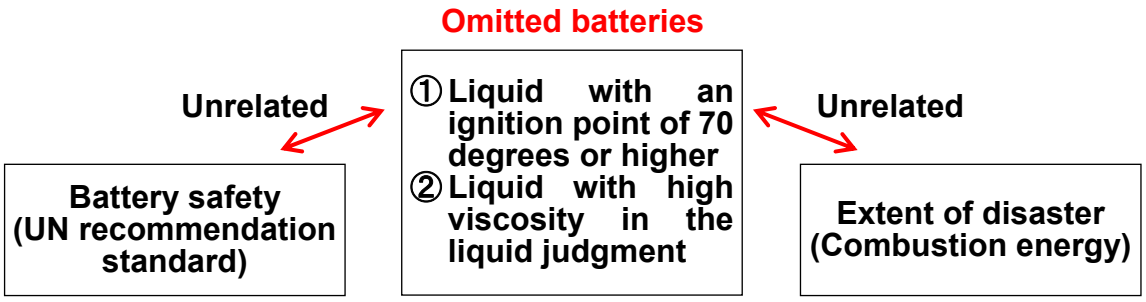
Examples where Notice 48 is omitted



Flammability is key

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Fire risk of Class IV petroleum

Conclusion: This should be assessed via comparison of flammability before and after sealing.

The fire risk of Class IV petroleum has conventionally been determined based on the ignition point.

Discussion that mixes in release of stored energy is unreasonable.

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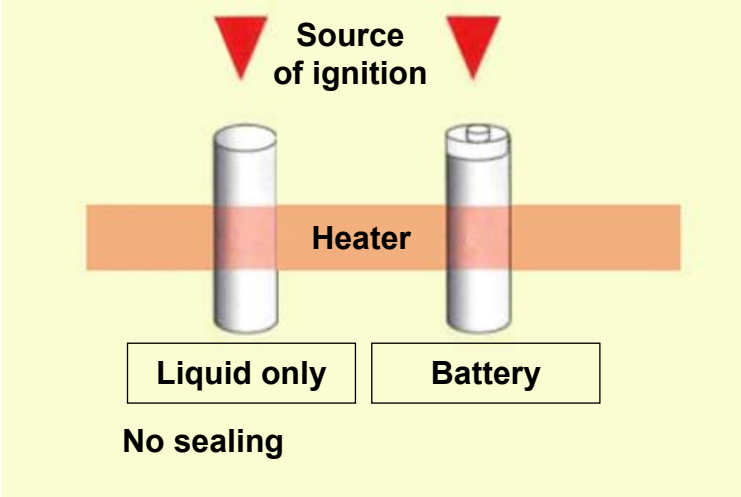
Example of flammability comparison test before and after sealing proposed by the Battery Association of Japan



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Issue in point 2: Handling of lithium ion batteries

Tell us the basis for regulating lithium ion batteries under the category of Class IV Type 2 petroleum.

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Comparison with Paper soaked in liquid

Lithium ion batteries are further sealed with paper (separator in the case of batteries) soaked with Class IV Type 2 petroleum, and this is far more resistant to ignition than paper soaked in Class IV alcohol.

Ease of ignition:	**Paper soaked in liquid**	**>**	**Becomes the seal (battery)**

(Relation to hazardous substance judgment)

Question 3: In cases of paper soaked in Class IV alcohol such as sanitizing wet tissues and so on, where the Class IV alcohol doesn't ooze out of the paper in the ordinary state (room temperature, normal pressure), is it permissible to treat the paper soaked in the said Class IV alcohol as a non-dangerous substance.

Answer: As you would expect

29

Issue in point 3: Legislation in foreign countries

Concerning foreign legislation:

Are there any cases of excessive regulations being imposed based on total quantity of the integrated amount of electrolyte in lithium ion batteries?

30

Response from the PRBA

PRBA: The Portable Rechargeable Battery Association

A group composed of battery producers, users and authenticating agencies and so on in North America

There are no provisions that treated lithium ion batteries as petroleum (flammable).

Extract from the written response received from the Secretary:

I am not aware of any regulations on Li ion cells/batteries that would regulate these as flammable.

Response from RECHARGE

RECHARGE: The European Association of the Portable Rechargeable Batteries Industry

A group composed of European battery producers, users and recyclers, etc.

Lithium ion batteries are "Articles;" they are not petroleum "chemicals in containers."

Extract from the written response received from the Secretary:

At EU level, we have obtained that batteries are classified as "Articles" and we have obtained that batteries are not considered as "chemicals in

Study Results in International Conference

Conference name:

RBRF 2011 (World Rechargeable Battery Regulatory Forum)
Date: **June 14 (Tuesday) and 15 (Wednesday) 2011**
Venue: **Annapolis, United States**
Participants: **Approximately 50 battery producers and users from North America, South America, Europe, South Korea and Japan, etc.**

Comments from participants

- **There are regulations concerning the storage, keeping and transportation of flammable liquids.**
- **There are no rules or operating examples of these being applied to batteries.**
- **If information is provided by the Fire and Disaster Management Agency of Japan, we will investigate.**
- **We would like a report of any results obtained by the working group in Japan.**

Issue in point 4: What are the impediments to a global standard?

