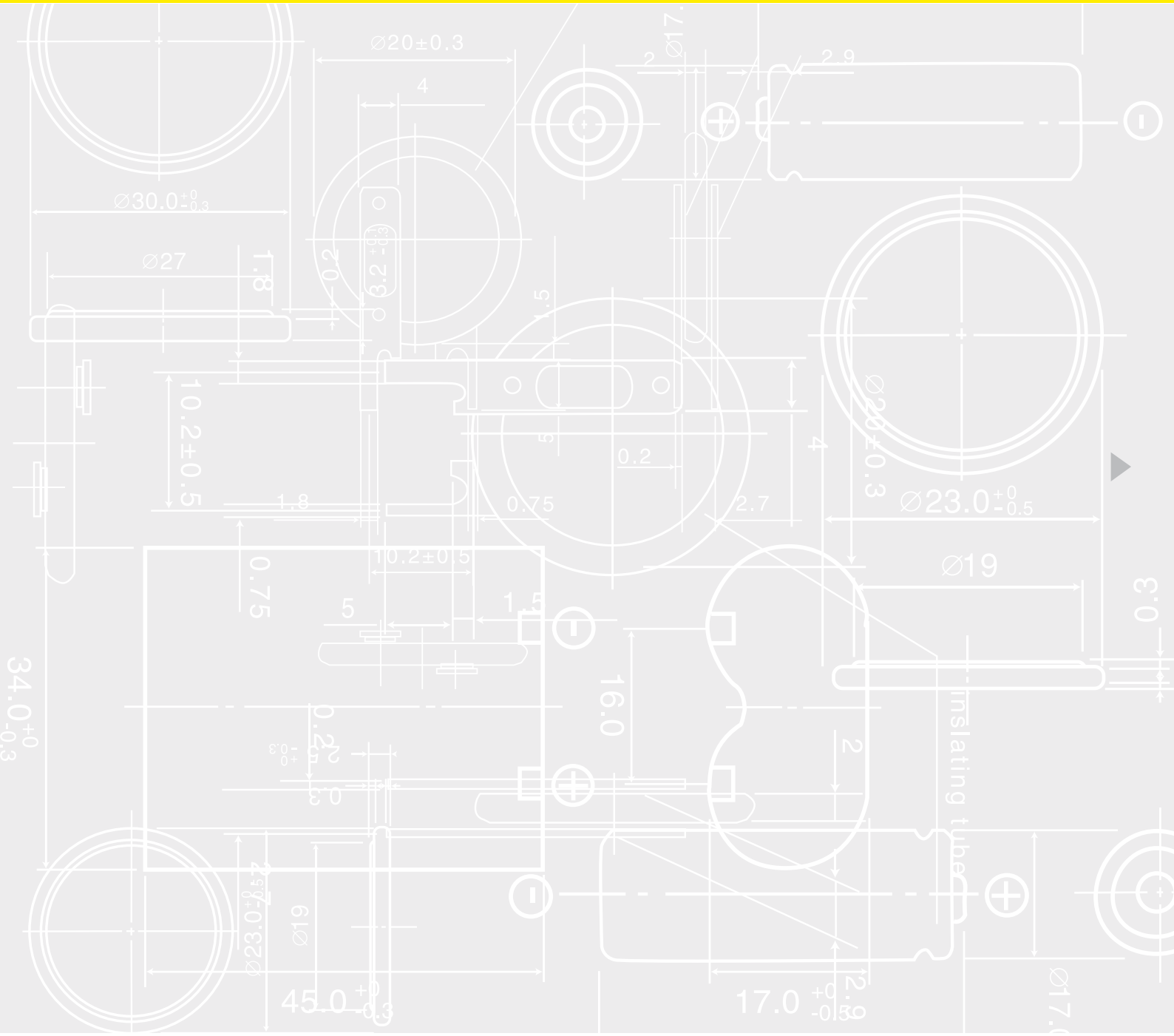
Panasonic
ideas for life

LITHIUM HANDBOOK

ENGLISH

INDUSTRIAL BATTERIES



Panasonic BATTERIES
Quality is our Business.

PANASONIC INDUSTRIAL EUROPE FIND OUT HOW WE CAN POWER YOUR BUSINESS!

Panasonic Corporation, founded in Osaka 1918, is one of the world's largest manufacturers of quality electronic and electrical equipment. Its subsidiary, Panasonic Industrial Europe GmbH (PIE) deals with a wide diversified range of industrial products for all European countries.
This company was formed in 1998 to strengthen Panasonic's Pan-European industry operation, and today is active in such different business fields as Automotive, AV/Communication, Appliance, Industry & Devices to satisfy its customer's needs.

Panasonic quality –
certified by authorised companies.

We are able to offer you a wide range of individual power solutions for portable and stationary applications. Our product range includes high reliability batteries such as Lithium-Ion, Lithium, Nickel-Metal-Hydride, Valve-Regulated-Lead-Acid (VRLA), Alkaline and Zinc-Carbon. Based on this battery range we can power your business in virtually all applications.

Panasonic Energy (PEC) started its production of Panasonic batteries in 1931. Today PEC is the most diversified global battery manufacturer with a network of 20 manufacturing companies in 14 countries. More than 16,000 employees are dedicated to the research and development of new batteries for a new world.

When it comes to production our facilities employ leading edge manufacturing processes meeting the highest quality standards. Our factories are certified to ISO standards. This means that each factory has its own quality and environmental management. The ISO 9000 and ISO 14000 series are the minimum benchmarks that ensure our excellent product reliability.

Furthermore the majority of our factories is also certified to OHSAS 18001 (Occupational Health and Safety Assessment Series), an international standard for assessing a management system for occupational safety. This confirms that our factories have been proactive in putting the occupational health and safety of its staff at the centre of the company's dealings. In addition our VRLA batteries are for example approved to German VdS standard and U.S. UL standard.

PIE Organisation Divisions

- ➜ Automotive
- ➜ AV/Communication
- ➜ Appliance
- ➜ Industry & Devices
- ➜ PMG (Product Marketing Group)
- ➜ Factory Solutions

Holistic sustainability

Wood is capital for human beings, animals and plants. The organisation Programme for the Endorsement of Forest Certification Schemes (PEFC) is working continuously to sustain the ecological equilibrium in our woods. Companies which are certified by PEFC are showing strongly their efforts towards the environment and their responsibility in working with the essential raw material wood. PEFC means holistic sustainability: an integrated concept which combines ecological, social and economical aspects. This Panasonic catalog is printed in compliance with this paper standard.

PEFC

PANASONIC LEADS THE WAY ... WITH ‘ECO IDEAS’

Pursuing coexistence with the global environment in its business vision, Panasonic places reduction of the environmental impact in all its business activities as one of the important themes in its mid-term management plan. In its ‘eco ideas’ Strategy, which focuses in particular on rapid implementation of measures to prevent global warming and global promotion of environmental sustainability management, Panasonic is advancing three key initiatives: ‘eco ideas’ for Manufacturing, ‘eco ideas’ for Products, and ‘eco ideas’ for Everybody, Everywhere.

Our energy will Drive eco Innovation.

THE PANASONIC ‘ECO IDEAS’ HOUSE

We are approaching a global turning corner and it would not be an exaggeration to call it the ‘Environmental Industrial Revolution’. Based on this recognition, Panasonic has built an ‘eco ideas’ House on the premise of our showroom, Panasonic Center Tokyo in April 2009 in order to help create a carbon-free society and reduce CO_2 emissions from a household sector.

The concept of this ‘eco ideas’ House can be decribed as follows:

1. Virtually zero CO_2 emissions in an entire house envisaged in three to five years into the future
2. Synergy of technology and nature

Aforementioned concepts shows that Panasonic is not only aware of it´s environmental responsibility moreover this Panasonic takes action.

‘ECO IDEAS’ FOR MANUFACTURING

Our Plans

We will reduce CO_2 emissions across all our manufacturing sites.

Our Goals

In each of our factories a CO_2 emissions of 10% reduction till 2010.

Our Measures

Our factories are evaluated with regard to CO_2 emission, waste disposal, recycling measures as well as chemical and water consumption within the scope of the ‘Clean Factory’ program and they are set performance targets according to these indicators.

Example

The Wakayama Plant of the Energy Company is strengthening its management structure to cut CO_2 emissions from the main production bases for Lithium-Ion batteries, which are a core component of Panasonic’s energy business. As a result, it has succeeded in roughly halving CO_2 emissions per production unit, as well as sharply curbing an increase in CO_2 emissions even as production has expanded.

‘ECO IDEAS’ FOR PRODUCTS

Our Plans

We will produce energy-efficient products.

Our Goals

In March 2010 at least 20 products with the ‘Superior Green Products‘ classification should be available.

Our Measures

The developers at Panasonic carry out an environmental impact assessment for all our products. Products that meet the highest environmental requirements in the branch with regard to conservation of energy and energy efficiency are classified as a ‘Superior Green Product’ and awarded the Panasonic logo ‘eco ideas’.

Example

We have dispensed with the use of highly toxic Lithium Thionyl Chloride in the production of our Lithium batteries. This is quite rightly classified as highly toxic and should never under any circumstances be released into the environment.

‘ECO IDEAS’ FOR EVERYBODY, EVERYWHERE

Our Plans

We will encourage the spread of environmental activities throughout the world.

Our Goals

Intensive commitment on the part of the company owners, international cooperations and involvement of the employees.

Our Measures

Not only do we sponsor the work of the WWF for the Arctic, Panasonic has also launched a couple of other environmental initiatives such as the ECO RELAY initiative in which hundreds of colleagues the world over take part voluntarily for several days in environmental campaigns.

Example

With the support of the GRS Batterien (German Battery Recycling Association) Panasonic arranged a battery collection day with the aim of collecting as many of these spent energy sources as possible and giving out information about the recycling loop of batteries from which valuable raw materials such as Zinc, Manganese and Iron can be recovered.

INDEX

Chapter		Page
1	**General Information**	
	Safety Warnings and Precautions	7
	Introduction	8
	General Features	9 – 10
	Primary vs. Rechargeable Lithium batteries	11
	Applications	12
	Selecting a battery/Model Number	13
	Battery Selection Chart	14 – 16
	General Safety Precautions for Using, Handling and Designing	17 – 20
	Design for Memory Back-up Use	21 – 22
2	**Primary Lithium batteries**	
	Cylindrical Type Lithium batteries – Poly-Carbonmonofluoride Lithium batteries (BR series)	24 – 27
	Cylindrical Type Lithium batteries – Manganese Dioxide Lithium batteries (CR series for consumer)	28 – 31
	Cylindrical Type Lithium batteries – Manganese Dioxide Lithium batteries (CR series for industrial)	32 – 33
	Coin Type Lithium batteries – Poly-Carbonmonofluoride Lithium batteries (BR series)	34 – 38
	Coin Type Lithium batteries – High Temperature Poly-Carbonmonofluoride Lithium batteries (BR-A series)	39 – 42
	Coin Type Lithium batteries – Manganese Dioxide Lithium batteries (CR series)	43 – 52
	Pin Type Lithium batteries – Poly-Carbonmonofluoride Lithium batteries (BR series)	53 – 54
3	**Rechargeable Lithium batteries**	
	Coin Type Rechargeable Lithium batteries – Vanadium Rechargeable Lithium batteries (VL series)	56 – 61
	Coin Type Rechargeable Lithium batteries – Manganese Rechargeable Lithium batteries (ML series)	62 – 68
	Coin Type Rechargeable Lithium batteries – Niobium Rechargeable Lithium batteries (NBL series)	69 – 70
	Coin Type Rechargeable Lithium batteries – Titanium Rechargeable Lithium batteries (MT series)	71 – 73
	Reflowable Coin Type Rechargeable Lithium batteries – Manganese Rechargeable Lithium batteries (ML-R series)	74 – 76
	Reflowable Coin Type Rechargeable Lithium batteries – Niobium Rechargeable Lithium batteries (NBL-R series)	77 – 78
4	**Batteries with Terminals and Soldering Lithium batteries**	
	Batteries with Terminals	80
	Soldering Lithium batteries	80
5	**Standards and Regulations**	
	ISO9001 Approval	82
	Transporting Lithium batteries	82
	Security Export Control	82
6	**Avoiding Hazards and Preventing Quality Problems**	
	Avoiding Hazards	84
	Preventing Quality Problems	85 – 87

⚠ Please be sure to observe the following warnings. As batteries contains flammable substances such as Lithium or other organic solvents, they may cause heating, rupture or ignition.

CYLINDRICAL TYPE LITHIUM BATTERIES

⚠ **Warning**

1. It may cause rupture or ignite.
   - ➜ Do not charge, short (an exception is to pass batteries through dipping solder) disassemble, deform or heat batteries. Do not throw batteries into fire.
   - ➜ Do not connect the ⊕ and ⊖ electrodes to each other with metal or wire. Do not carry or store batteries together with a metallic necklace, etc.
   - ➜ Avoid inversed connection of ⊕ and ⊖ terminals to devices.
   - ➜ Avoid mixed use of new and old batteries or batteries of other series.
   - ➜ Avoid direct soldering to batteries.
2. When discarding batteries, insulate the ⊕ and ⊖ terminals of batteries with insulating tape, etc. (see Fig. 1). When disposed of improperly, Lithium batteries may short, causing them to become hot, burst or ignite.
3. Keep batteries out of reach of small children. Should a child swallow a battery, consult a physician immediately.

⚠ **Caution**

Keep batteries away from direct sunlight, high temperature, and high humidity.

COIN TYPE LITHIUM BATTERIES

⚠ **Warning**

1. Do not charge, short (an exception is to pass batteries through dipping solder) disassemble, deform or heat batteries. Do not throw batteries into fire.
2. Keep batteries out of reach of small children. Should a child swallow a battery, consult a physician immediately.
3. When discarding batteries, insulate the ⊕ and ⊖ terminals of batteries with insulating tape, etc. (see Fig. 1). When disposed of improperly, Lithium batteries may short, causing them to become hot, burst or ignite.

⚠ **Caution**

1. Be sure to connect the ⊕ and ⊖ electrodes correctly.
2. Avoid mixed use of batteries, i.e. new, used or different types.
3. Avoid direct soldering to batteries.
4. Keep batteries away from direct sunlight, high temperature, and high humidity.

COIN TYPE RECHARGEABLE LITHIUM BATTERIES

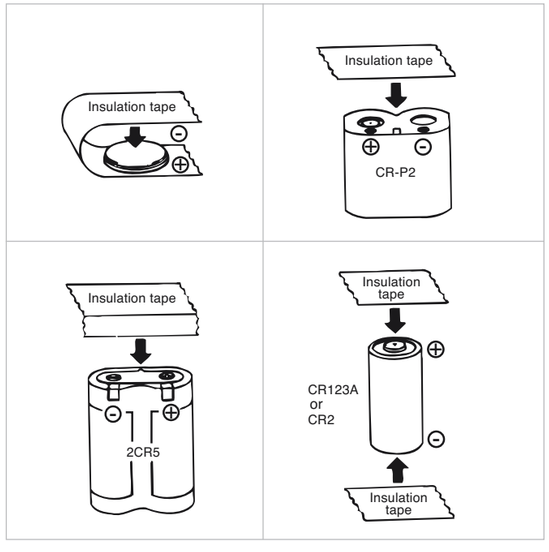
⚠ **Warning**

1. Do not charge, short (an exception is to pass batteries through dipping solder) disassemble, deform or heat batteries. Do not throw batteries into fire.
2. Do not charge rechargeable batteries with a higher voltage than specified.
3. Keep batteries out of reach of small children. Should a child swallow a battery, consult a physician immediately.
4. When discarding batteries, insulate the ⊕ and ⊖ terminals of batteries with insulating tape, etc. (see Fig. 1). When disposed of improperly, Lithium batteries may short, causing them to become hot, burst or ignite.

⚠ **Caution**

1. Be sure to connect the ⊕ and ⊖ electrodes correctly.
2. Avoid mixed use of batteries, i.e. new, used or different types.
3. Avoid direct soldering to batteries.
4. Keep batteries away from direct sunlight, high temperature, and high humidity.

Fig. 1 When disposing batteries (Example of insulating)*



* Discharge circuits will be made by the contact of batteries, which may cause heating, rupture, or ignition of batteries.

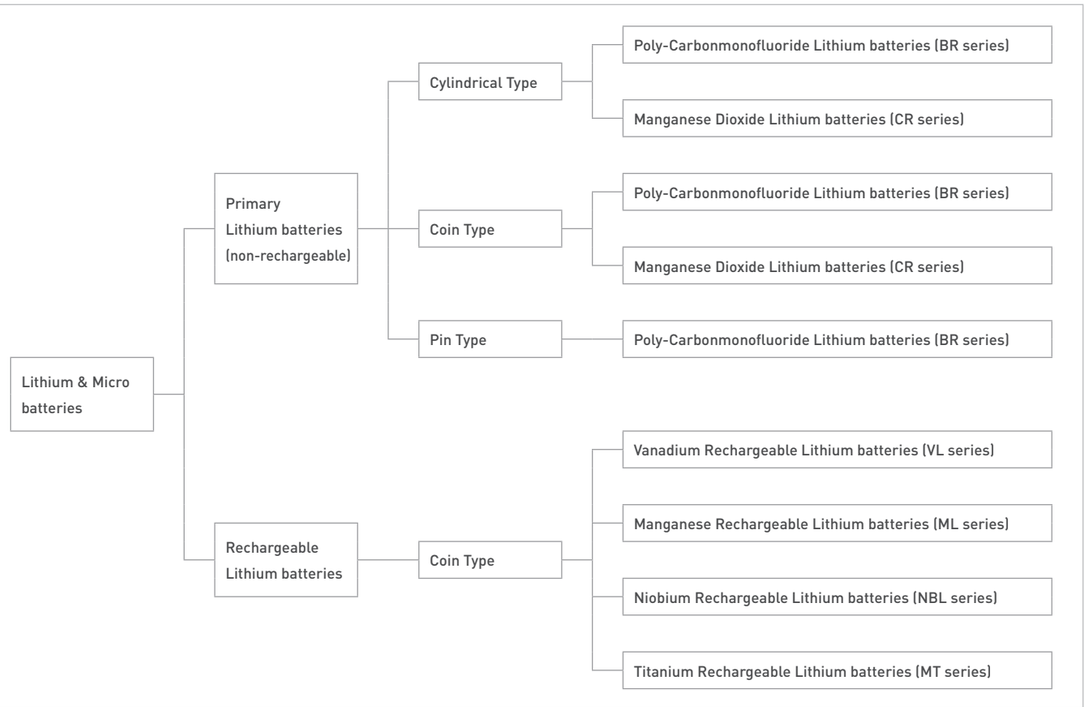
LITHIUM & MICRO BATTERIES: TYPES AND FEATURES

Ever since Panasonic became the first company in the world to develop and commence the mass production of Lithium batteries for consumer products in 1971, Panasonic has launched a series of Lithium batteries in many shapes and sizes including cylindrical types, coin types and pin types. Panasonic has also successfully introduced coin type rechargeable Lithium batteries to the market for applications such as memory back-up or watches.

Today, Lithium batteries have a proven track record of opening up a host of new fields where conventional batteries cannot be used. Applications range from high-current discharge applications typified by 35 mm cameras to ultra-low current discharge applications in such products as electronic watches or applications as power supplies for IC memory back-up which require long-term reliability.

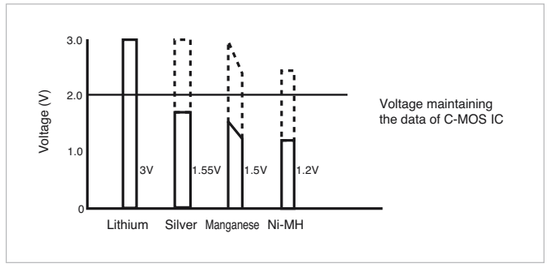
Panasonic has conducted repeated tests on the various safety and performance characteristics, plus the effects of environmental factors such as temperature. We have accumulated a wealth of corroborative data on the performance of our batteries which cannot be pinpointed by short-term accelerated tests. As a result, Panasonic batteries have won approval under the UL safety standards in the United States and wide recognition throughout the world for their high reliability and safety.