The following is proposed with a view to securing safety of lithium ion batteries.

Concerning transportation, storage and keeping in Japan: Unification with a global standard (UN recommendations)

→ **Contribution towards eliminating poor quality products during domestic storage and transportation**
→ **This will help reduce fire risk.**

Storage and transportation of lithium ion batteries: Comparison with the EU

<table>
<tr><th></th><th>EU</th><th>Japan</th></tr>
<tr><td>Marine transportation
Air transportation</td><td colspan="2">Class 9
lithium batteries
UN recommendations</td></tr>
<tr><td>Land transportation
Storage and keeping</td><td>Battery safety testing required</td><td>Class 3
Petroleum
Battery safety testing not required</td></tr>
</table>

Extracts of opinions voiced in the Regulatory Forum

- Japan should adopt the same policy as the EU.
- It is dangerous if UN recommendations are not effective for land transportation in Japan.
- Steps should be taken to prevent the delivery of dangerous batteries.

Can Notice 48 be modified? Is it possible?

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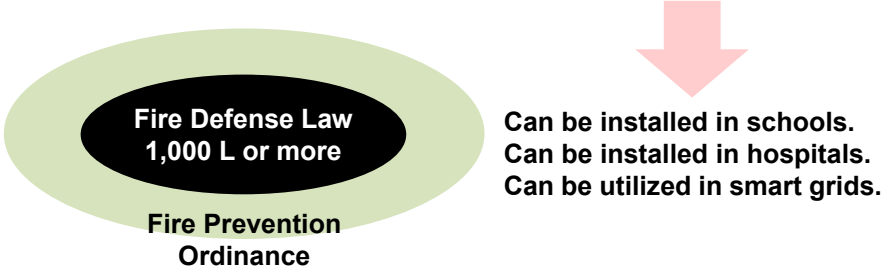
Issue in point 5: Value examination in fire prevention ordinances

Concerning installation of power source system: Unification of examination in fire prevention ordinances

Examination for thorough elimination of fire risk

→ Total cooperation will be forthcoming for verification testing (effectiveness of cubicles, etc.).



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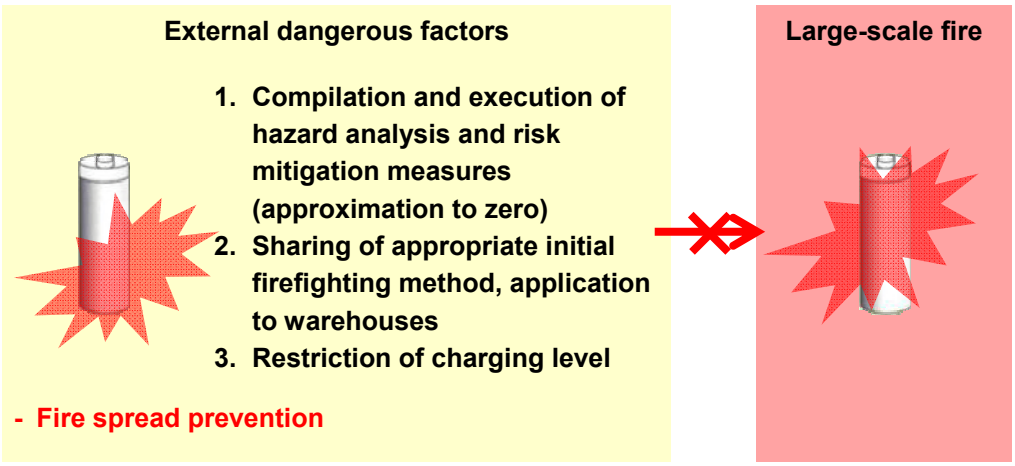
Issue in point 6: Activities for Enhancing Safety

In order to lower the risk of major fire occurring in warehouses towards zero, it is hoped to promote the following initiative under the guidance of the Fire and Disaster Management Agency.



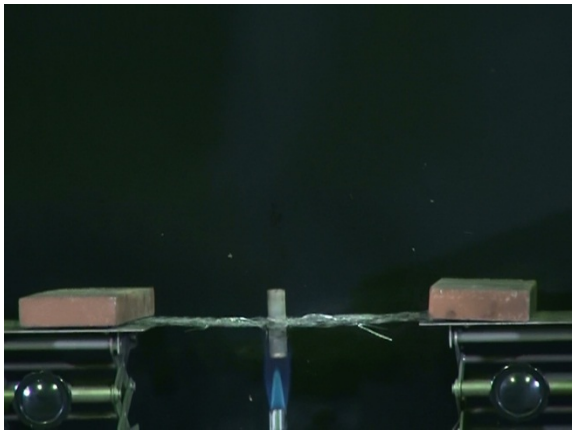
ANNEX 3

DEMONSTRATION TEST RESULTS

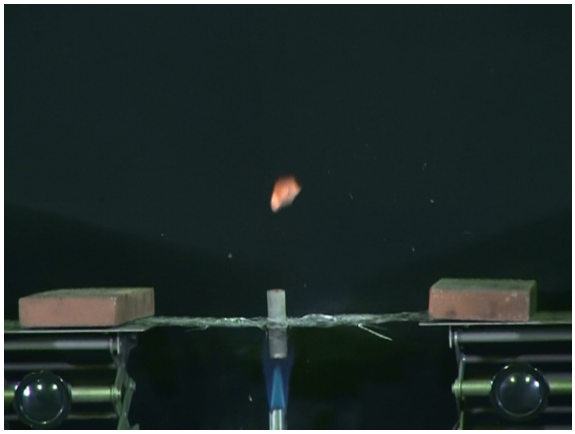
Fire Risk Assessment Test Results Before and After Sealing

(1) Battery before sealing

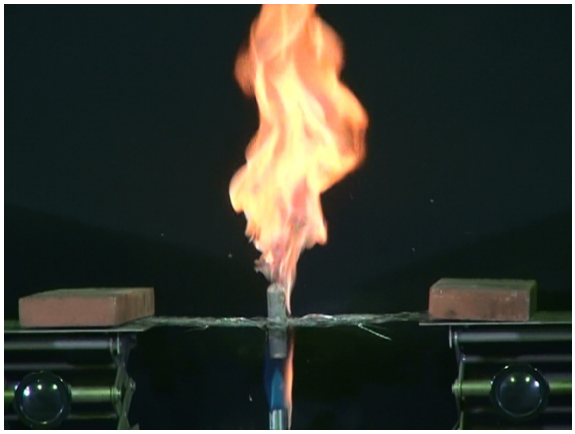
a) 2nd test (implemented November 24)