TYPES OF LITHIUM & MICRO BATTERIES



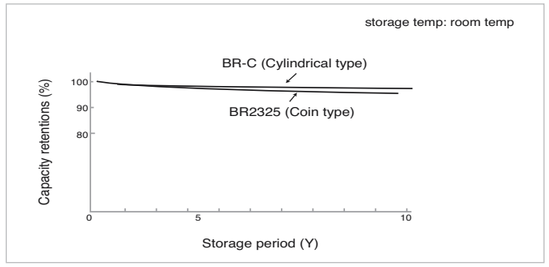
High voltage

The high energy density of Lithium batteries and their high voltage of 3V (there are 1.5V and 2V lineups also) make them ideally suited for use in all kinds of products where the trend is to achieve increasing miniaturization. A single Lithium battery can replace two, three or more conventional batteries. The figure on the right shows the number of cells required to provide the C-MOS IC data holding voltage for each type of battery.



Low selfdischarge rate and superior storability

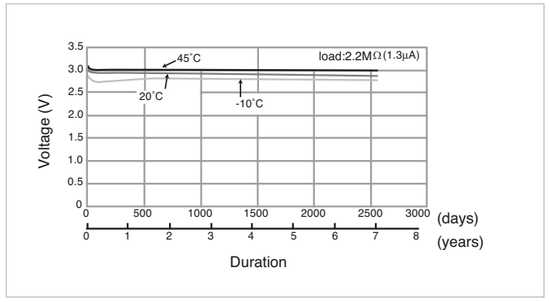
Since the substance that is chemically very stable is used for plus terminal as an active material (BR series: Poly-Carbonmonofluoride, CR series: Manganese Dioxide), if preservation conditions are proper, 90% of capacity remains even after ten years storage.



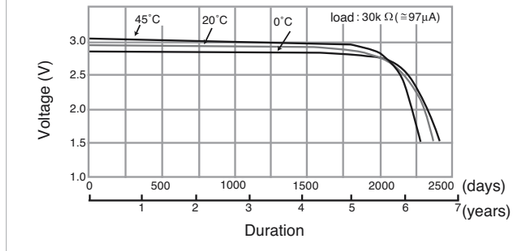
Long-term discharge

Long-term discharge has been verified at all operating temperatures under low-load discharge conditions.

BR-2325



BR-C



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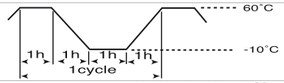
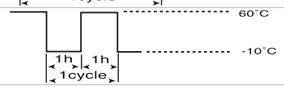
Outstanding electrolyte leakage resistance

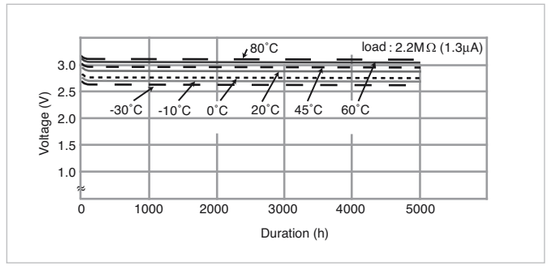
Lithium batteries employ organic electrolytes with minimum creeping so they are vastly superior in terms of leakage resistance under environmental changes compared to other types of batteries that employ aqueous solution electrolytes. The batteries achieve stable characteristics under high temperature and humidity conditions (45°C/90% RH, 60°C/90% RH), and even under heat shock which constitutes the severest challenge for batteries.

Leakage resistance evaluation items	Test conditions
High-temperature storage	60°C
High-temperature High-humidity storage	45°C / 90%RH 60°C / 90%RH
Temperature cycle	
Heat shock	

Wide operating temperature range

Due to the use of organic electrolytes with a solidifying point that is much lower than the aqueous solution electrolytes used in other types of batteries, Lithium batteries are capable of operation in a wide range of temperatures. Not only do the high operating temperature BR series cells use a special engineering plastic as the material for the gasket and separator instead of the conventional polyolefin resin but its operating temperature range has also been significantly increased by employing an electrolyte with a high boiling point.

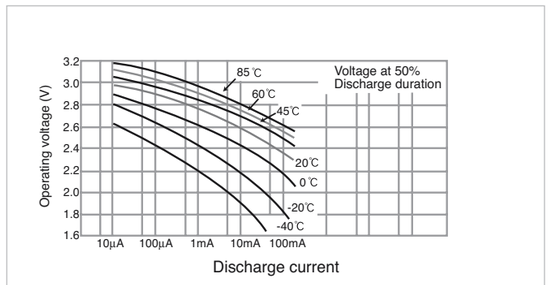
BR-2325 Operating voltage under high-resistance discharge



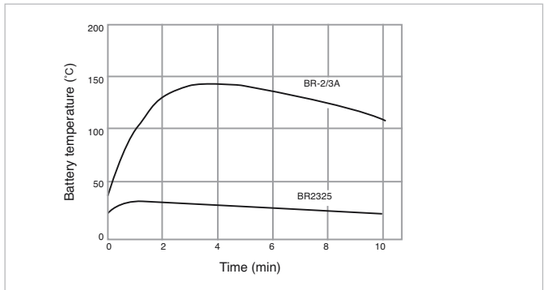
Superior safety

Lithium batteries feature stable substances for the active materials and a structural design that assures safety and, as such, their superior safety has been verified from the results of repeatedly subjecting them to a number of different safety tests. As a result, Panasonic's Lithium batteries have been approved under the safety standard (UL1642) of UL (Underwriters Laboratories Inc.).

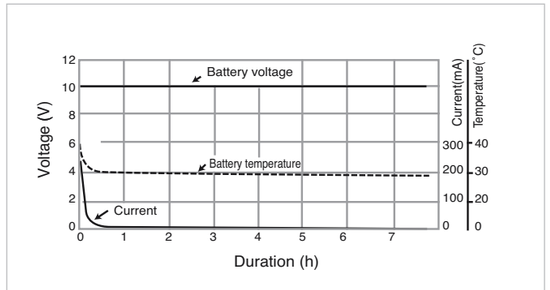
BR-2/3A Current drain vs. operation voltage



Battery surface temperature when short-circuited



BR-2325 Charge resistance (10V consistent-voltage charge)



Leakage resistance test results

Model	Conditions	60°C		45°C/90%		60°C/90%		Temp. cycle	Heat shock
	Storage	1 month	3 months	1 month	3 months	1 month	3 months	60 cycles	120 cycles
BR-2325		○	○	○	○	○	○	○	○
BR-2/3A		○	○	○	○	○	○	○	○

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COIN TYPE RECHARGEABLE LITHIUM BATTERIES

Rechargeable Lithium batteries come with excellent characteristics and high reliability.

- ➜ Long-term reliability
- ➜ High capacity
- ➜ Low self-discharge rate
- ➜ Resistance to continuous discharge
- ➜ Resistance to over discharge

COMPARISON TABLE OF LITHIUM BATTERY TYPES

Item	Type	Primary battery		Rechargeable battery			
	Model	BR	CR	VL	ML	NBL	MT
Material	⊕ electrode	(CF)n	MnO_2	V_2O_5	LixMnOy	Nb_2O_5	LixOy
	⊖ electrode	Li	Li	LiAl	LiAl	LiAl	LixTiOy
Nominal voltage		3.0	3.0	3.0	3.0	2.0	1.5
Operating temperature range (°C)		**cylindrical :** -40 to +85 **coin :** -30 to +80 **high operating temperature coin :** -40 to +125 **pin :** -30 to +80	**cylindrical :** -40 to +70 **coin :** -30 to +60	-20 to +60	-20 to +60	-20 to +60	-10 to +60
Self-discharge (per year) under standard conditions	Cylindrical type	0.5%	1.0%	2.0%	2.0%	2.0%	2.0%
	Coin type	1.0%	1.0%				
Average discharge voltage (V)		–	–	2.85	2.5	1.5	1.2
Charge voltage (V)		–	–	3.25 to 3.55	2.8 to 3.2	1.8 to 2.5	1.6 to 2.6
Cut-off voltage (V)		2.0	2.0	2.5	2.0	1.0	1.0
Charge-discharge cycles		–	–	**1,000** charge/discharge partly (charge/discharge for 10% of discharge depth)	**1,000** charge/discharge partly (charge/discharge for 10% of discharge depth)	**1,000** charge/discharge partly (charge/discharge for 10% of discharge depth)	**500** charge/discharge up to 1V or discharge limit voltage (charge/discharge for 100% of discharge depth)

COMPARISON BETWEEN BR AND CR

Model		BR/CR
Performance	**Discharge capacity**	BR = CR
	Voltage during discharging	BR < CR (Higher)
	Flatness of discharge voltage	(Flatter) BR > CR
	Load characteristics	BR < CR (Superior)
	Storage properties (self-discharge) < 60°C	(Less self-discharge) BR ≥ CR
	> 60°C	(Less self-discharge & stable) BR > CR

Notes: In terms of their characteristics, the CR series provides a slightly higher voltage during discharge than the BR series. BR batteries, compared with CR batteries, show more stable characteristics with less discharge voltage variations. These characteristics should be taken into consideration when selecting a battery for each application.

◎ Recommended applications
○ Potential applications

PRIMARY TYPE

Usage		Coin type			Cylindrical type			Pin type
		BR series	BR-A series	CR series	BR series	CR series	CR series for industrial	BR series
Cameras						◎		
Household use	Lights				○	○		
	Shaver					○		
Watches	Analog	○		○				
	Digital	○		○				
	Clocks	○		○				
Business use	Communication equipment				○		◎	
	Test equipment				○		◎	
	Fire alarm				○		◎	
Meters (gas, water, etc)					◎			
RTC/Memory back-up of SRAM card		◎	◎	○				
Car equipment	Keyless entry			○				
	ETC		○		○		◎	
Electronic organizer				○				
Portable game players				◎				
IC tags				○				
IC cards				○				
Fishing equipment	Electronic float with lighting diode							◎
	Light for a poledіode							◎
	Lighted luresdiode							◎
Memory back-up (low load)		◎	◎	○	◎			

RECHARGEABLE TYPE

Usage	Coin type			
	VL series	ML series	NBL series	MT series
Memory back-up	◎	◎	◎	○
Keyless entry	○			
Rechargeable watches				◎

SELECTING A BATTERY

The steps for selecting the batteries for the power supplies of specific equipment are summarized below.

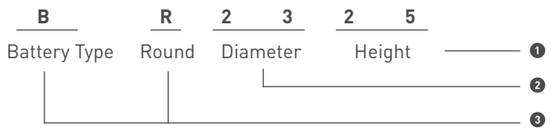
Preparation of required specifications (draft)
The required specifications (draft) are studied by checking the requirements for the batteries to be used as the power supplies of the specific equipment and their conditions against the battery selection standards. The technical requirements for battery selection are shown in the table below for reference purposes.

Selection of a battery
Select several candidate batteries by referring to the catalogs and data sheets of batteries which are currently manufactured and marketed. From this short list, select the battery which will best meet the ideal level of the requirements. In actual practice, however, the 'perfect' battery is seldom found by this method, instead, the basic procedure followed should be to examine the possibility of finding a compromise or partial compromise with the required specifications (draft) and then make a selection under the revised requirements from the batteries currently manufactured and marketed. Such a procedure enables batteries to be selected more economically. Questions and queries arising at this stage should be directed to our battery engineers. Sometimes, although it may not be shown in the catalog, the appropriate battery has become available through recent development or improvement. As a rule, the required specifications are finalized at this stage.

Requests for developing or improving batteries
If the battery that meets the essential and specific requirements cannot be found through the selection process described above, a request for battery development or improvement should be made to our technical Department. A request like this should be coordinated as early as possible to allow for a sufficient study period. While this period depends on the nature of the request and the difficulties involved, a lead time of at least 6 to 12 months is usually required.

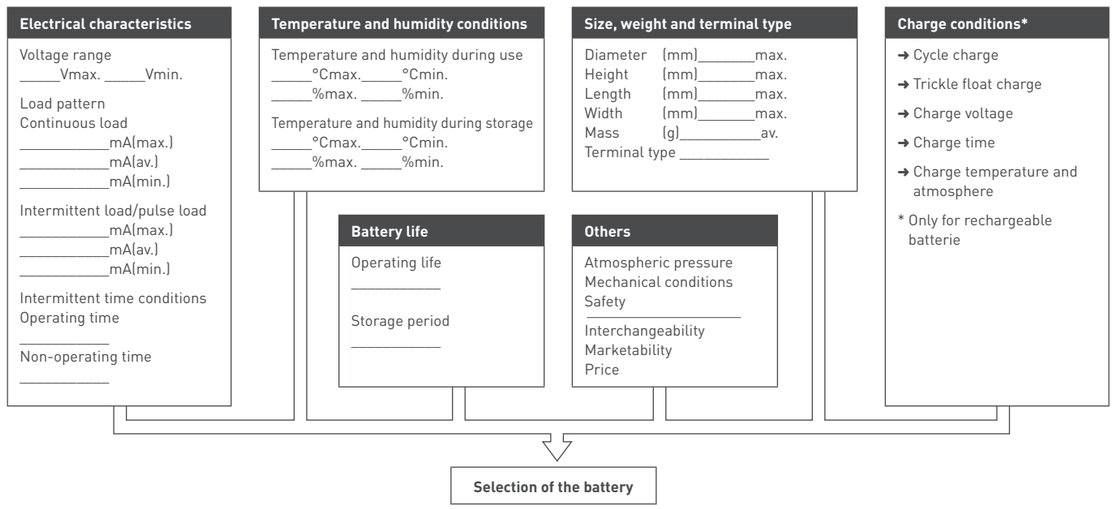
MODEL NUMBER

How to interpret the model numbers generally used for coin type Lithium batteries
The model numbers are normally indicated using two uppercase English letters and a figure consisting of three or more digits as shown in the example below. This numbering system is supported by the Japan International Standard Committee of Clocks and Watches and is also an established practice in Japan.



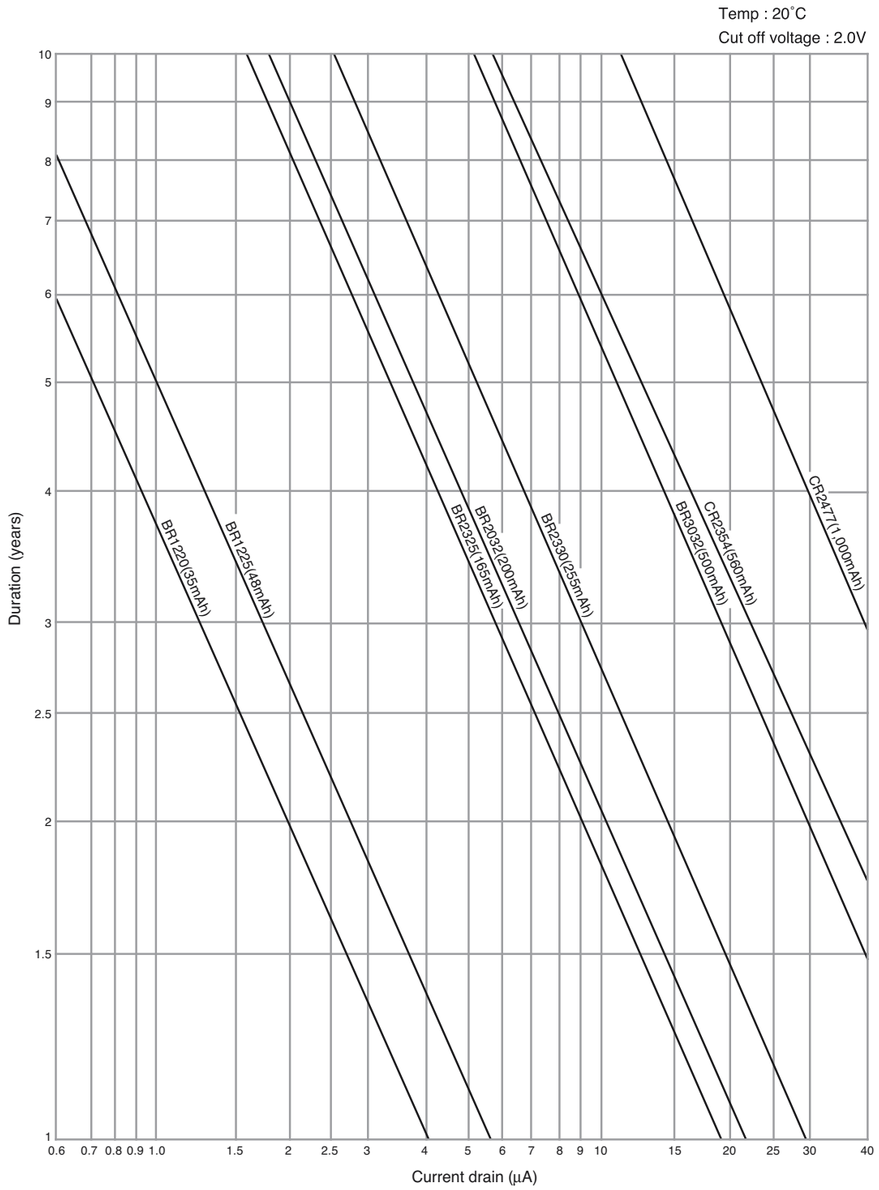
1. Figures to first decimal place with decimal point omitted (ex. 2.5mm)
2. Integers omitting fractions (ex. 23mm Dia.)
3. In accordance with JIS and IEC standards

TECHNICAL CONDITIONS FOR SELECTING BATTERIES



COIN TYPE PRIMARY LITHIUM BATTERIES (EXAMPLE)

DISCHARGE LIFE AS A FUNCTION OF OPERATING CURRENT



GENERAL FORMULA (ROUGH VALUE WITH 20°C, STANDARD LOAD)

Calculation Duration (years) = $\frac{\text{Nominal capacity (mAh)}}{\text{Current drain (mA) x 24 (hours) x 365 (days)}}$

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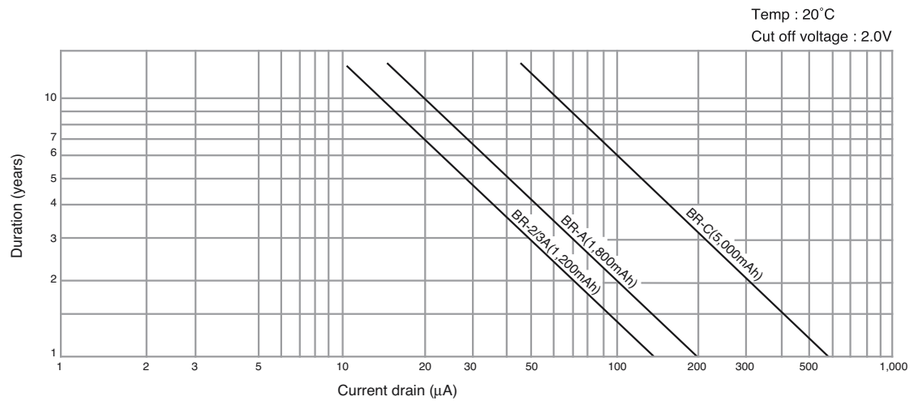
CYLINDRICAL TYPE PRIMARY LITHIUM BATTERIES (EXAMPLE)

DISCHARGE LIFE AS A FUNCTION OF OPERATING CURRENT



GENERAL FORMULA (ROUGH VALUE WITH 20°C, STANDARD LOAD)

Calculation Duration (years) = $\frac{\text{Nominal capacity (mAh)}}{\text{Current drain (mA) x 24 (hours) x 365 (days)}}$