After start of heating

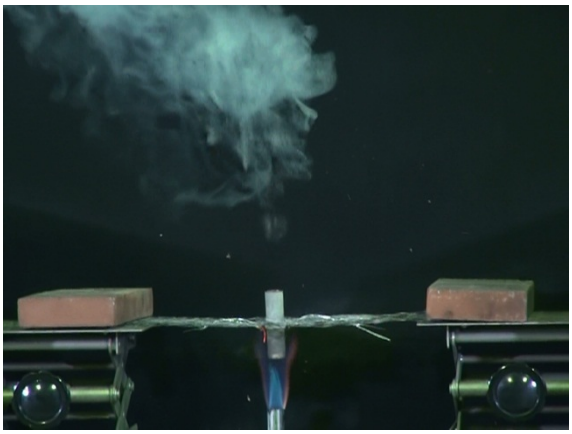


After 4 seconds

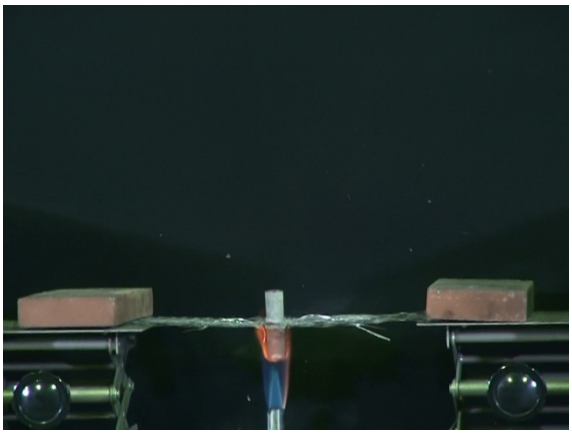


After 6 seconds

After 17 seconds

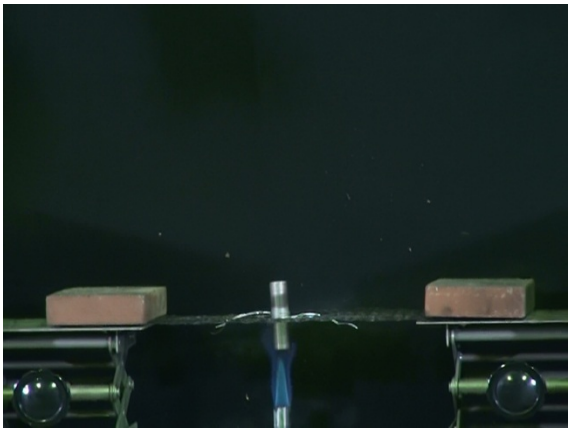


After 21 seconds



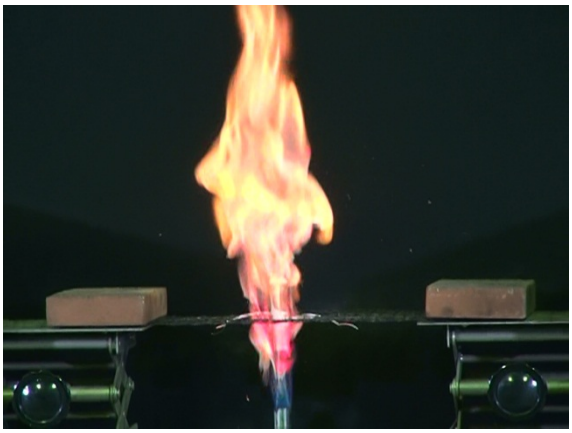
After 32 seconds

b) 3rd test (implemented November 24)

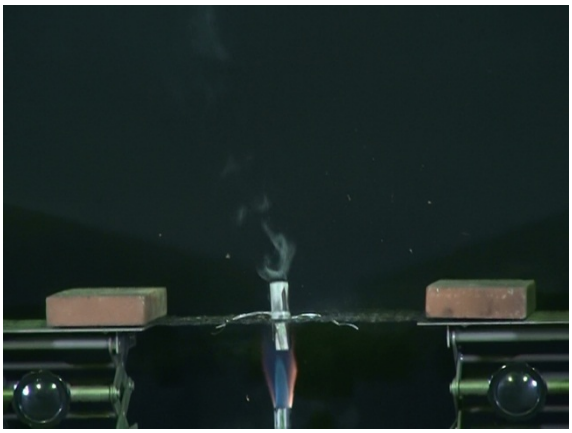


After start of heating

After 6 seconds



After 7 seconds



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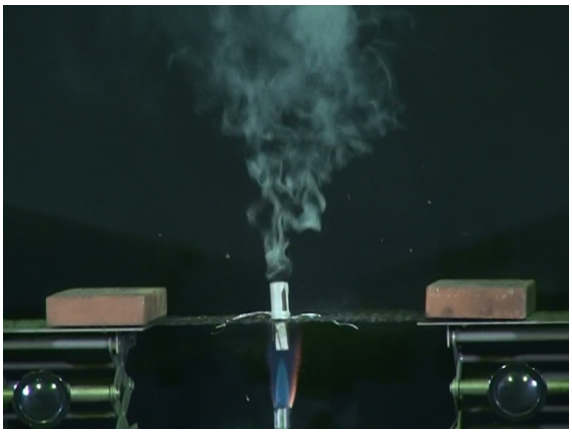
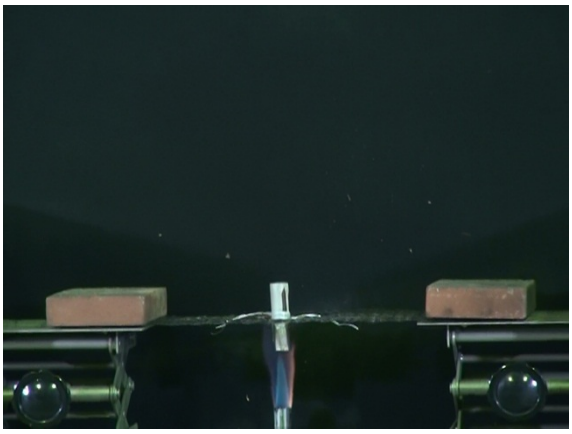


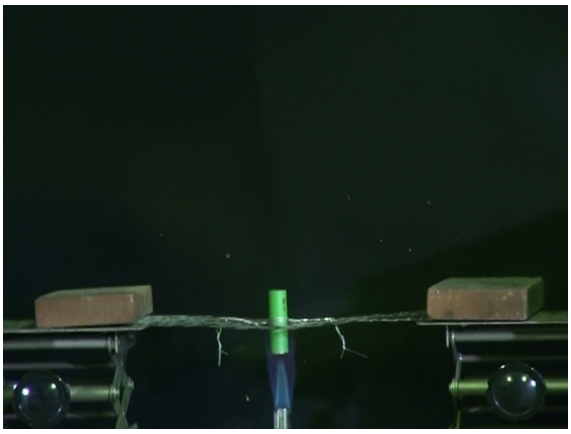
After 27 seconds



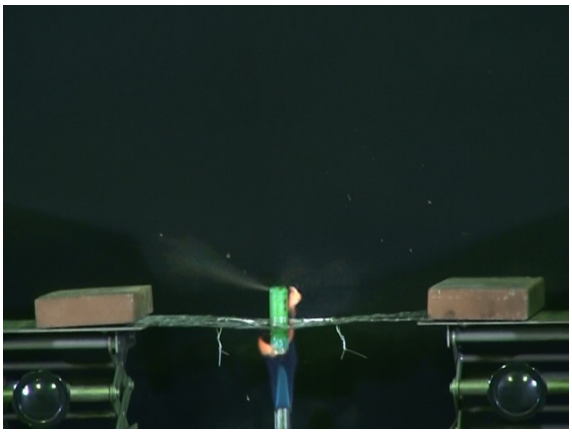
After 35 seconds

(2) Battery after sealing (charging rate 50%)

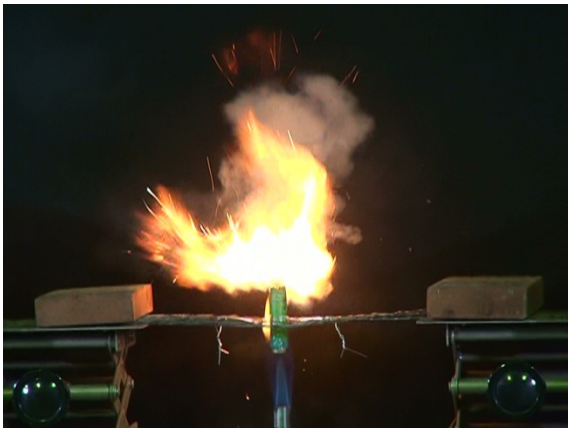
a) 2nd test (implemented November 24)



After start of heating

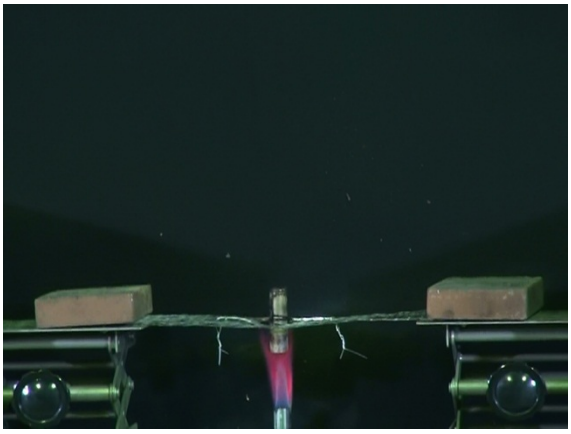


After 19 seconds



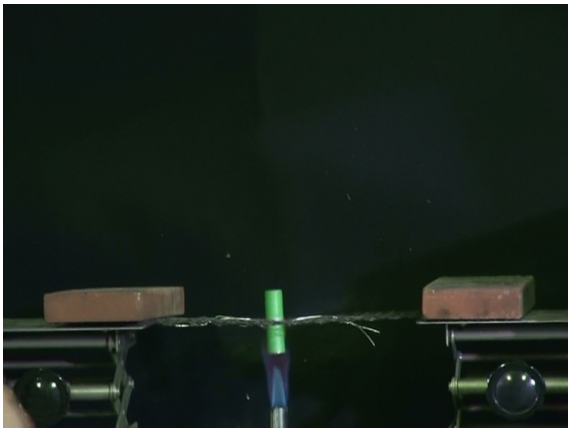
Immediately after 19 seconds

After 26 seconds

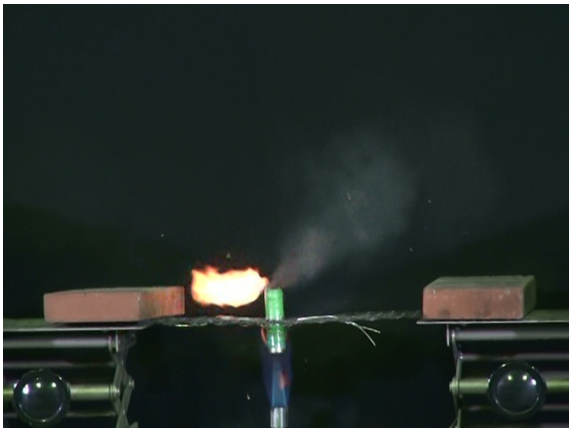


After 46 seconds

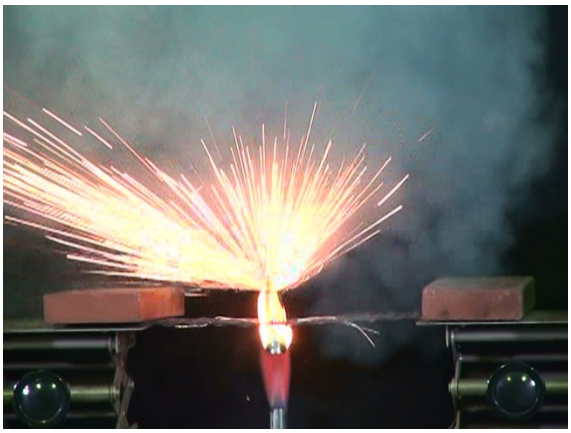
b) 3rd test (implemented November 24)