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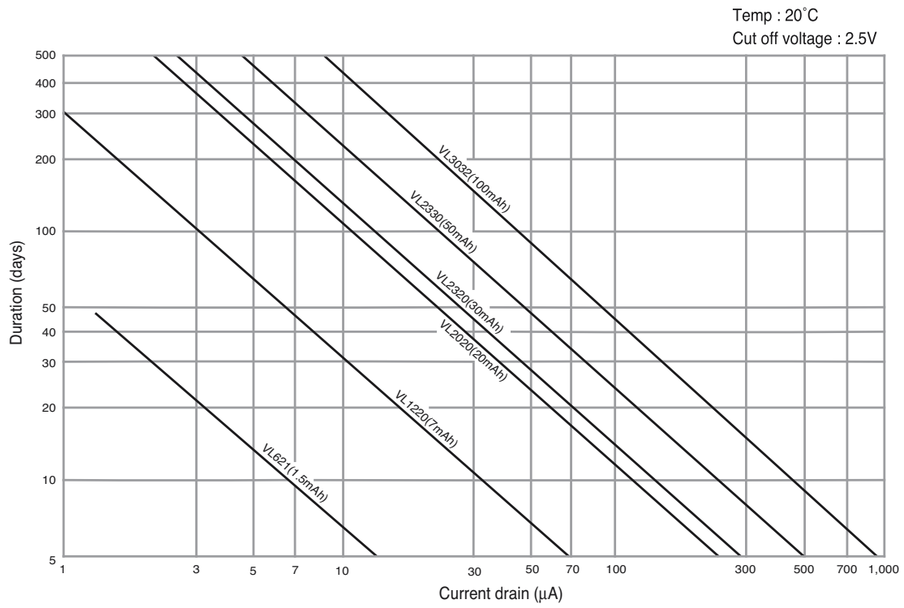
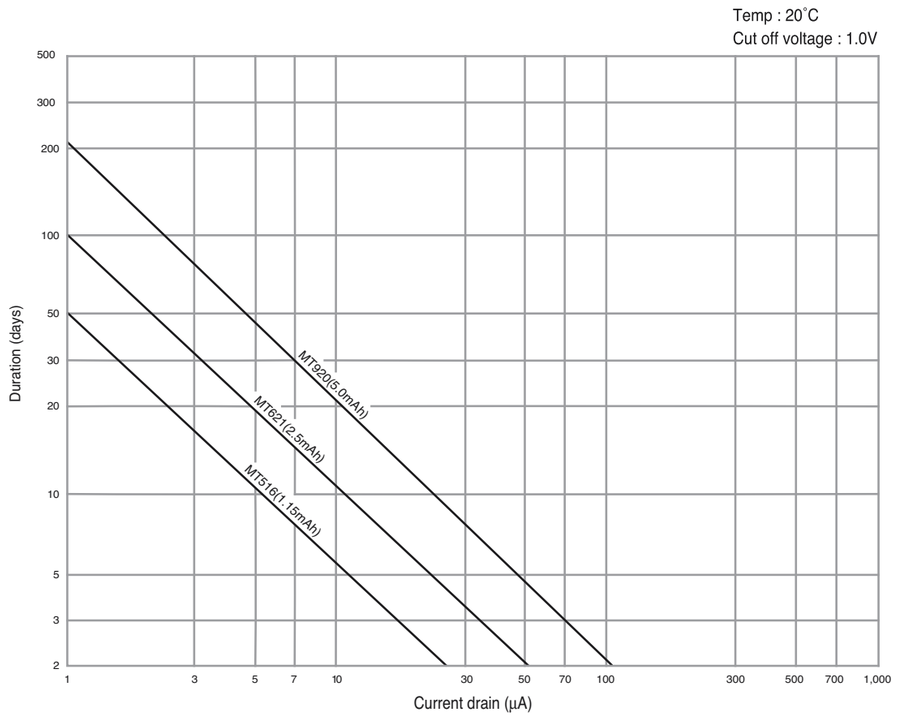
COIN TYPE RECHARGEABLE LITHIUM BATTERIES (EXAMPLE)

DISCHARGE LIFE AS A FUNCTION OF OPERATING CURRENT





APPLICABLE BOTH PRIMARY AND RECHARGEABLE BATTERIES

Classification	Item	Precaution
Batteries	Voltage measurement	To measure the battery voltage, use an instrument with an input resistance of 10MΩ or higher.
	Internal resistance measurement	To measure the internal resistance, use a 1000Hz AC instrument.
	Electrical characteristics check	Even minimal shorting causes the battery voltage to drop, requiring a period of time for the voltage to recover. Checking the voltage characteristics before the voltage has sufficiently recovered in such a situation may result in a misjudgment of battery voltage.
	Cleaning	Prior to installation in the equipment, wipe the batteries and equipment terminals clean using a dry cloth, etc.
	Washing and drying	→ Washing: Use of a conductive detergent causes batteries to discharge, the battery voltage to drop and the battery performance to deteriorate in other ways. Be sure to use a non-conductive detergent. → Drying: The heat produced when the temperature of the battery units rises above 85 C deforms the gaskets and causes electrolyte leakage and a deterioration in performance. Be sure to dry batteries only for short periods of time at temperatures below 85 C.
	Mounting	→ Ensure that dust and other foreign substance will not cause shorting between the poles. → When handling batteries, wear finger covers or gloves made of rubber, cotton, etc. to protect the batteries from dirt.
	UL	Strictly comply with the conditions outlined on the next page.
	Use of multiple batteries	Give sufficient consideration to safety in design when a multiple number of batteries are to be used. Consult with Panasonic concerning packs of multiple batteries.
	Simultaneous use of other types of batteries	When other types of batteries are also to be used in the some equipment, design the circuitry in such a way that the current (leakage current) from the other batteries will not flow to the Lithium batteries. (This applies to primary batteries.)
	Use of batteries in series or in parallel	This requires special circuitry: Please consult with Panasonic. Do not use Lithium batteries together with different types of batteries in series or in parallel.
	Battery life	Prior to installation in the equipment, wipe the batteries and equipment terminals clean using a dry cloth, etc.
Battery compartments in equipment	Design	→ Ensure that the batteries can be replaced easily and that they will not fall out of position. → Give consideration to the battery dimensions, tolerances, etc. → Give consideration to the shape of ⊕ and ⊖ electrodes of the batteries and their tolerances to prevent installation in reverse. → Clearly indicate on the battery compartment the type of batteries to be used and their correct installation direction (polarities). → Limit the electrical circuits inside the battery compartment only to the circuits relating to the battery contacts. → With the exception of the terminal areas, insulate the battery compartment from the electrical circuits. → Take steps to minimize any damage to the equipment resulting from electrolyte leakage from the battery compartment. → Batteries should be free from leakage of liquids, which can damage equipment and spoil the contact at terminals, making the operation of equipment unstable.
	Battery layout and construction and materials of compartment	→ Take steps to ensure the batteries are not located heat generating component in the equipment. Installing batteries near a heat source will heat up the batteries, causing thermal deformation of the gasket and resulting in electrolyte leakage and a deterioration in characteristics. → Adopt a construction which allows the gases to be vented. → Give consideration to the impact and the effect on the environment in selecting the materials to be used.
Contacts and connection terminals	Contact point materials	Use nickel-plated iron or nickel-plated stainless steel for the contact points.
	Contact pressure of contacts	In order to ensure stable contact, use the following levels of contact as a general guideline: 5N to 15N for cylindrical types 2N to 10N for coin types.
	Shape of terminals	Use of Y-shaped terminals (2-point contact) for both the ⊕ and ⊖ electrodes yield stable contact.
	Connection terminals	If lead wires and connection terminals such as tab terminals are required for the batteries, consult with Panasonic since we offer a range of external terminals (connectors, etc.).

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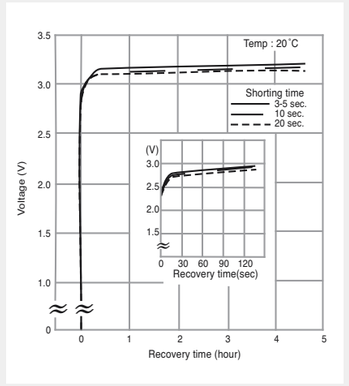
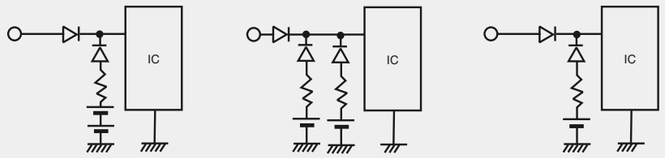
Classification	Item	Precaution
Notes		1. Shorting causes the battery voltage to drop to about 0V before slowly recovering from the open state. It takes time for the initial voltage to be restored. Notice that measuring the open-circuit voltage immediately after shorting may lead to a misjudgment that the battery is abnormal. The figure on the right illustrates how voltage recovers after shorting. 2. Reverse current preventing diodes.Since Lithium primary batteries are not rechargeable, use of a reverse current preventing diode and a protective resistor in series is required where there is the possibility of charging in the equipment circuit. Use a silicon diode or Schottky diode with a low reverse current as the reverse current preventing diode. To maintain the characteristics of a coin-type Lithium battery, the total charging amount of the battery during its total usage period must be kept within 3% of the nominal capacity of the battery. **BR-2/3A** voltage recovery after short-circuited (example)   (A) 2-cell 6V usage (B) Parallel usage (C) UL conditions

PRIMARY BATTERIES

Since Lithium primary batteries are not rechargeable, use a reverse current blocking diode and a protective resistor in series where there is the possibility of charging in the equipment circuit.

Reverse current blocking diode

Diode used

Use a low leak current diode (this current varies with temperature).

Selection standard

The total allowable charging amount of a battery during its total usage period must not be greater than 3% of the nominal capacity of the battery for a coin type battery or 1% for a cylindrical battery.

Example

When a CR-2477 (1000mAh) coin-type battery is to be used for 5 years, a reverse current preventing diode with a reverse current of 0.7μA or less is required.

Calculation method

1000mAh (CR-2477) x ≤ 3% (coin type battery) = ≤ 30mAh

30mAh ÷ usage period (5 years x 365 days x 24 hours) = 0.7μA

Use of protective resistor in series: Selection and installation (UL Standard)

A resistor must be installed in series with the battery to limit the charge current which will flow to the battery in case of destruction in continuity of the reverse current preventing diode. The maximum allowable current is specified for each battery size in the table at the right, and the resistance value of the protective resistor is determined as:

R > V ÷ I (where 'I' is the maximum allowable charge current specified by UL).

Conditions for UL Standard

(Contact Panasonic for further details.)

1. Use of protective resistor in series

Selection

Select the protective resistor in such a way that the charge current which will flow to the battery when the diode is destroyed is less than the value given in the table on the right.

Installation

To protect the battery from being charged in the event of the destruction of the diode, install a protective resistor in series with the battery.

2. Battery replacement

Replacement by qualified engineer

These batteries are intended for use as a part of an electrical circuit in equipment and any battery with an asterisk ' * ' in the table on the right should only be replaced by a qualified engineer.

Replacement by user

Those Lithium batteries which are not accompanied by an asterisk ' * ' in the table on the right and which include the use of up to four of them in series or in parallel may be replaced by users provided that the conditions specified by the UL Standard are met.

Use in series or in parallel

In replacing up to four batteries, the batteries must all be replaced with new ones at the same time. Set the maximum allowable charge current to within the current permitted by the number of batteries in series or in parallel.

RECHARGEABLE BATTERIES

Use of multiple batteries

Consult with Panasonic if two or more Vanadium rechargeable Lithium batteries (VL series) or Manganese rechargeable Lithium batteries (ML series) are to be used in series or in parallel.

Charging

Details on the charge voltage, charge current and charge circuit are given for each type of battery.

Conditions of UL approval

The maximum charge current must be restricted to 300mA when protective components have been subjected to short- or open-circuiting.

PRIMARY AND RECHARGEABLE BATTERIES

○ UL approval

UL APPROVAL AND MAXIMUM ALLOWABLE CHARGE CURRENT

	Shape	Model number	UL approval	Maximum abnormal charging current (mA)
Primary Lithium batteries	Cylindical Type BR series	BR-1/2AA	○	5
		BR-2/3A	○	10
		BR-2/3AG	○	10
		BR-A*	○	15
		BR-AG*	○	15
		BR-C*	○	20
	Cylindical Type CR series	CR-2	○	20
		CR-123A	○	25
		2CR-5	○	25
		CR-P2	○	25
		CR-V3	○	25
	Cylindical Type CR series for industrial	CR-AAZ*[1]	○	xx
		CR-2/3AZ	○	25
		CR-AG*	○	25
	Coin Type BR series	BR-1220	○	3
		BR-1225	○	3
		BR-1632	○	4
		BR-2032	○	5
		BR-2325	○	5
		BR-2330	○	5
		BR-3032	○	5
	Coin Type BR-A series	BR-1225A	○	3
		BR-1632A	○	4
		BR-2330A*	○	5
		BR-2450A*	○	5
		BR-2477A*	○	5
	Coin Type CR series	CR-1025	○	2
		CR-1216	○	3
		CR-1220	○	3
		CR-1612	○	3
		CR-1616	○	4
		CR-1620	○	4
		CR-1632	○	4
		CR-2012	○	10
		CR-2016	○	10
		CR-2025	○	10
		CR-2032	○	10
		CR-2330	○	10
		CR-2354	○	10
		CR-2412	○	10
		CR-2450	○	30
		CR-2477	○	10
		CR-3032	○	10
	Pin Type BR series	BR-425	○	0.1
		BR-435	○	0.2
Rechargeable Lithium batteries	Coin Type VL series	VL-621*	○	300
		VL-1220	○	300
		VL-2020	○	300
		VL-2320	○	300
		VL-2330	○	300
		VL-3032	○	300
	Coin Type ML series	ML-414	○	300
		ML-421	○	300
		ML-614	○	300
		ML-621	○	300
		ML-920	○	300
		ML-1220	○	300
		ML-2020*	○	300
	Coin Type NBL series	NBL-414	○	300
		NBL-621	○	300
	Coin Type MT series	MT-516	○	300
		MT-621	○	300
		MT-920	○	300
	Reflowable Coin Type ML-R/NBL-R series	ML-414RM	○	300
		NBL-414L	○	300

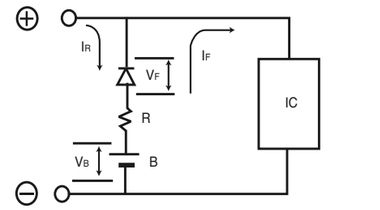
* Please read 'Conditions for compliance with UL Standard' carefully.
*[1] Development concluded but large-scale production not started yet.

Selecting batteries

When selecting batteries, give consideration to such factors as the current consumption of the equipment in which the batteries are to be used, the expected life of the batteries, and temperature in the operating environment. At low operating environment temperatures, the consumption current of the ICs drops but the discharge voltage of the batteries will also decrease. Also it is important to note that the capacity deterioration of batteries in long-term use becomes significant at high operating environment temperatures.

Memory back-up circuit and holding voltage

The circuit typically used for memory back-up is shown in the figure on the right. The memory holding voltage is expressed as: $V_B - V_F - I_F \times R >$ memory holding voltage of IC.



Reverse current blocking diode

Since Lithium primary batteries are not rechargeable, use of a reverse current blocking diode and a protective resistor in series is required where there is the possibility of charging in the equipment circuit. Use a diode with a low leak current as the reverse current blocking diode. To maintain the characteristics of a coin type Lithium battery, the total charging amount of the battery during its total usage period must be kept within 3% of the nominal capacity of the battery.

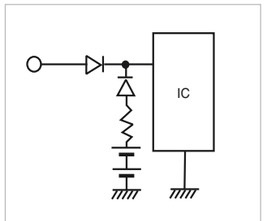
For example, assuming that a CR-2477 (1000mAh) will be used in a memory back-up power supply for 5 years, charging by the leak current of the reverse current blocking diode should be no greater than 30mAh (= 3% of 1000mAh), thus: 30mAh ÷ usage period (5 years x 365 days x 24 hours) = 0.7μA. In other words, a leak current blocking diode whose reverse current is not greater than 0.7μA must be selected.

Allowable total charging amount

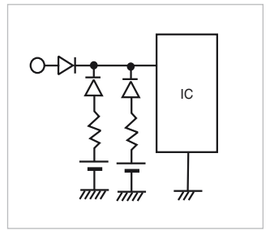
Within 3% for coin type batteries
Within 1% for cylindrical type batteries

Note that the leakcurrent of reverse current blocking diodes varies with temperature.

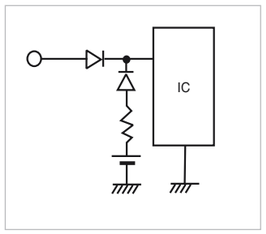
(A) 2-cell 6V usage



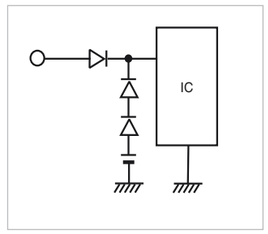
(B) Parallel usage



(C) UL conditions
(When a protective resistor has been inserted)

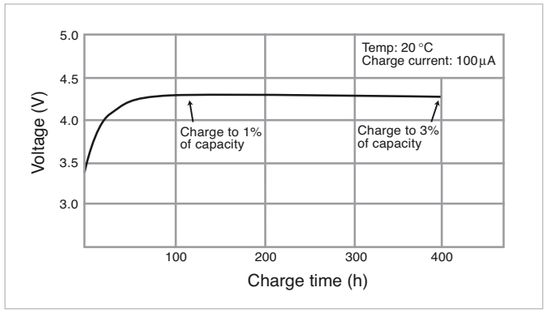


(D) UL conditions
(Protective Diode)

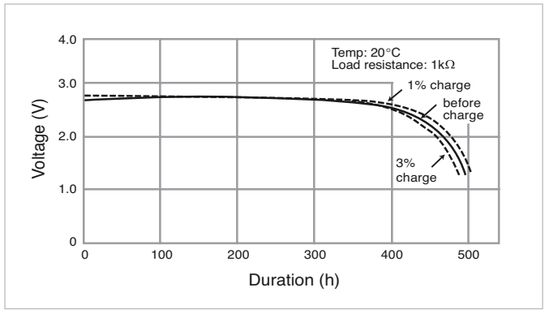


Charge test results assuming diode leakage current

BR-2/3A (cylindrical type) charge test



BR-2/3A (cylindrical type) discharge test after charging



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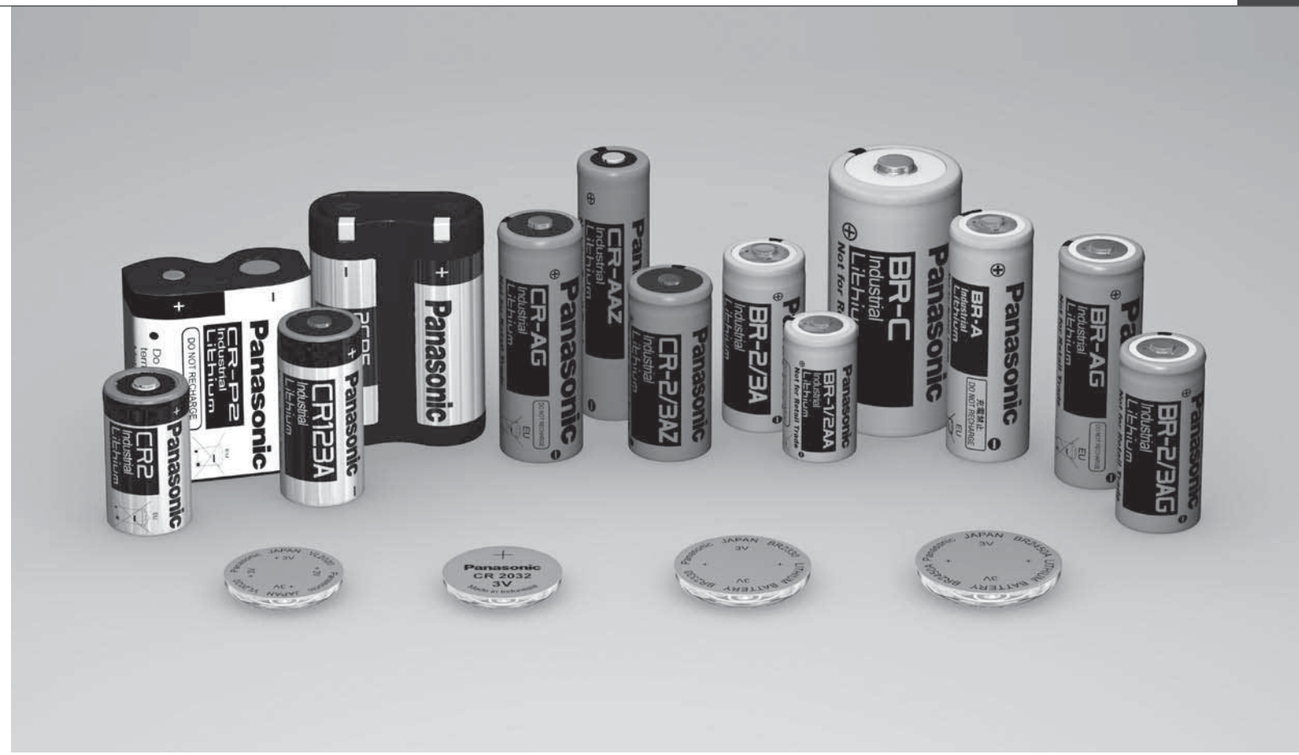


	Page
Cylindrical Type Lithium batteries	
Poly-Carbonmonofluoride Lithium batteries (BR series)	24 – 27
Manganese Dioxide Lithium batteries (CR series for consumer)	28 – 31
Manganese Dioxide Lithium batteries (CR series for industrial)	32 – 33
Coin Type Lithium batteries	
Poly-Carbonmonofluoride Lithium batteries (BR series)	34 – 38
High Temperature Poly-Carbonmonofluoride Lithium batteries (BR-A series)	39 – 42
Manganese Dioxide Lithium batteries (CR series)	43 – 52
Pin Type Lithium batteries	
Poly-Carbonmonofluoride Lithium batteries (BR series)	53 – 54

POLY-CARBONMONOFLUORIDE LITHIUM BATTERIES (BR SERIES) – CYLINDRICAL TYPE LITHIUM BATTERIES

Ever since their market launch in 1973, our Poly-Carbonmonofluoride Lithium batteries (BR series) have accumulated a proven track record and figured prominently as the batteries of choice for varied applications. In particular, their long-term operating performance spanning some ten years has made them the ideal power supply for products such as meters or smoke detectors, and they continue to lead the way in applications that demand long-term reliability.