After start of heating

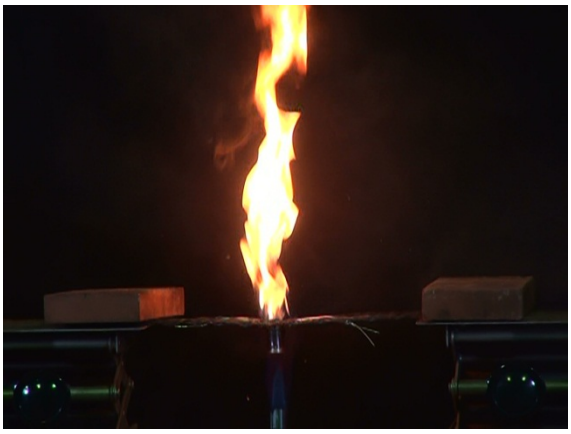


After 22 seconds

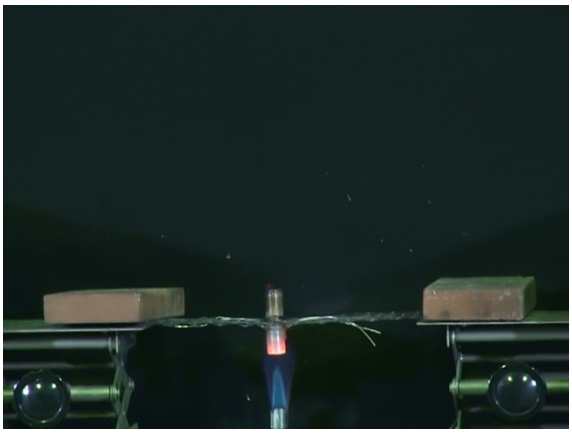


After 23 seconds

After 30 seconds



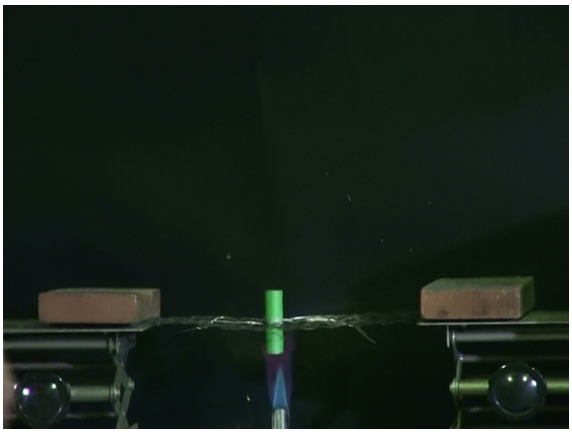
After 30 seconds



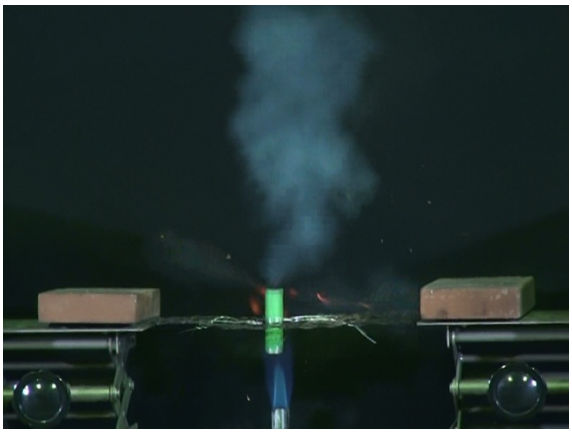
After 55 seconds

(3) Battery after sealing (charging rate 100%)

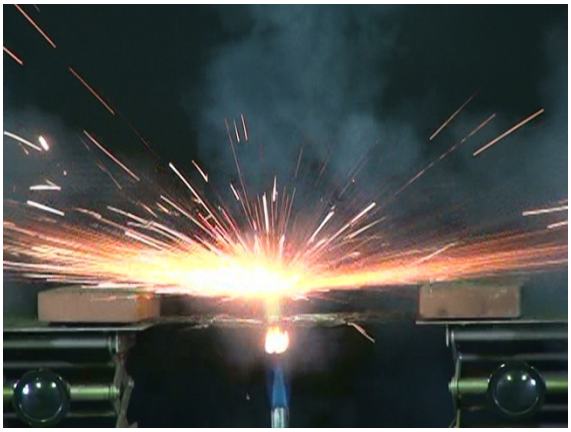
a) 2nd test (implemented November 24)



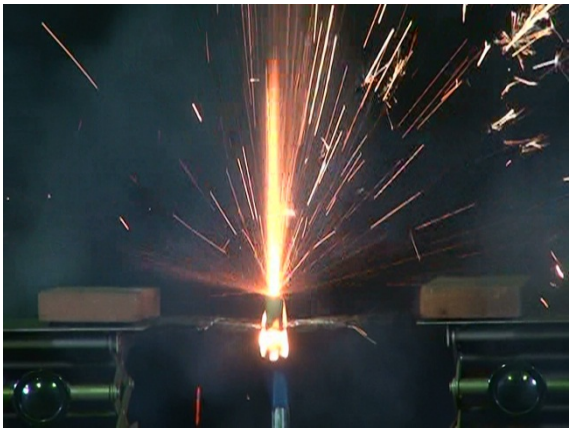
After start of heating



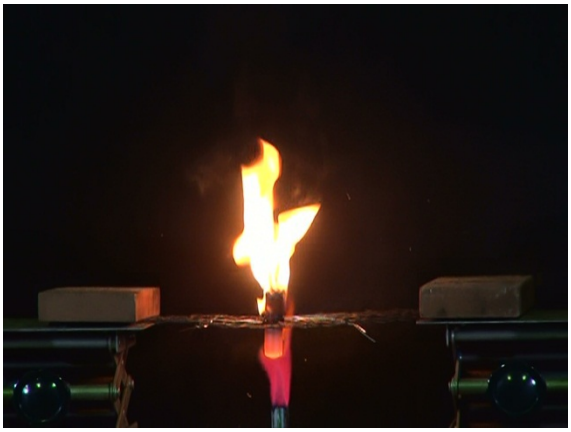
After 17 seconds



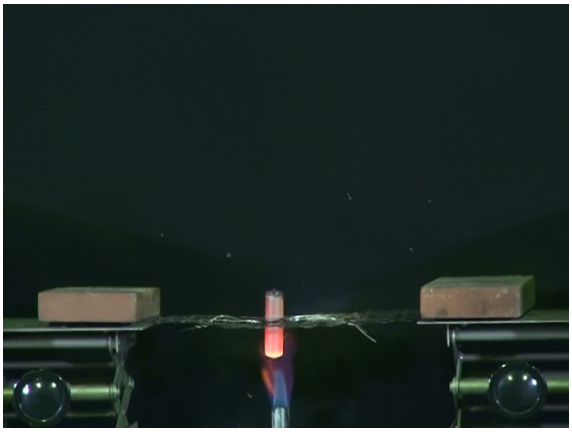
Immediately after 17 seconds



Immediately after 17 seconds

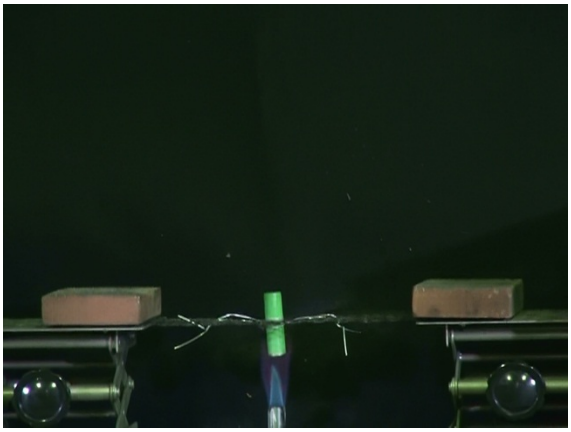


After 23 seconds

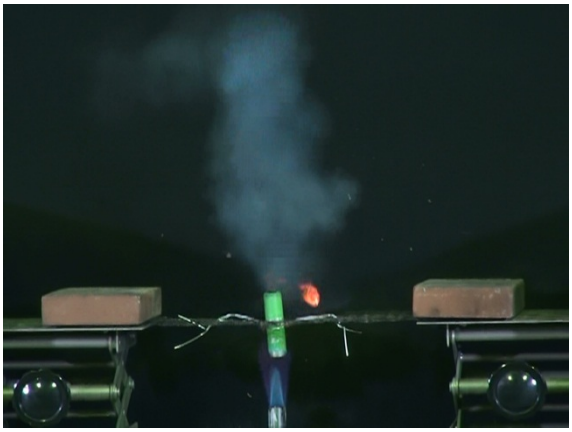


After 34 seconds

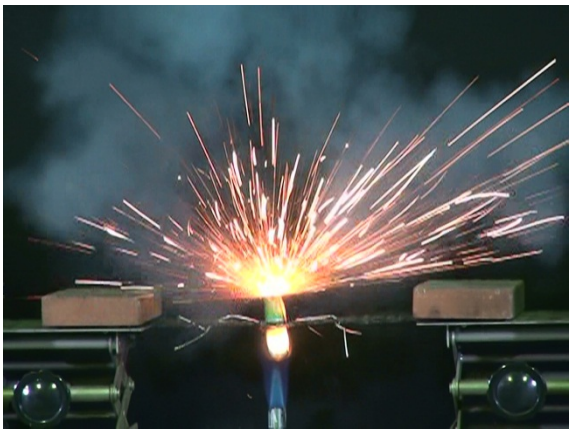
b) 3rd test (implemented November 24)