GENERAL SPECIFICATIONS

Model number*1	Electrical Characteristics at 20°C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*2	Continuous Standard Drain (mA)	Diameter	Height			
BR-1/2AA*3	3	1,000	2.5	14.5	25.5	8.0	–	–
BR-2/3A	3	1,200	2.5	17.0	33.5	13.5	–	BR-17335
BR-2/3AG	3	1,450	2.5	17.0	33.5	13.5	–	BR-17335
BR-A	3	1,800	2.5	17.0	45.5	18.0	–	–
BR-AG	3	2,200	2.5	17.0	45.5	18.0	–	–
BR-C	3	5,000	5.0	26.0	50.5	42.0	–	–

Applications

- ➜ Heatcost allocators
- ➜ Water & Gas meters
- ➜ ETC (Electronic Toll Collection) systems
- ➜ Smoke detectors
- ➜ Entry Systems
- ➜ Data Loggers, etc.

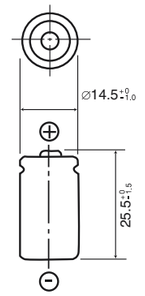
3D ILLUSTRATION

1 Positive pole
2 Positive pole platform
3 Jacket
4 Cell can
5 Collector
6 Negative pole
7 Insulator
8 Anode (lithium)
9 Cathode (carbonmonofluride)
10 Separator
11 Gasket

*1 G indicates higher capacity versions.
*2 Based on standard drain and cut off voltage down to 2.0V at 20°C.
*3 This cell is only available with assembled tab.

POLY-CARBONMONOFLUORIDE LITHIUM BATTERIES (BR SERIES) 2

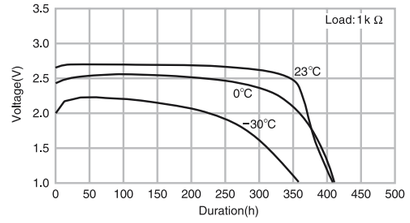
BR-1/2AA



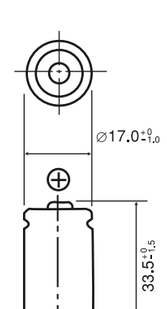
SPECIFICATIONS

Name	BR-1/2AA
Nominal voltage (V)	3
Nominal capacity (mAh)	1,000
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +100
Weight (g)	8.0

DISCHARGE TEMPERATURE CHARACTERISTICS



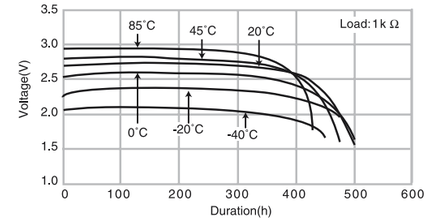
BR-2/3A



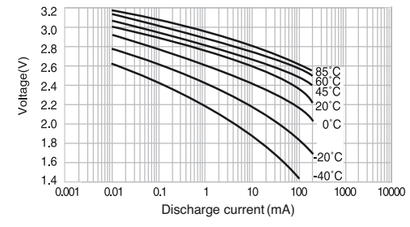
SPECIFICATIONS

Name	BR-2/3A
Nominal voltage (V)	3
Nominal capacity (mAh)	1,200
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +85
Weight (g)	13.5

DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



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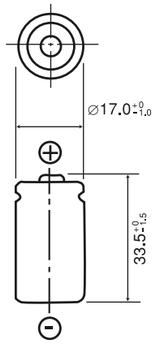
* Voltage at 50% discharge depth.

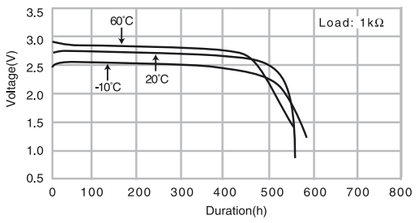
BR-2/3AG



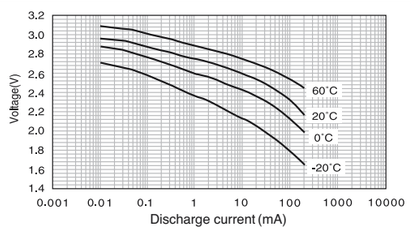
SPECIFICATIONS

Name	BR-2/3AG
Nominal voltage (V)	3
Nominal capacity (mAh)	1,450
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +85
Weight (g)	13.5

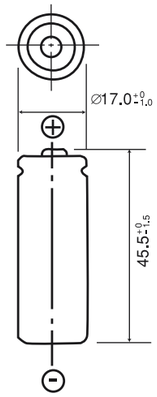
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



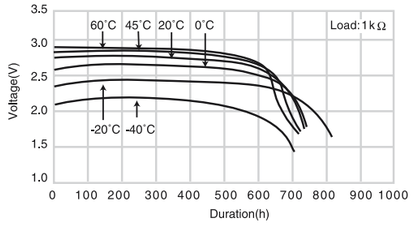
BR-A



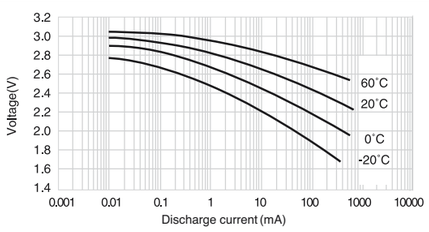
SPECIFICATIONS

Name	BR-A
Nominal voltage (V)	3
Nominal capacity (mAh)	1,800
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +85
Weight (g)	18.0

DISCHARGE TEMPERATURE CHARACTERISTICS



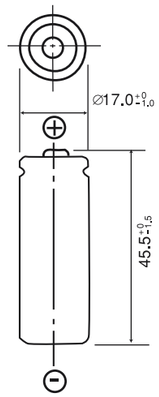
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

* Voltage at 50% discharge depth.

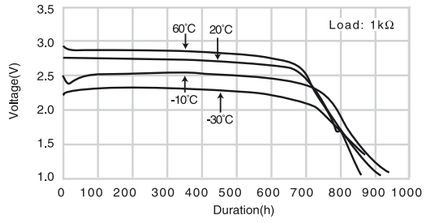
BR-AG



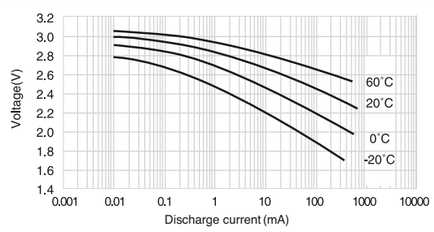
SPECIFICATIONS

Name	BR-AG
Nominal voltage (V)	3
Nominal capacity (mAh)	2,200
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +85
Weight (g)	18.0

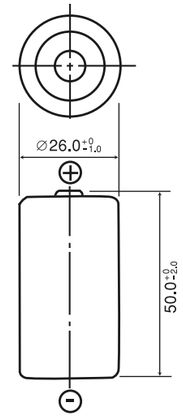
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



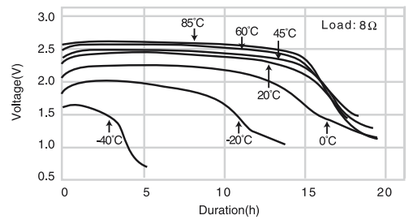
BR-C



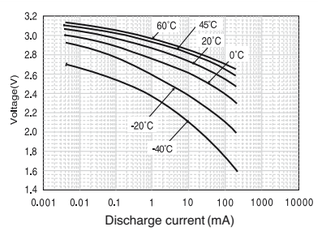
SPECIFICATIONS

Name	BR-C
Nominal voltage (V)	3
Nominal capacity (mAh)	5,000
Continuous drain (mA)	5.0
Operating temperature (°C)	-40 to +85
Weight (g)	42.0

DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



This product does not correspond to the special provision A45 (catalog P81*[1]) of IATA Dangerous Goods Regulations 47th Edition. Please be aware that this product must follow the Dangerous Goods Regulations transportation method of United Nations Class 9 (Packing Group II) at the time of transportation.

The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

* Voltage at 50% discharge depth.

*[1] If you are looking at the web site, please see 'Transporting' of 'Lithium & Micro batteries Data Files are here'.

MANGANESE DIOXIDE LITHIUM BATTERIES (CR SERIES FOR CONSUMER) – CYLINDRICAL TYPE LITHIUM BATTERIES

Panasonic Lithium Cylindrical batteries type CR come as either single cells or dual cell packs. Pack batteries are packaged in a resin case enabling easy replacement by users. Their development was pioneered by Panasonic. All Cylindrical Type Manganese Dioxide Lithium batteries (CR series) feature a spiral structure, and by enlarging the surface areas of the positive and negative electrodes they allow a current as high as several amperes to be drawn.

GENERAL SPECIFICATIONS

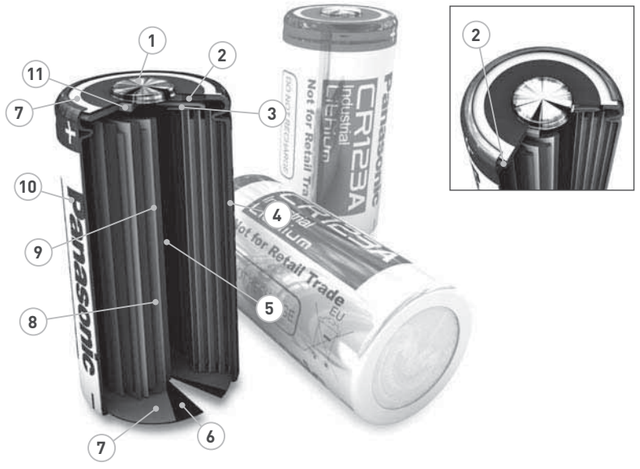
Model number*1	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*2	Continuous Standard Drain (mA)	Diameter	Height			
CR-2*1, 3	3	850	20	15.6	27.0	11.0	CR-2, CR-15H270	CR-15H270
CR-123A*1, 3	3	1,400	20	17.0	34.5	17.0	CR-123A, CR-17345	CR-17345
2CR-5*2, 3	6	1,400	20	34.0	45.0	36.0	2CR-5	2CR-5
CR-P2*2, 3	6	1,400	20	35.0	36.0	37.0	CR-P2	CR-P2
CR-V3*1, 3	3	3,300	200	29.0 x 14.5	52.0	39.0	–	–

Applications

- ETC (Electronic Toll Collection) systems
- Cameras
- High energy flashlights
- RFID tags
- E-Call automotive devices
- Life vests, etc.

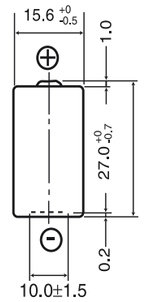
3D ILLUSTRATION

1 Positive pole
2 PTC (positive temperature coefficient device)
3 Collector
4 Cell can
5 Cathode (manganese dioxide)
6 Negative pole
7 Insulator
8 Anode (lithium)
9 Separator
10 Jacket
11 Vent diaphragm



*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.
*2 Width Based on standard drain and cut off voltage down to 4.0V at 20°C.
*3 In case of usage below 20mA discharge please consult Panasonic.

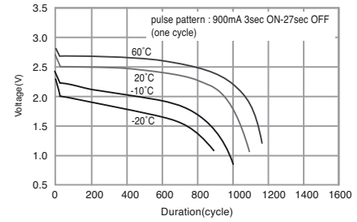
CR-2



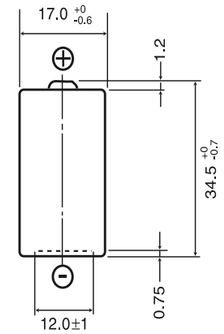
SPECIFICATIONS

Name	CR-2
Nominal voltage (V)	3
Nominal capacity (mAh)	850
Continuous drain (mA)	20
Operating temperature (°C)	-40 to +70*
Weight (g)	11.0

DISCHARGE TEMPERATURE CHARACTERISTICS



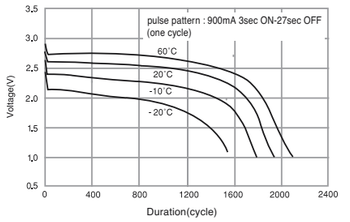
CR-123A



SPECIFICATIONS

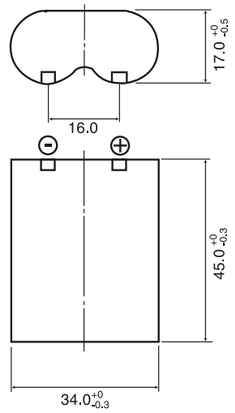
Name	CR-123A
Nominal voltage (V)	3
Nominal capacity (mAh)	1,400
Continuous drain (mA)	20
Operating temperature (°C)	-40 to +70*
Weight (g)	17.0

DISCHARGE TEMPERATURE CHARACTERISTICS



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.
* Please consult Panasonic for use below and above -20°C to +60°C.

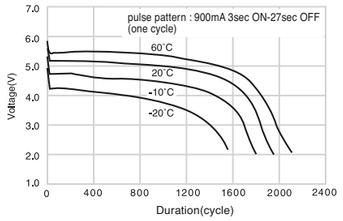
2CR-5



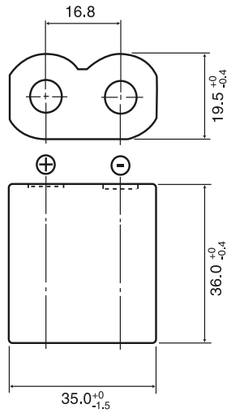
SPECIFICATIONS

Name	2CR-5
Nominal voltage (V)	6
Nominal capacity (mAh)	1,400
Continuous drain (mA)	20
Operating temperature (°C)	-40 to +70*
Weight (g)	38.0

DISCHARGE TEMPERATURE CHARACTERISTICS



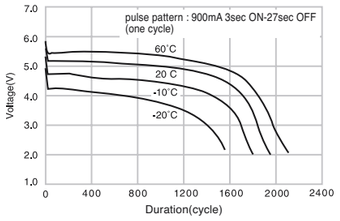
CR-P2



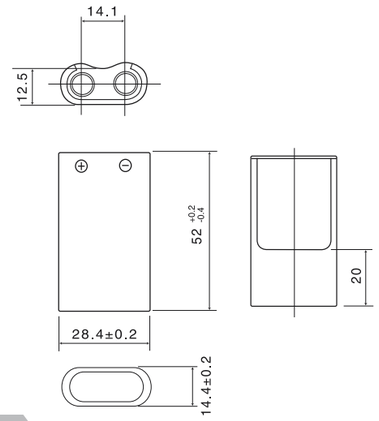
SPECIFICATIONS

Name	CR-P2
Nominal voltage (V)	6
Nominal capacity (mAh)	1,400
Continuous drain (mA)	20
Operating temperature (°C)	-40 to +70*
Weight (g)	37.0

DISCHARGE TEMPERATURE CHARACTERISTICS



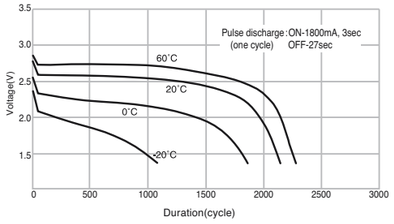
CR-V3



SPECIFICATIONS

Name	CR-V3
Nominal voltage (V)	3
Nominal capacity (mAh)	3,300
Continuous drain (mA)	200
Operating temperature (°C)	-40 to +70*
Weight (g)	39.0

DISCHARGE TEMPERATURE CHARACTERISTICS



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* Please consult Panasonic for use below and above -20°C to +60°C.

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* Please consult Panasonic for use below and above -20°C to +60°C.

MANGANESE DIOXIDE LITHIUM BATTERIES (CR SERIES FOR INDUSTRIAL) – CYLINDRICAL TYPE LITHIUM BATTERIES

Industrial equipment-targeted series offering both excellent high-rate discharge performance and long-term use.

GENERAL SPECIFICATIONS

Model number*1	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*2	Continuous Standard Drain (mA)	Diameter	Height			
CR-AAZ*1,3	3	1,700	2.5	14.5	50.5	19.0	–	CR-14500
CR-2/3AZ*1	3	1,600	2.5	17.0	33.5	17.0	–	–
CR-AG*1	3	2,400	2.5	17.0	45.5	24.0	–	–

Applications

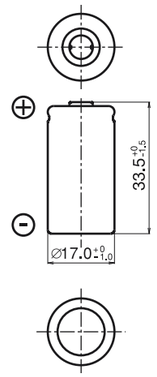
- Smoke detector
- ETC (Electronic Toll Collection) systems
- Alarm systems
- Marine devices

3D ILLUSTRATION

1 Positive pole
2 PTC (positive temperature coefficient device)
3 Collector
4 Cell can
5 Cathode (manganese dioxide)
6 Negative pole
7 Insulator
8 Anode (lithium)
9 Separator
10 Jacket
11 Vent diaphragm

*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.
*2 Width Based on standard drain and cut off voltage down to 4.0V at 20°C.
*3 Development concluded but large-scale production not started yet.

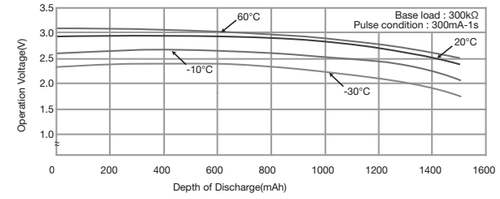
CR-2/3AZ



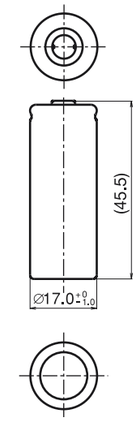
SPECIFICATIONS

Name	CR-2/3AZ
Nominal voltage (V)	3
Nominal capacity (mAh)	1,600
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +70
Weight (g)	17.0

PULSE DISCHARGE PERFORMANCE



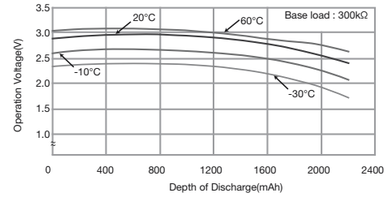
CR-AG



SPECIFICATIONS

Name	CR-AG
Nominal voltage (V)	3
Nominal capacity (mAh)	2,400
Continuous drain (mA)	2.5
Operating temperature (°C)	-40 to +70
Weight (g)	24.0

DISCHARGE TEMPERATURE CHARACTERISTICS



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

POLY-CARBONMONOFLUORIDE LITHIUM BATTERIES (BR SERIES) – COIN TYPE LITHIUM BATTERIES

Panasonic Lithium batteries coin type BR feature a high energy density, and were developed and commercialised using Panasonic's extensive experience in battery technology. They exhibit stable performance under relatively high environmental temperatures.

GENERAL SPECIFICATIONS

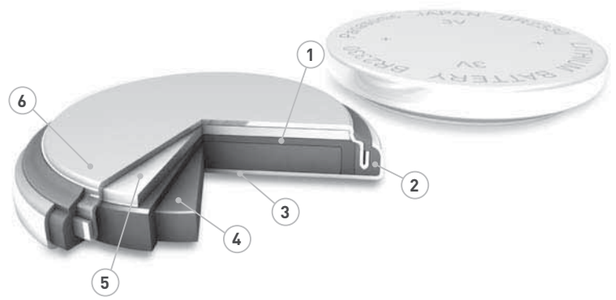
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
BR-1220	3	35	0.03	12.5	2.0	0.7	–	–
BR-1225	3	48	0.03	12.5	2.5	0.8	–	BR-1225
BR-1632	3	120	0.03	16.0	3.2	1.5	–	–
BR-2032	3	200	0.03	20.0	3.2	2.5	–	–
BR-2325	3	165	0.03	23.0	2.5	3.0	–	BR-2325
BR-2330	3	255	0.03	23.0	3.0	3.2	–	–
BR-3032	3	500	0.03	30.0	3.2	5.5	–	–

Applications

- ETC (Electronic Toll Collection) systems
- Varied range of meters
- Memory back-up power supplies
- Electronic notebooks, etc.

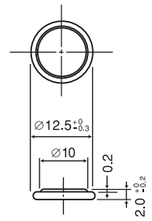
3D ILLUSTRATION

1 Separator
2 Gasket
3 Positive pole (cell can)
4 Cathode (poly-carbonmonofluride)
5 Anode (lithium)
6 Negative pole



*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

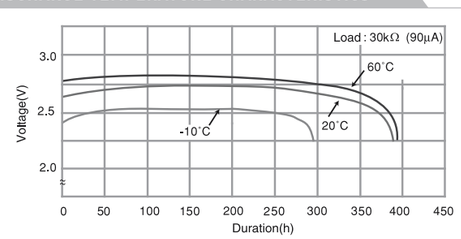
BR-1220



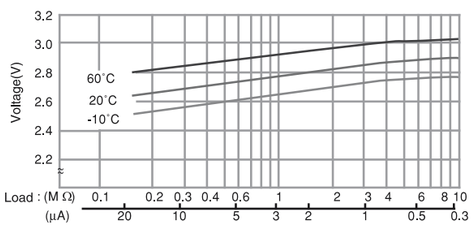
SPECIFICATIONS

Name	BR-1220
Nominal voltage (V)	3
Nominal capacity (mAh)	35
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	0.7

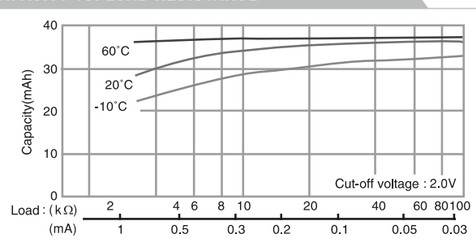
DISCHARGE TEMPERATURE CHARACTERISTICS



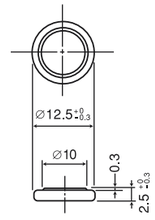
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



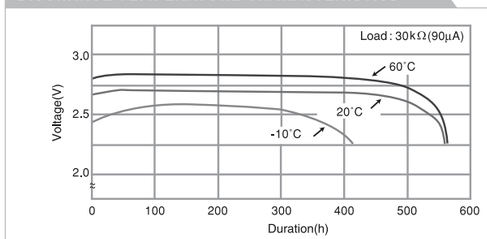
BR-1225



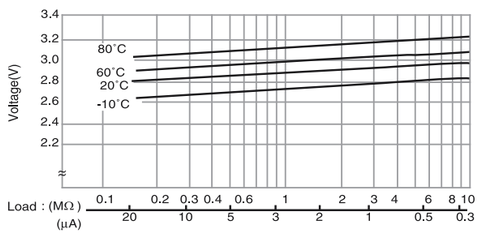
SPECIFICATIONS

Name	BR-1225
Nominal voltage (V)	3
Nominal capacity (mAh)	48
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	0.8

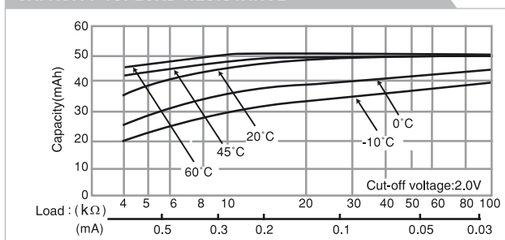
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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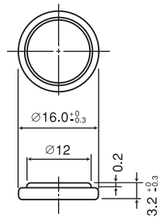
* Voltage at 50% discharge depth.

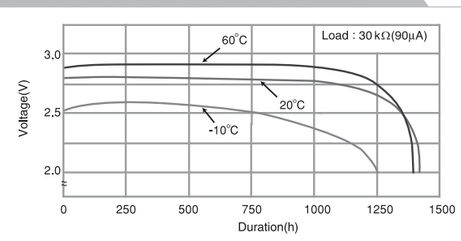
BR-1632



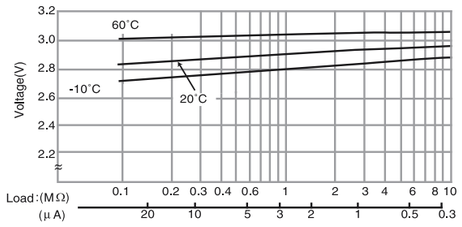
SPECIFICATIONS

Name	BR-1632
Nominal voltage (V)	3
Nominal capacity (mAh)	120
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	1.5

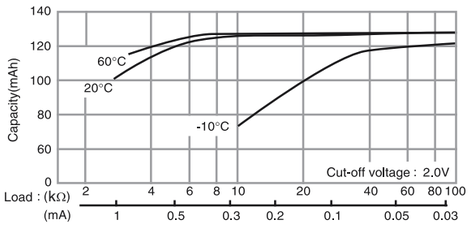
DISCHARGE TEMPERATURE CHARACTERISTICS



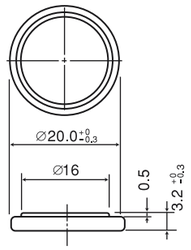
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



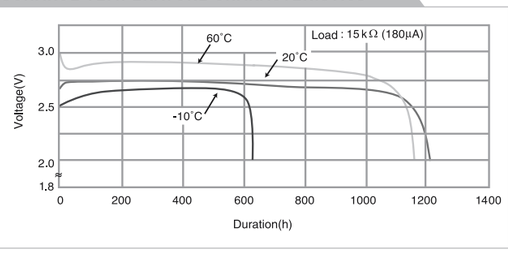
BR-2032



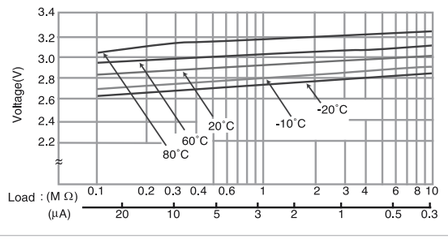
SPECIFICATIONS

Name	BR-2032
Nominal voltage (V)	3
Nominal capacity (mAh)	200
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	2.5

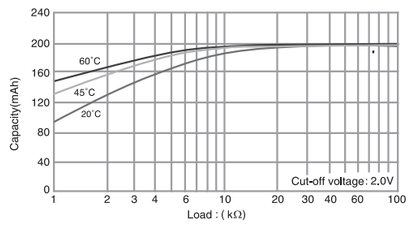
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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* Voltage at 50% discharge depth.

Lithium battery holders for BR-2032

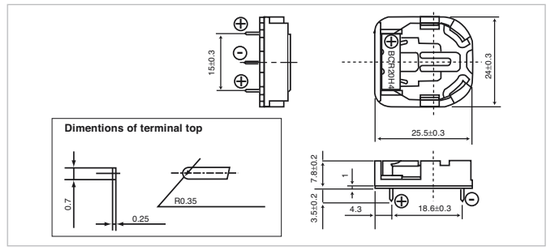
These battery holders are designed for sure and easy loading/removal of Panasonic Coin Type Lithium batteries in/from equipment enabling the batteries to fully exploit their capabilities as the back-up power supply in C-MOS RAM memory and microcomputer memory. All of the battery holders are designed to prevent inverted insertion of the battery.

BCR20H4

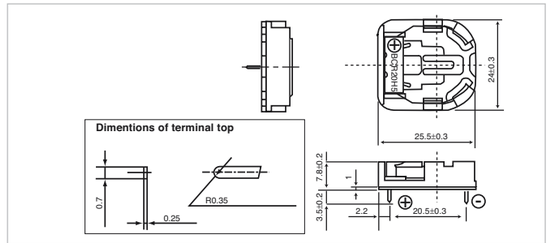
BCR20H5

BCR20V4

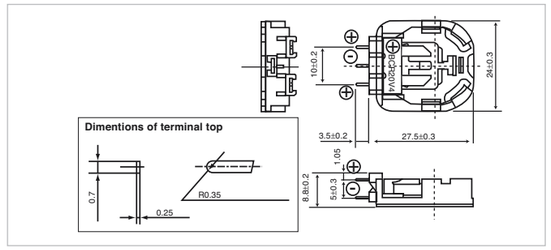
BCR20H4 (3 terminals)



BCR20H5 (2 terminals)



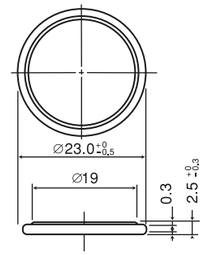
BCR20V4 (3 terminals)



Precaution for washing battery holders

The battery holders can be adversely affected by some detergents use in the circuit board washing process and may result in cracks forming in the holder. Please test the holders in your washing process before use.

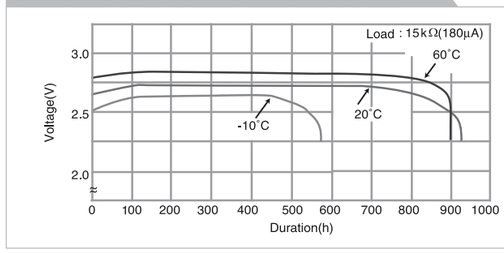
BR-2325



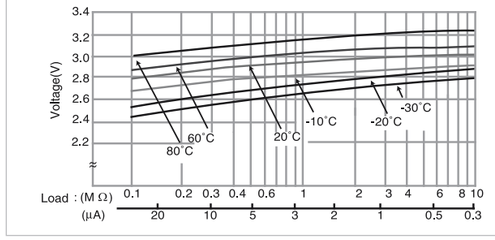
SPECIFICATIONS

Name	BR-2325
Nominal voltage (V)	3
Nominal capacity (mAh)	165
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	2.5

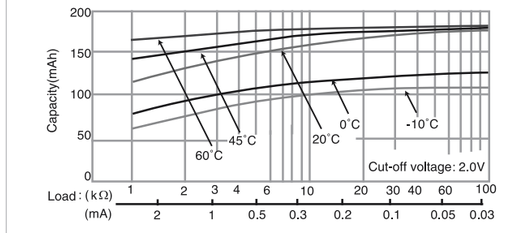
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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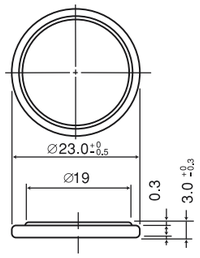
* Voltage at 50% discharge depth.

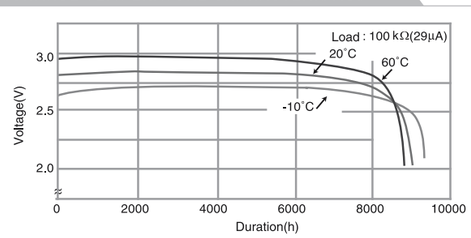
BR-2330



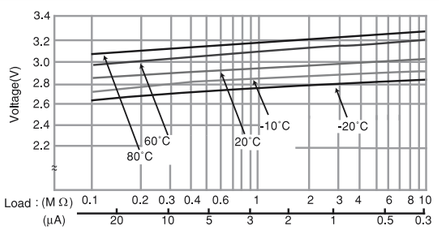
SPECIFICATIONS

Name	BR-2330
Nominal voltage (V)	3
Nominal capacity (mAh)	255
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	3.0

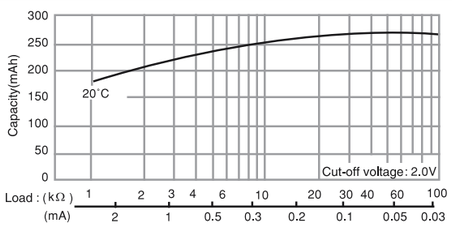
DISCHARGE TEMPERATURE CHARACTERISTICS



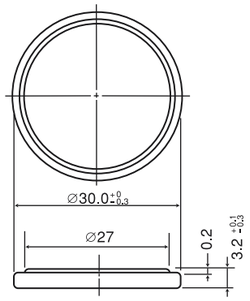
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



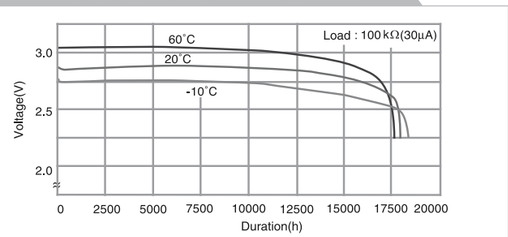
BR-3032



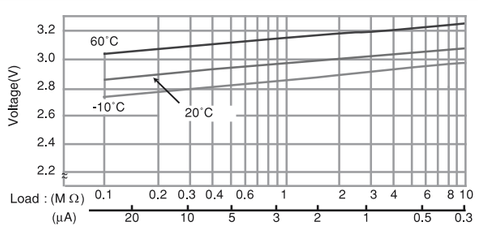
SPECIFICATIONS

Name	BR-3032
Nominal voltage (V)	3
Nominal capacity (mAh)	500
Continuous drain (mA)	0.03
Operating temperature (°C)	-30 to +80
Weight (g)	5.5

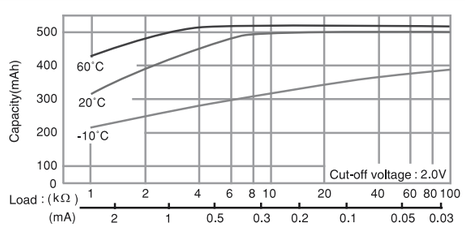
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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* Voltage at 50% discharge depth.

HIGH OPERATING TEMPERATURE POLY-CARBONMONOFLUORIDE LITHIUM BATTERIES (BR-A SERIES) – COIN TYPE LITHIUM BATTERIES

The materials for the gasket and separator featured in these Coin Type Lithium batteries have been replaced with a special engineering plastic and the operating temperature has been significantly increased by employing an electrolyte with a high boiling point. These benefits make this battery series the ideal power supply in high ambient temperature applications.

GENERAL SPECIFICATIONS

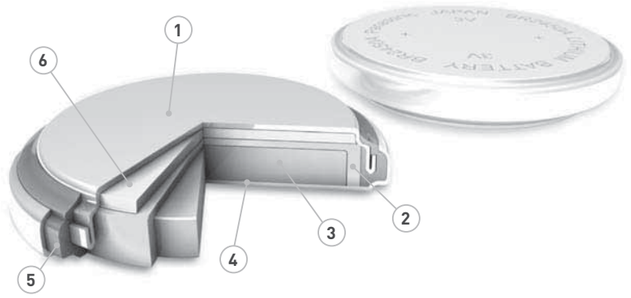
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
BR-1225A*2	3	48	0.03	12.5	2.5	0.8	–	–
BR-1632A*2	3	120	0.03	16.0	3.2	1.5	–	–
BR-2330A*2	3	255	0.03	23.0	3.0	3.2	–	–
BR-2450A*2	3	550	0.03	24.5	5.0	5.9	–	–
BR-2477A*2	3	1,000	0.03	24.5	7.7	8.0	–	–

Applications

- Tire Pressure Monitoring Systems (TPMS)
- Water Meters
- Heat cost allocators
- Memory back-up power supplies in high
- High ambient temperature applications, etc.

3D ILLUSTRATION

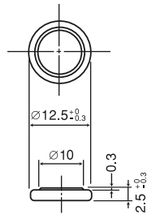
1. Negative pole
2. Separator
3. Cathode (poly-carbonmonofluride)
4. Positive pole (cell can)
5. Gasket
6. Anode (lithium)



*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

*2 Indicates terminal specification. Note: Only battery with terminal are handled.