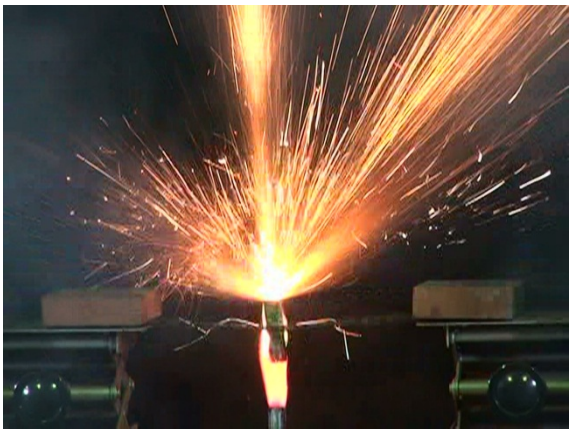
After start of heating



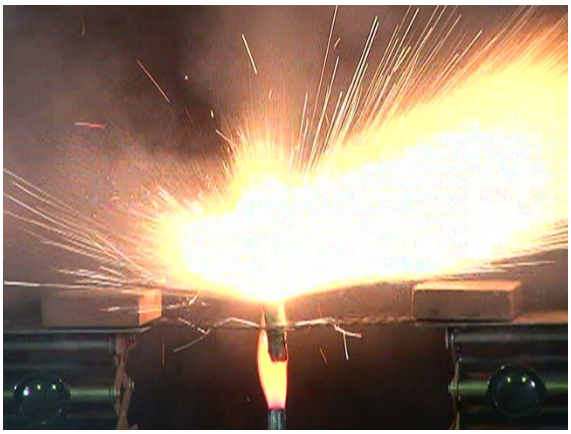
After 12 seconds



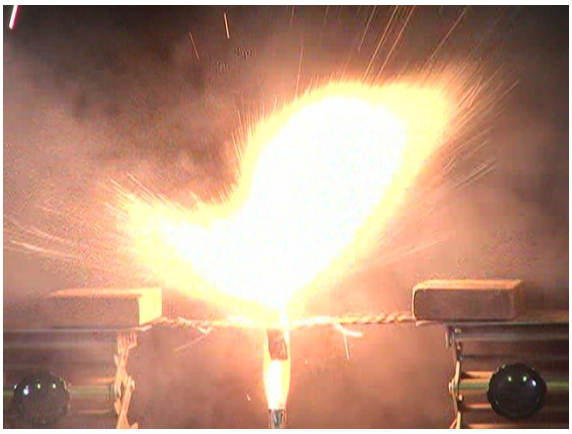
Immediately after 12 seconds



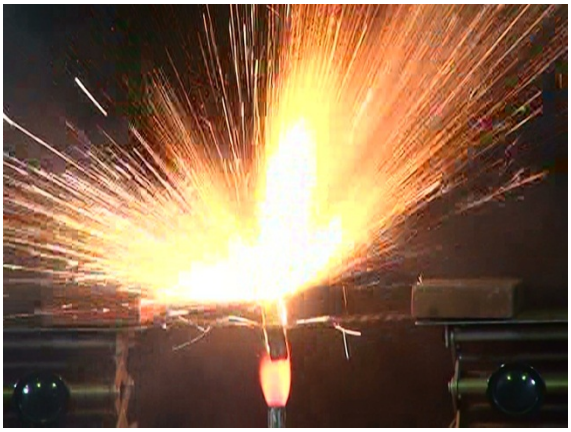
After 13 seconds



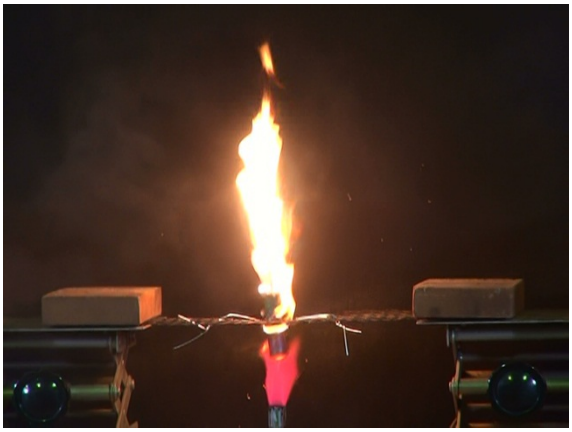
13~14 seconds



13~14 seconds



13~14 seconds



15 seconds

After 25 seconds