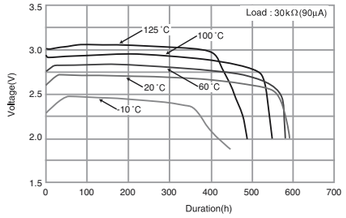
BR-1225A



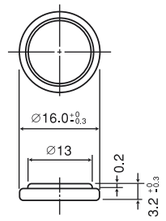
SPECIFICATIONS

Name	BR-1225A
Nominal voltage (V)	3
Nominal capacity (mAh)	48
Continuous drain (mA)	0.03
Operating temperature (°C)	-40 to +125
Weight (g)	0.8

DISCHARGE TEMPERATURE CHARACTERISTICS



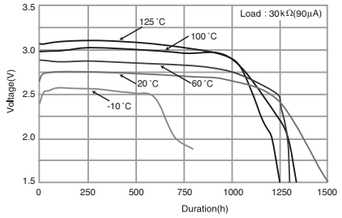
BR-1632A



SPECIFICATIONS

Name	BR-1632A
Nominal voltage (V)	3
Nominal capacity (mAh)	120
Continuous drain (mA)	0.03
Operating temperature (°C)	-40 to +125
Weight (g)	1.5

DISCHARGE TEMPERATURE CHARACTERISTICS



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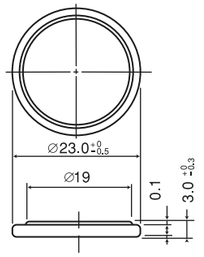
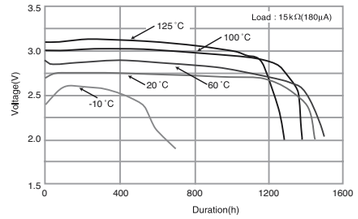
BR-2330A



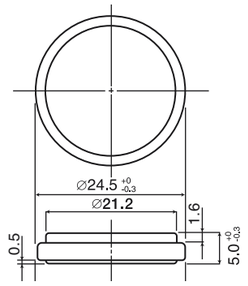
SPECIFICATIONS

Name	BR-2330A
Nominal voltage (V)	3
Nominal capacity (mAh)	255
Continuous drain (mA)	0.03
Operating temperature (°C)	-40 to +125
Weight (g)	3.2

DISCHARGE TEMPERATURE CHARACTERISTICS



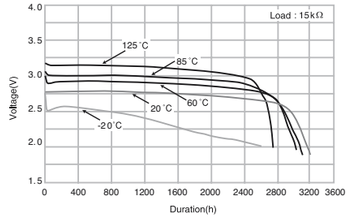
BR-2450A



SPECIFICATIONS

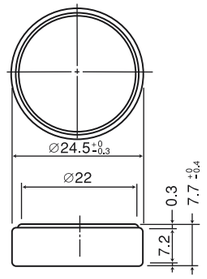
Name	BR-2450A
Nominal voltage (V)	3
Nominal capacity (mAh)	550
Continuous drain (mA)	0.03
Operating temperature (°C)	-40 to +125
Weight (g)	5.9

DISCHARGE TEMPERATURE CHARACTERISTICS



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

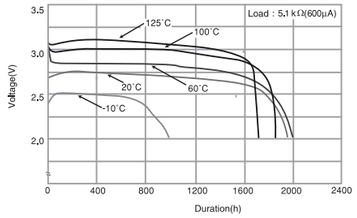
BR-2477A



SPECIFICATIONS

Name	BR-2477A
Nominal voltage (V)	3
Nominal capacity (mAh)	1,000
Continuous drain (mA)	0.03
Operating temperature (°C)	-40 to +125
Weight (g)	8.0

DISCHARGE TEMPERATURE CHARACTERISTICS



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MANGANESE DIOXIDE LITHIUM BATTERIES (CR SERIES) – COIN TYPE LITHIUM BATTERIES

As with the BR series of Coin Type Lithium batteries, these Panasonic Lithium coin-type CR batteries feature a high-energy density, and they were developed and commercialised using Panasonic's extensive experience in battery technology. These batteries have proven to be especially useful in equipment requiring relatively high currents.

GENERAL SPECIFICATIONS

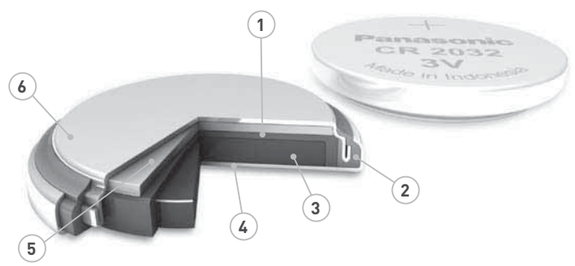
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
CR-1025	3	30	0.10	10.0	2.5	0.7	CR-1025	CR-1025
CR-1216	3	25	0.10	12.5	1.6	0.7	CR-1216	CR-1216
CR-1220	3	35	0.10	12.5	2.0	1.2	CR-1220	CR-1220
CR-1612	3	40	0.10	16.0	1.2	0.8	–	–
CR-1616	3	55	0.10	16.0	1.6	1.2	CR-1616	CR-1616
CR-1620	3	75	0.10	16.0	2.0	1.3	–	CR-1620
CR-1632	3	140	0.10	16.0	3.2	1.8	–	–
CR-2012	3	55	0.10	20.0	1.2	1.4	CR-2012	CR-2012
CR-2016	3	90	0.10	20.0	1.6	1.6	CR-2016	CR-2016
CR-2025	3	165	0.20	20.0	2.5	2.3	CR-2025	CR-2025
CR-2032	3	220	0.20	20.0	3.2	2.9	CR-2032	CR-2032
CR-2330	3	265	0.20	23.0	3.0	3.8	CR-2330	CR-2330
CR-2354	3	560	0.20	23.0	5.4	5.8	–	CR-2354
CR-2412	3	100	0.20	24.5	1.2	2.0	–	–
CR-2450	3	620	0.20	24.5	5.0	6.3	CR-2450	CR-2450
CR-2477	3	1,000	0.20	24.5	7.7	10.5	–	–
CR-3032	3	500	0.20	30.0	3.2	6.8	–	–

Applications

- Keyless Entry
- RFID
- Price tags
- ETC (Electronic Toll Collection) systems
- Electronic notebooks
- Back-up for vending machines, etc.

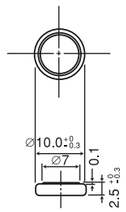
3D ILLUSTRATION

1 Separator
2 Gasket
3 Cathode (manganese dioxide)
4 Positive pole (cell can)
5 Anode (lithium)
6 Negative pole



*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

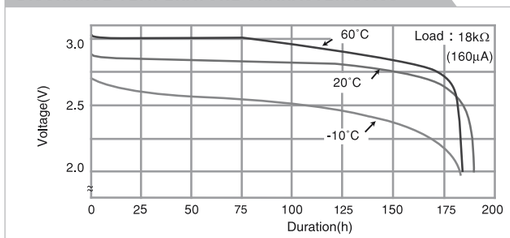
CR-1025



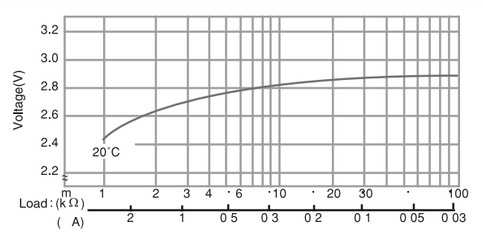
SPECIFICATIONS

Name	CR-1025
Nominal voltage (V)	3
Nominal capacity (mAh)	30
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	0.7

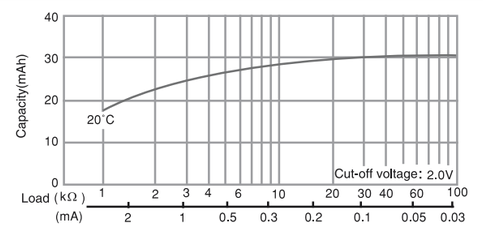
DISCHARGE TEMPERATURE CHARACTERISTICS



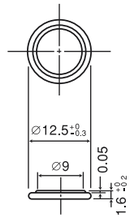
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



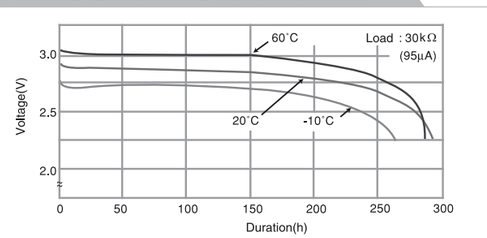
CR-1216



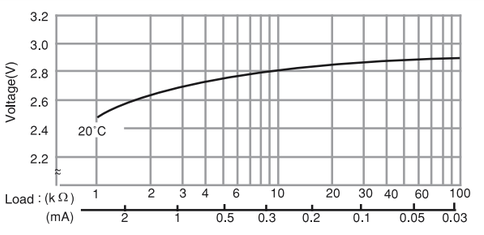
SPECIFICATIONS

Name	CR-1216
Nominal voltage (V)	3
Nominal capacity (mAh)	25
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	0.7

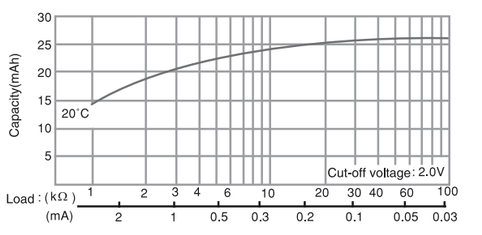
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



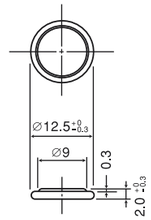
CAPACITY VS. LOAD RESISTANCE



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

* Voltage at 50% discharge depth.

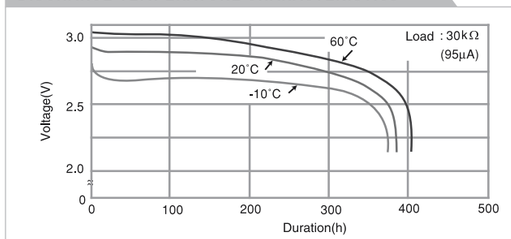
CR-1220



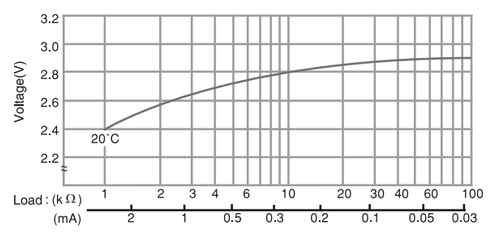
SPECIFICATIONS

Name	CR-1220
Nominal voltage (V)	3
Nominal capacity (mAh)	35
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	1.2

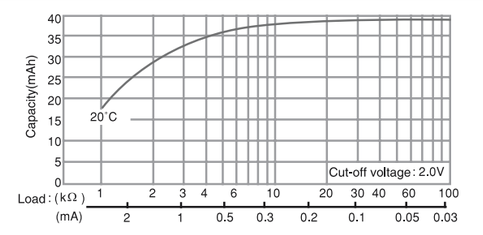
DISCHARGE TEMPERATURE CHARACTERISTICS



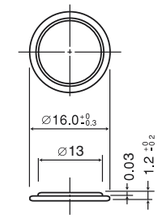
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



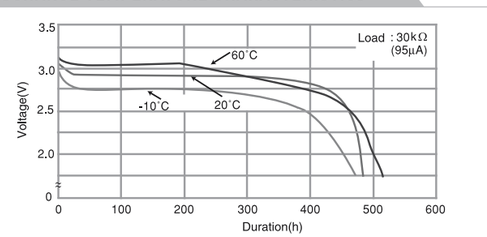
CR-1612



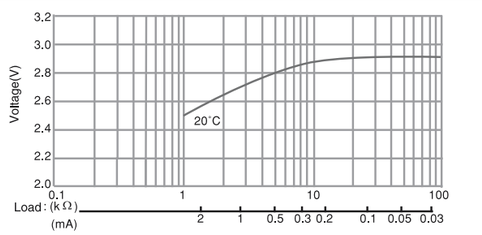
SPECIFICATIONS

Name	CR-1612
Nominal voltage (V)	3
Nominal capacity (mAh)	40
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	0.8

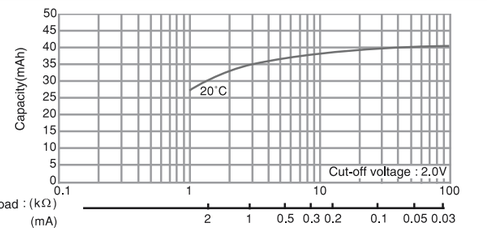
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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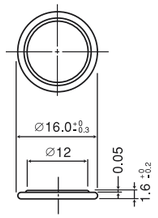
* Voltage at 50% discharge depth.

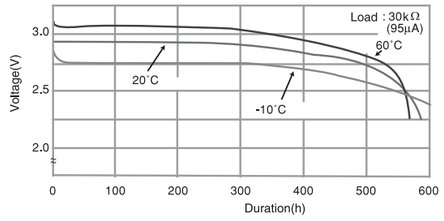
CR-1616



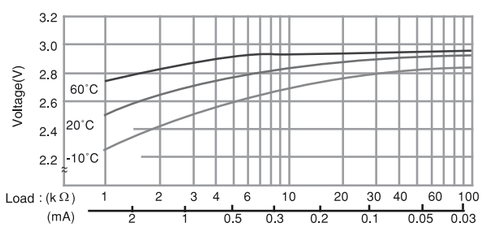
SPECIFICATIONS

Name	CR-1616
Nominal voltage (V)	3
Nominal capacity (mAh)	55
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	1.2

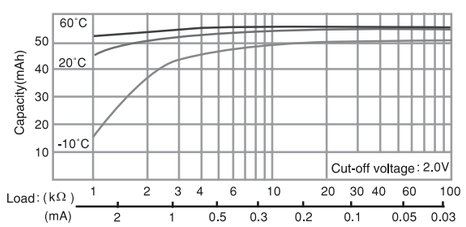
DISCHARGE TEMPERATURE CHARACTERISTICS



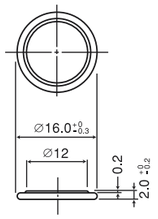
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



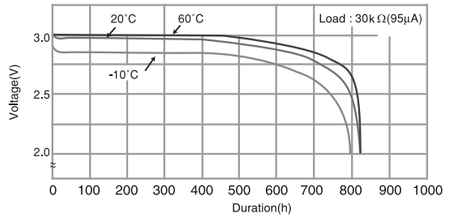
CR-1620



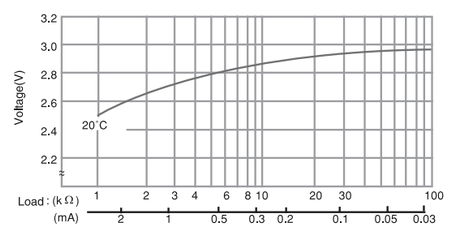
SPECIFICATIONS

Name	CR-1620
Nominal voltage (V)	3
Nominal capacity (mAh)	75
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	1.3

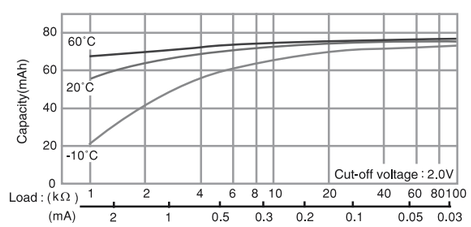
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



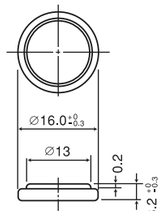
CAPACITY VS. LOAD RESISTANCE



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

* Voltage at 50% discharge depth.

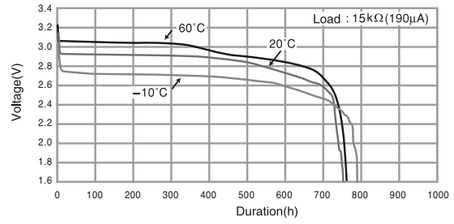
CR-1632



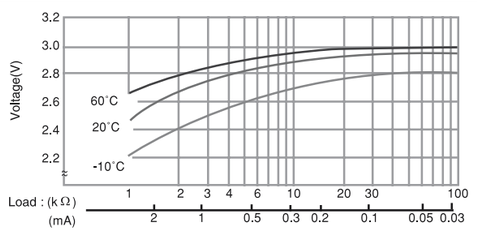
SPECIFICATIONS

Name	CR-1632
Nominal voltage (V)	3
Nominal capacity (mAh)	140
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	1.8

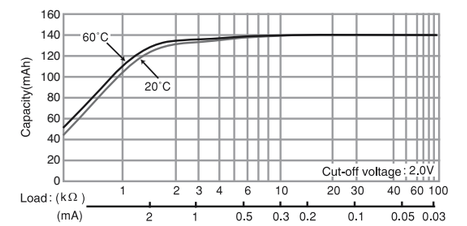
DISCHARGE TEMPERATURE CHARACTERISTICS



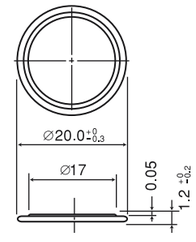
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



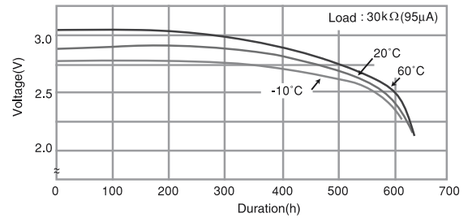
CR-2012



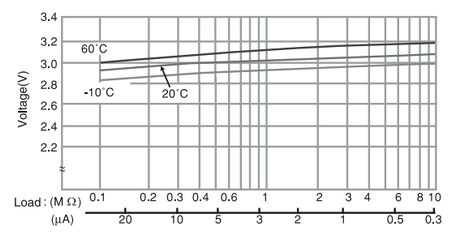
SPECIFICATIONS

Name	CR-2012
Nominal voltage (V)	3
Nominal capacity (mAh)	55
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	1.4

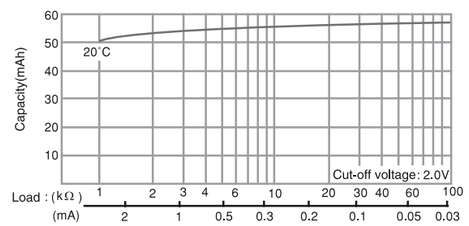
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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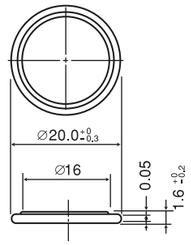
* Voltage at 50% discharge depth.

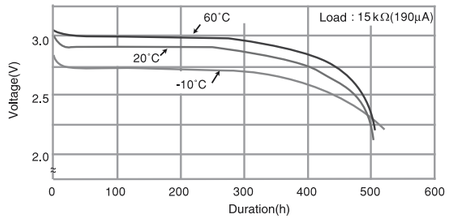
CR-2016



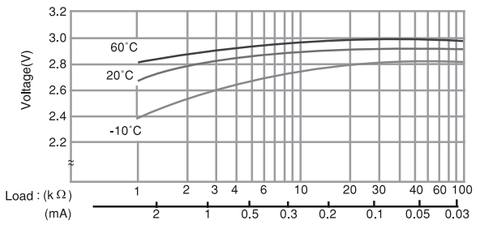
SPECIFICATIONS

Name	CR-2016
Nominal voltage (V)	3
Nominal capacity (mAh)	90
Continuous drain (mA)	0.1
Operating temperature (°C)	-30 to +60
Weight (g)	1.6

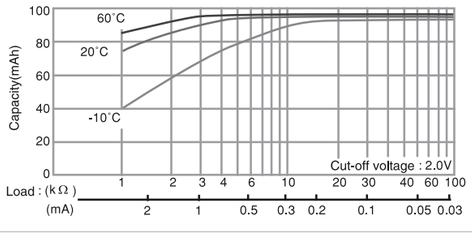
DISCHARGE TEMPERATURE CHARACTERISTICS



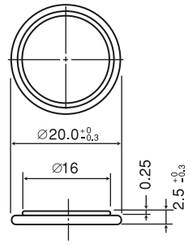
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



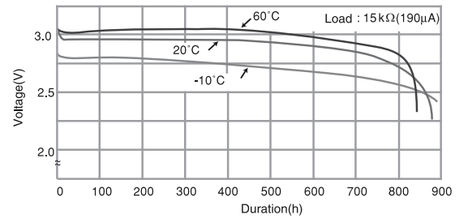
CR-2025



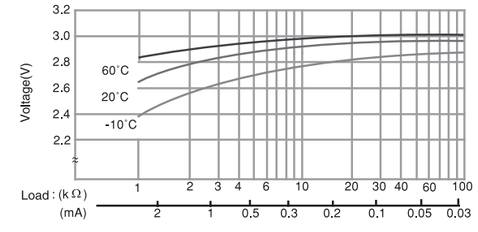
SPECIFICATIONS

Name	CR-2025
Nominal voltage (V)	3
Nominal capacity (mAh)	165
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	2.3

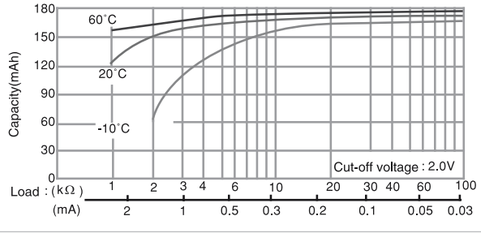
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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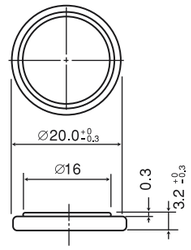
* Voltage at 50% discharge depth.

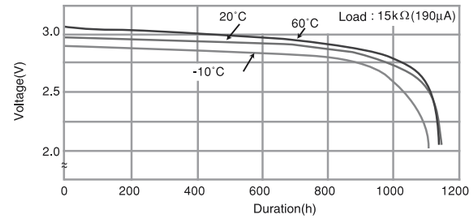
CR-2032



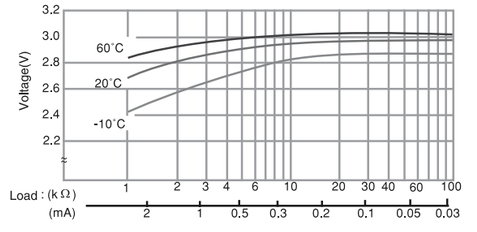
SPECIFICATIONS

Name	CR-2032
Nominal voltage (V)	3
Nominal capacity (mAh)	220
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	2.9

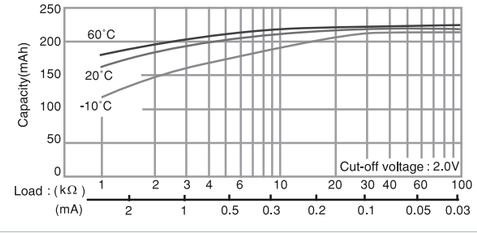
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE

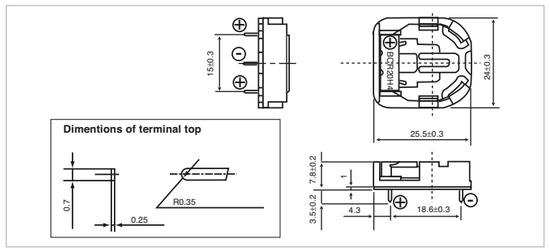


Lithium battery holders for CR-2032

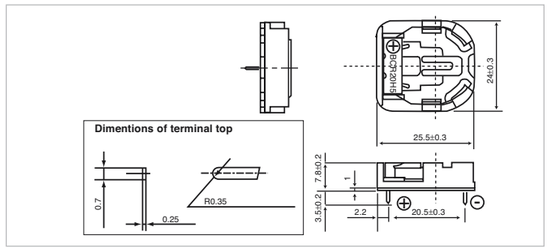
These battery holders are designed for sure and easy loading/removal of Panasonic Coin Type Lithium batteries in/from equipment enabling the batteries to fully exploit their capabilities as the back-up power supply in C-MOS RAM memory and microcomputer memory. All of the battery holders are designed to prevent inverted insertion of the battery.

BCR20H4 **BCR20H5** **BCR20V4**

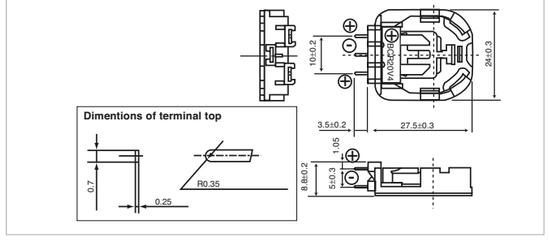
BCR20H4 (3 terminals)



BCR20H5 (2 terminals)



BCR20V4 (3 terminals)



Precaution for washing battery holders

The battery holders can be adversely affected by some detergents use in the circuit board washing process and may result in cracks forming in the holder. Please test the holders in your washing process before use.

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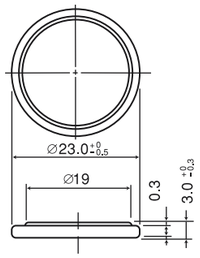
* Voltage at 50% discharge depth.

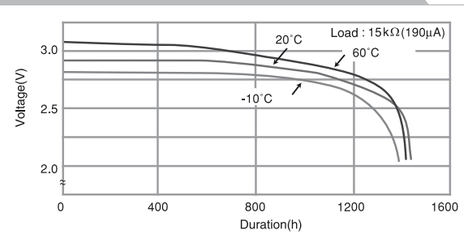
CR-2330



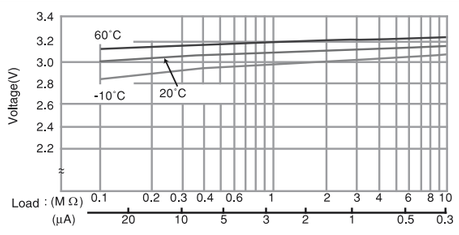
SPECIFICATIONS

Name	CR-2330
Nominal voltage (V)	3
Nominal capacity (mAh)	265
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	3.8

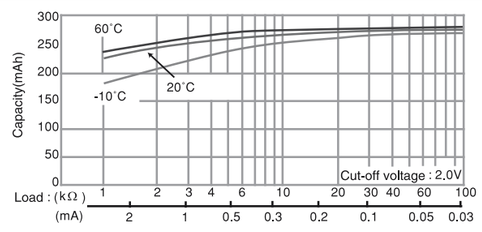
DISCHARGE TEMPERATURE CHARACTERISTICS



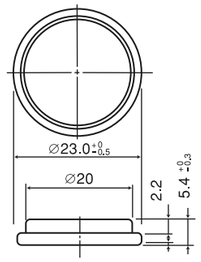
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



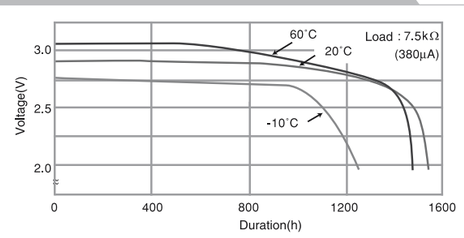
CR-2354



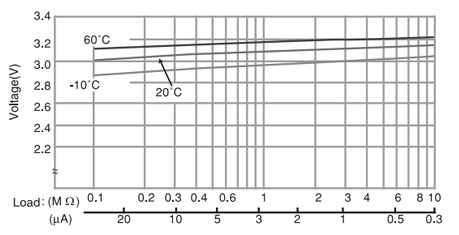
SPECIFICATIONS

Name	CR-2354
Nominal voltage (V)	3
Nominal capacity (mAh)	560
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	5.8

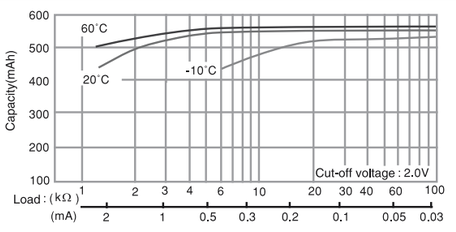
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



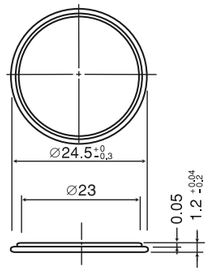
CAPACITY VS. LOAD RESISTANCE



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

* Voltage at 50% discharge depth.

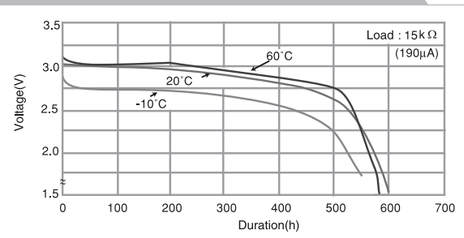
CR-2412



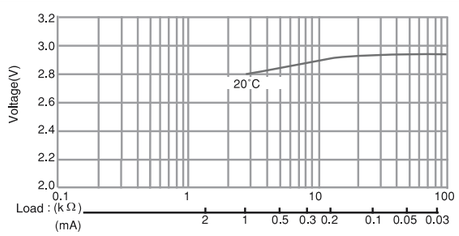
SPECIFICATIONS

Name	CR-2412
Nominal voltage (V)	3
Nominal capacity (mAh)	100
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	2.0

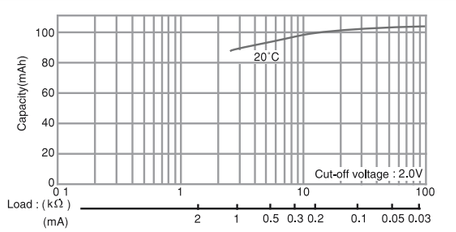
DISCHARGE TEMPERATURE CHARACTERISTICS



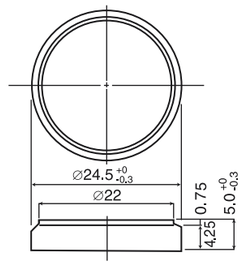
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



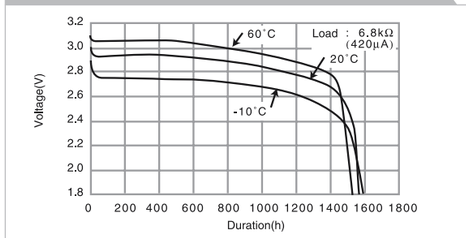
CR-2450



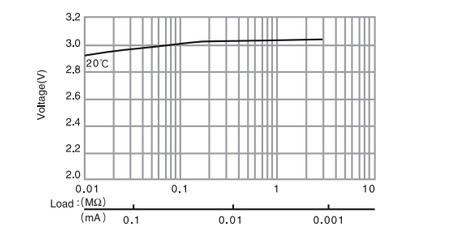
SPECIFICATIONS

Name	CR-2450
Nominal voltage (V)	3
Nominal capacity (mAh)	620
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	6.3

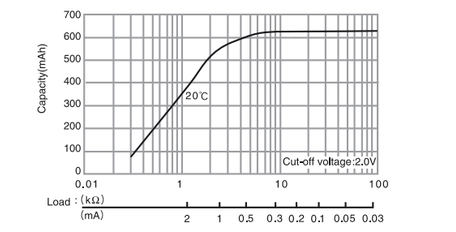
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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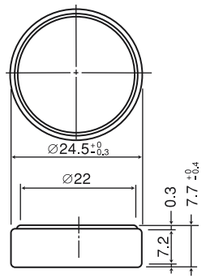
* Voltage at 50% discharge depth.

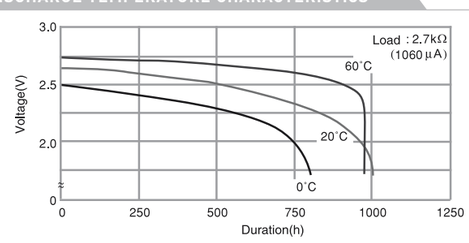
CR-2477



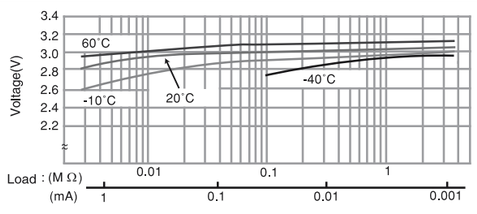
SPECIFICATIONS

Name	CR-2477
Nominal voltage (V)	3
Nominal capacity (mAh)	1,000
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	10.5

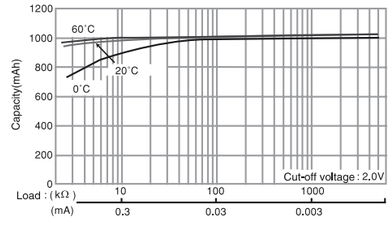
DISCHARGE TEMPERATURE CHARACTERISTICS



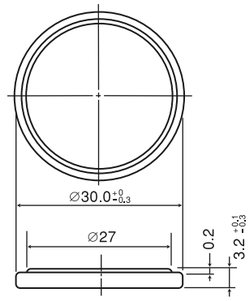
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



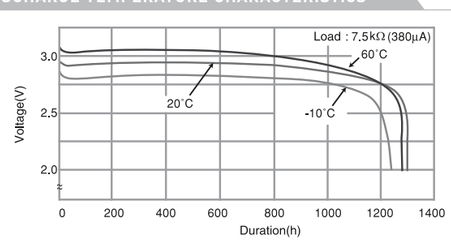
CR-3032



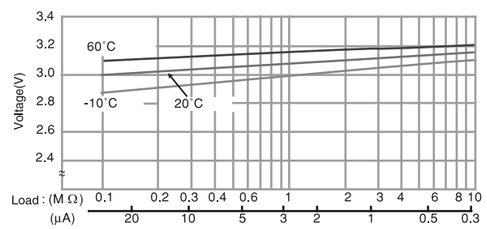
SPECIFICATIONS

Name	CR-3032
Nominal voltage (V)	3
Nominal capacity (mAh)	500
Continuous drain (mA)	0.2
Operating temperature (°C)	-30 to +60
Weight (g)	6.8

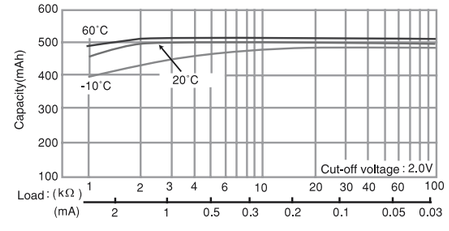
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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* Voltage at 50% discharge depth.

POLY-CARBONMONOFLUORIDE LITHIUM BATTERIES (BR SERIES) – PIN TYPE LITHIUM BATTERIES

These slim-line Pin Type Lithium batteries are contained in an aluminum casing and were originally developed by Panasonic. A single cell Lithium pin battery can light an LED.

GENERAL SPECIFICATIONS

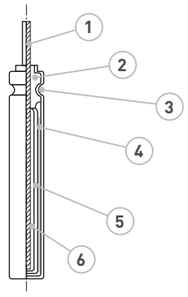
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
BR-425	3	25	0.5	4.2	25.9	0.6	–	–
BR-435	3	50	1.0	4.2	35.9	0.9	–	–

Applications

- LED-type night fishing floats
- Various illumination products
- Fishing pole tip lights
- Toys

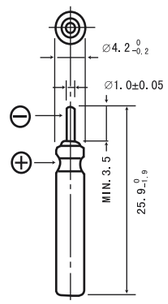
GENERAL CONSTRUCTION

1. Anode cap
2. Gasket
3. Collector
4. Cathode (Poly-carbon monofluoride)
5. Separator
6. Anode (lithium)



*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

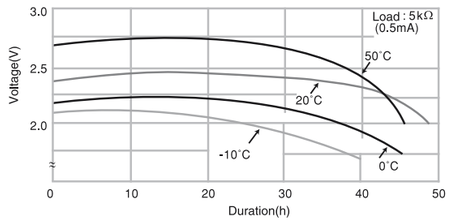
BR-425



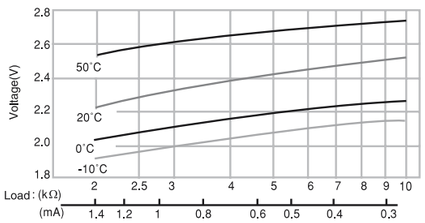
SPECIFICATIONS

Name	BR-425
Nominal voltage (V)	3
Nominal capacity (mAh)	25
Continuous drain (mA)	0.5
Operating temperature (°C)	-30 to +80
Weight (g)	0.6

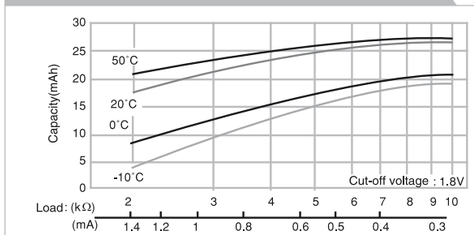
DISCHARGE TEMPERATURE CHARACTERISTICS



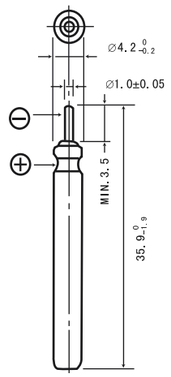
OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



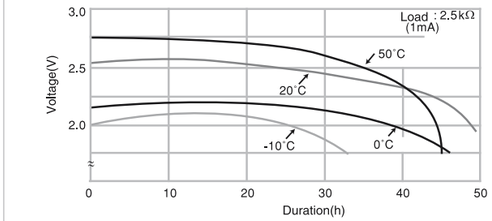
BR-435



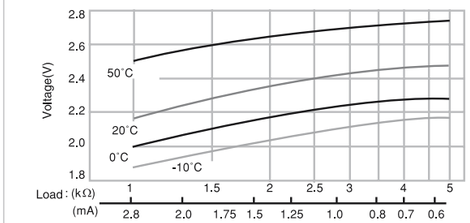
SPECIFICATIONS

Name	BR-435
Nominal voltage (V)	3
Nominal capacity (mAh)	50
Continuous drain (mA)	1.0
Operating temperature (°C)	-30 to +80
Weight (g)	0.9

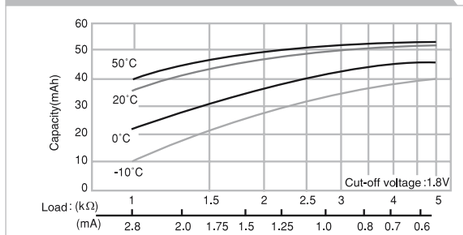
DISCHARGE TEMPERATURE CHARACTERISTICS



OPERATING VOLTAGE VS. DISCHARGE CURRENT*



CAPACITY VS. LOAD RESISTANCE



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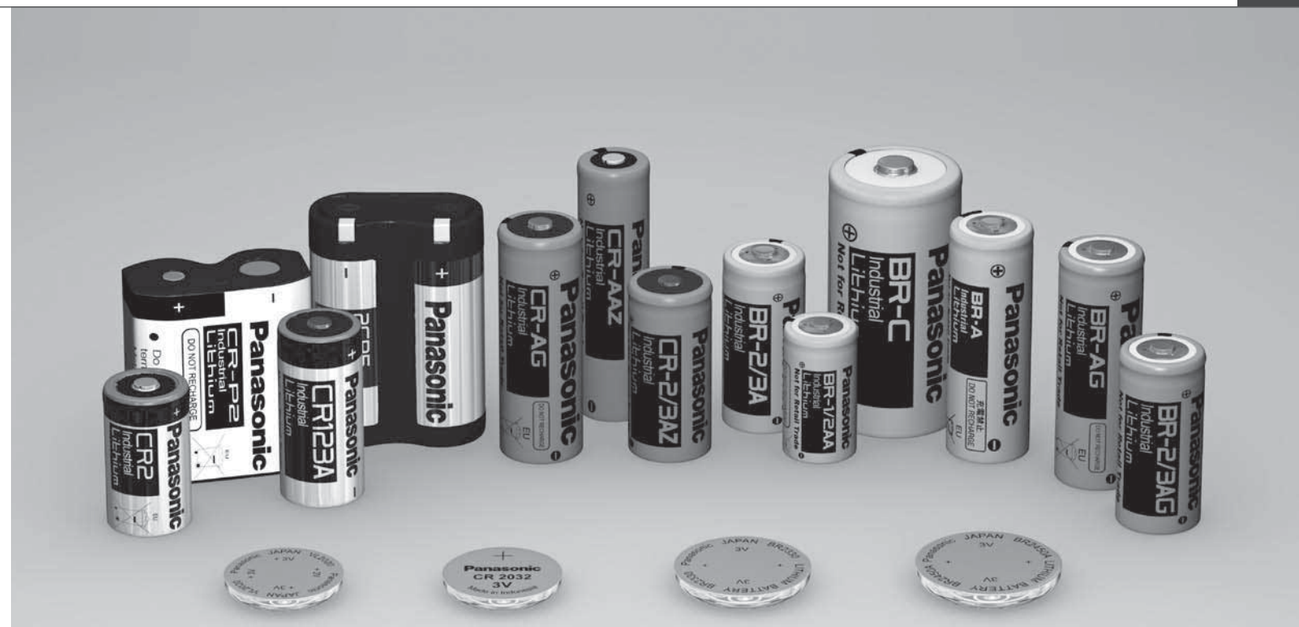
* Voltage at 50% discharge depth.



	Page
Coin Type Rechargeable Lithium batteries	
Vanadium Rechargeable Lithium batteries (VL series)	56 – 61
Manganese Rechargeable Lithium batteries (ML series)	62 – 68
Niobium Rechargeable Lithium batteries (NBL series)	69 – 70
Titanium Rechargeable Lithium batteries (MT series)	71 – 73
Reflowable Coin Type Rechargeable Lithium batteries	
Reflowable Manganese Rechargeable Lithium batteries (ML-R series)	74 – 76
Reflowable Niobium Rechargeable Lithium batteries (NBL-R series)	77 – 78

VANADIUM RECHARGEABLE LITHIUM BATTERIES (VL SERIES) – COIN TYPE RECHARGEABLE LITHIUM BATTERIES

These completely new Coin Type Lithium batteries feature vanadium oxide for the positive pole, Lithium alloy for the negative pole and a non-aqueous solvent for the electrolyte.

GENERAL SPECIFICATIONS

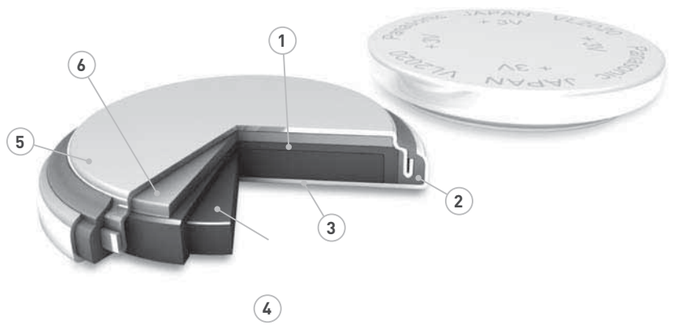
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
VL-621*2	3	1.5	0.01	6.8	2.1	0.3	–	–
VL-1220*2	3	7.0	0.02	12.5	2.0	0.8	–	–
VL-2020*2	3	20.0	0.07	20.0	2.0	2.2	–	–
VL-2320*2	3	30.0	0.10	23.0	2.0	2.7	–	–
VL-2330*2	3	50.0	0.10	23.0	3.0	3.5	–	–
VL-3032*2	3	100.0	0.20	30.0	3.2	6.2	–	–

Applications

- Keyless Entry
- Memory back-up power supplies for office automation equipment (personal computers, fax machines, etc.)
- Audio-video equipment (VTRs, etc.)
- Communications equipment (mobile phones, etc.)
- Watches
- Hybrid systems with solar batteries (solar remote controllers, etc.)

3D ILLUSTRATION

1 Separator
2 Gasket
3 Positive pole (cell can)
4 Cathode (vanadium pentoxide)
5 Negative pole
6 Anode (lithium aluminium alloy)



*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.
*2 Indicates terminal specification. Note: Only battery with terminal are handled.

CHARGING

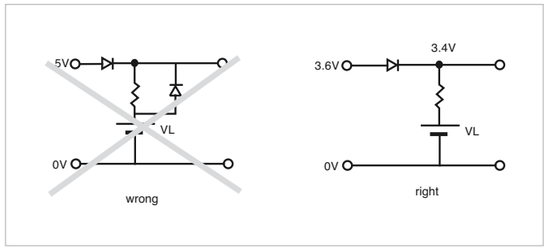
Charging circuits

Charging/discharging cycle	Approx. 1,000 times at 10% discharge depth to nominal capacity
Charging system*	Constant-voltage charging.(Please strictly adhere to the specified charge voltage)
Operating temperature	-20°C to +60°C

The charging circuit is crucial in terms of ensuring that full justice will be done to the battery characteristics. Consider it carefully as the wrong charging circuit can cause trouble.

Precautions regarding the charge voltage setting

Under no circumstances should trickle charging, which is used for nickel-cadmium batteries, be used. Ignoring this precaution will cause the battery voltage to rise to about 5V, resulting in a deterioration of performance.



Charge voltage range

If a fixed-charging method is applied, please adhere to the specified charging voltage. The guaranteed value over an operating temperature range from -20°C to +60°C is 3.4V ± 0.15V. (Actual value: 3.4V ± 0.20V)

- If the charging voltage exceeds the specifications, the internal resistance of the battery will rise and may cause battery deterioration. Also,with a charge voltage around 4V, corrosion of the ⊕ terminal (case) may occur, causing leakage.
- It is not possible for the battery capacity to recover completely when the charging voltage is below the specification.

Recommended charging circuits

Basic conditions

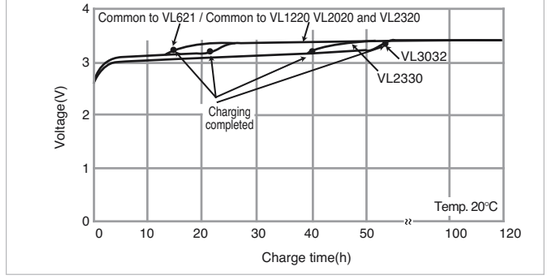
Charge voltage:	3.4V ± 0.15V
Charge current:	For a battery voltage of 3V
VL-621	Approx. 0.2mA or below
VL-1220	Approx. 0.5mA or below
VL-2020	Approx. 1.5mA or below
VL-2320, VL-2330	Approx. 2.0mA or below
VL-3032	Approx. 4.0mA or below

(It is permissible for the current to increase beyond the above level when the battery voltage drops below 3V.)

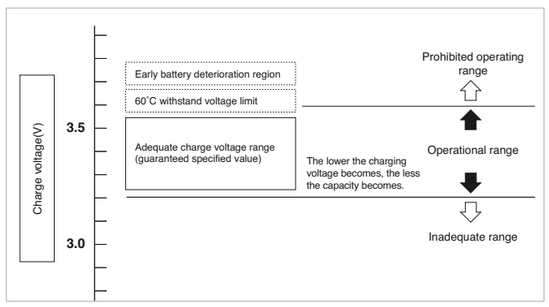
Mixed usage of batteries

Do not use these batteries and Lithium primary batteries or other rechargeable batteries together, and do not use new batteries and old batteries together even if they are of the same type.

Charging characteristics



Influence of the charge voltage on VL batteries



If the charge voltage goes beyond its adequate range, battery performance may deteriorate early. Be sure to observe the guaranteed charge voltage.

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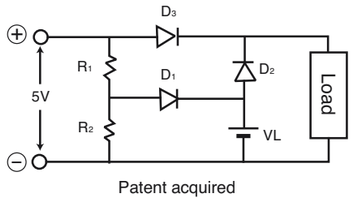
* Consult with Panasonic concerning constant-current charging systems.

Reference: Examples of charging circuits

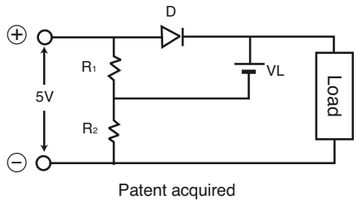


Patent acquired

Standard circuits

D_2: select a diode of small inverse current (I_R=1μA below/5V)
D_1, D_2: MA3X716 (Diode type code)
D_3: MA3X704, MA2J728

	R_1	R_2	Charge current (max.)
VL-621	2.2kΩ	5.6kΩ	0.2mA
VL-1220	750Ω	1.8kΩ	0.5mA
VL-2020	200Ω	510Ω	1.5mA
VL-2320, VL-2330	150Ω	390Ω	2.0mA
VL-3032	68Ω	180Ω	4.0mA



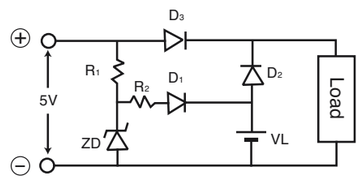
Patent acquired

Simple economical circuits

D: MA2J728 (Very small reverse current)

Load with 5V applied	1mA below	
D,Vf	0~0.30V	
	R_1	R_2
VL-621	6.2kΩ	2.4kΩ
VL-1220	1500Ω	560Ω
VL-2020	470Ω	180Ω
VL-2320, VL-2330	390Ω	150Ω
VL-3032	180Ω	68Ω

VF of D will be different from the value given above if a current in excess of 1 mA flows to the load during operation. Compensation must be provided by the resistors in such cases.

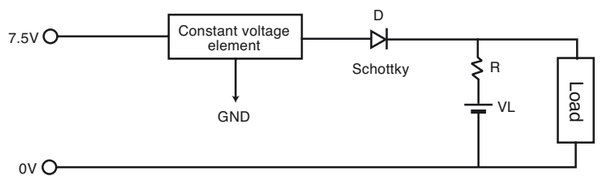


	ZD	D_1	R_1	
A	MAZ30360L	MA3X704	300	Common to all types
B	MAZ30360H	MA2J728	270	

Type		VL-3032	VL-2330	VL-2320	VL-2020	VL-1220	VL-621
R_2	A	Not required				470Ω	1.5kΩ
	B	Not required				560Ω	1.6kΩ

D_2: select a diode of small inverse current (I_R=1μA below/5V)

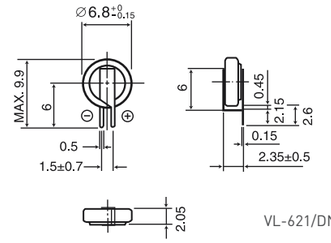
For minimizing current leakage due to resistance, etc., as when charging by another battery.



REG	D
3.7V	MA2J728

For details, refer to the constant voltage element specifications.

VL-621

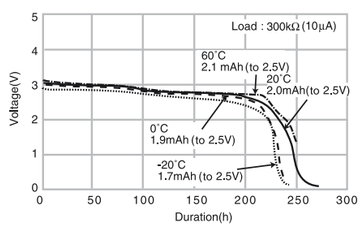


VL-621/DN

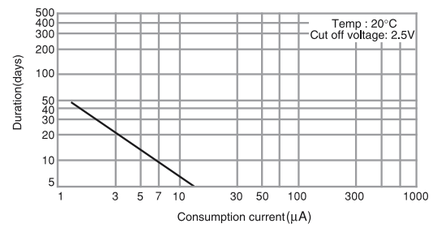
SPECIFICATIONS

Name	VL-621
Nominal voltage (V)	3
Nominal capacity (mAh)	1.5
Continuous drain (mA)	0.01
Operating temperature (°C)	-20 to +60
Weight (g)	0.3

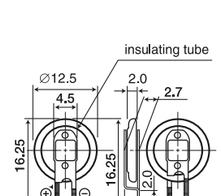
DISCHARGE TEMPERATURE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



VL-1220

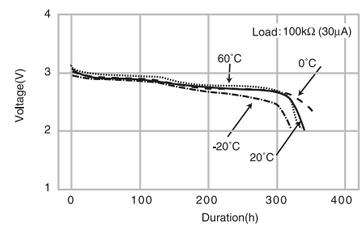


VL-1220/FCN

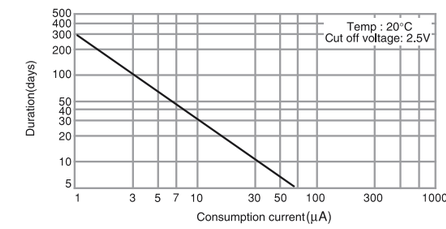
SPECIFICATIONS

Name	VL-1220
Nominal voltage (V)	3
Nominal capacity (mAh)	7.0
Continuous drain (mA)	0.02
Operating temperature (°C)	-20 to +60
Weight (g)	0.8

DISCHARGE TEMPERATURE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



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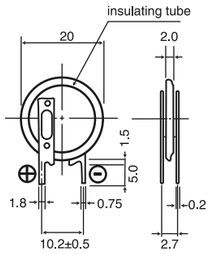
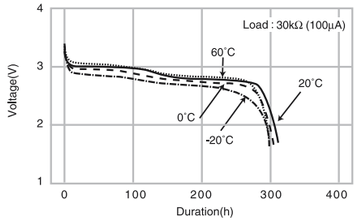
VL-2020



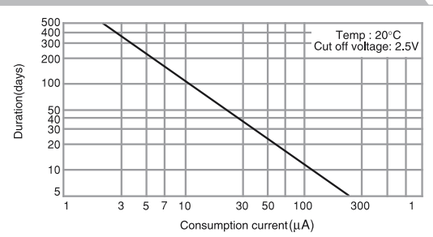
SPECIFICATIONS

Name	VL-2020
Nominal voltage (V)	3
Nominal capacity (mAh)	20.0
Continuous drain (mA)	0.07
Operating temperature (°C)	-20 to +60
Weight (g)	2.2

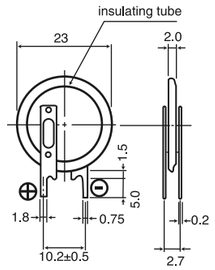
DISCHARGE TEMPERATURE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



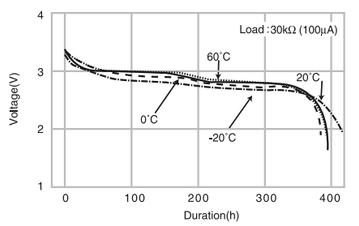
VL-2320



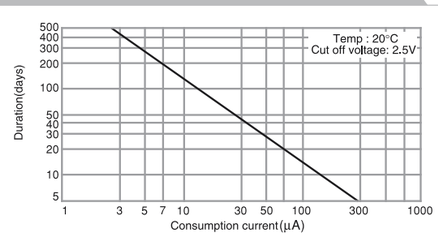
SPECIFICATIONS

Name	VL-2320
Nominal voltage (V)	3
Nominal capacity (mAh)	30.0
Continuous drain (mA)	0.1
Operating temperature (°C)	-20 to +60
Weight (g)	2.7

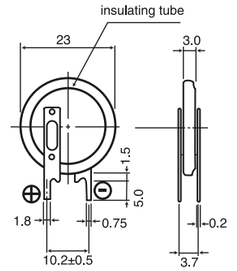
DISCHARGE TEMPERATURE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



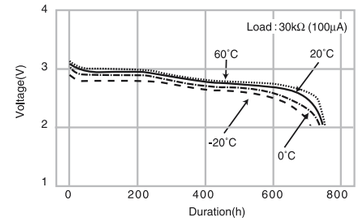
VL-2330



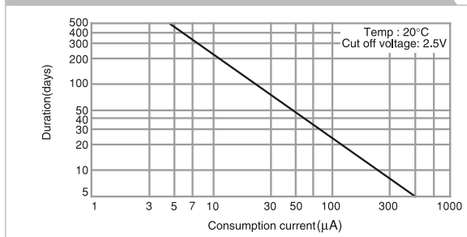
SPECIFICATIONS

Name	VL-2330
Nominal voltage (V)	3
Nominal capacity (mAh)	50.0
Continuous drain (mA)	0.1
Operating temperature (°C)	-20 to +60
Weight (g)	3.5

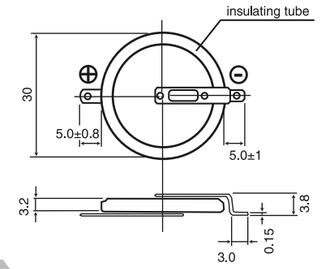
DISCHARGE TEMPERATURE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



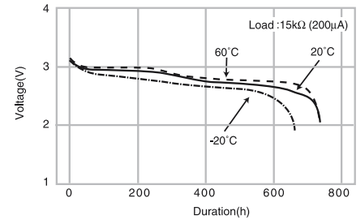
VL-3032



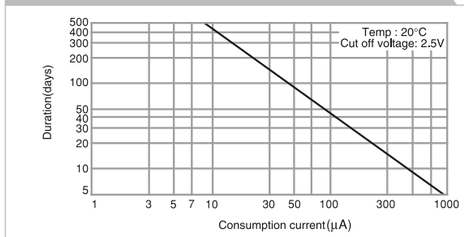
SPECIFICATIONS

Name	VL-3032
Nominal voltage (V)	3
Nominal capacity (mAh)	100.0
Continuous drain (mA)	0.2
Operating temperature (°C)	-20 to +60
Weight (g)	6.2

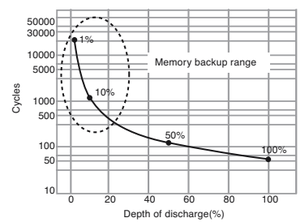
DISCHARGE TEMPERATURE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



CYCLE LIFE (VL SERIES)



MANGANESE RECHARGEABLE LITHIUM BATTERIES (ML SERIES) – COIN TYPE RECHARGEABLE LITHIUM BATTERIES

These super compact Rechargeable Lithium batteries feature a Manganese compound oxide for the positive electrode, a Lithium/Aluminum alloy for the negative electrode and a special non-aqueous solvent for the electrolyte. They can easily be incorporated into circuits where 3V ICs are used to save space.

GENERAL SPECIFICATIONS

Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
ML-414	3	1.2	0.005	4.8	1.4	0.09	–	–
ML-421	3	2.3	0.005	4.8	2.1	0.11	–	–
ML-614	3	3.4	0.010	6.8	1.4	0.16	–	–
ML-621	3	5.0	0.010	6.8	2.1	0.23	–	–
ML-920	3	11.0	0.030	9.5	2.0	0.40	–	–
ML-1220	3	17.0	0.030	12.5	2.0	0.80	–	–
ML-2020	3	45.0	0.120	20.0	2.0	2.20	–	–

Applications

- Memory back-up power supplies for mobile phones
- Memory cards
- Pagers and other compact communications equipment
- Data terminals and office automation equipment

*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

CHARGING

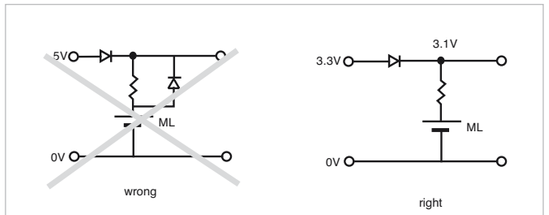
Charging circuits

Charging/discharging cycle	Approx. 1,000 times at 10% discharge depth to nominal capacity
Charging system*	Constant-voltage charging. (Please strictly adhere to the specified charge voltage)
Operating temperature	-20°C to +60°C

The charging circuit is crucial in terms of ensuring that full justice will be done to the battery characteristics. Consider it carefully as the wrong charging circuit can cause trouble.

Precautions regarding the charge voltage setting

Under no circumstances should trickle charging, which is used for Nickel-Cadmium batteries, be used. Ignoring this precaution will cause the battery voltage to rise to about 5V, resulting in a deterioration of performance.



Charge voltage range

If a fixed-charging method is applied, please adhere to the specified charging voltage. Guaranteed voltage is 2.8V to 3.2V at the temperature of -20°C to +60°C.

- If the charging voltage exceeds the specifications, the internal resistance of the battery will rise and may cause battery deterioration. Also, with a charge voltage around 4V, corrosion of the ⊕ terminal (case) may occur, causing leakage.
- It is not possible for the battery capacity to recover completely when the charging voltage is below the specification.

Recommended charging circuits

Basic conditions

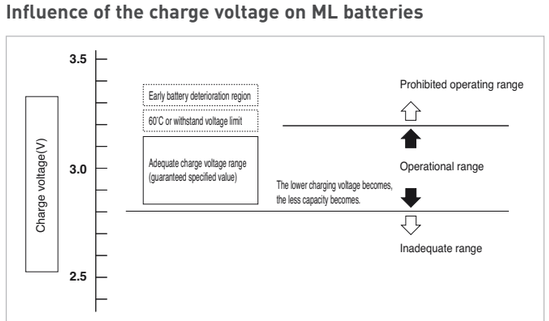
Fixed-voltage charge

Charge voltage:	2.8 to 3.2V (Standard voltage: 3.1V)
Charge current:	For a battery voltage of 2.5V
ML-414	Approx. 0.1mA or below
ML-421	Approx. 0.15mA or below
ML-614	Approx. 0.3mA or below
ML-621	Approx. 0.6mA or below
ML-920, ML-1220	Approx. 1.2mA or below
ML-2020	Approx. 3.0mA or below

Mixed usage of batteries

Do not use these batteries and Lithium primary batteries or other rechargeable batteries together, and do not use new batteries and old batteries together even if they are of the same type.

Influence of the charge voltage on ML batteries



If the charge voltage goes beyond its adequate range, battery performance may deteriorate early. Be sure to observe the guaranteed charge voltage.

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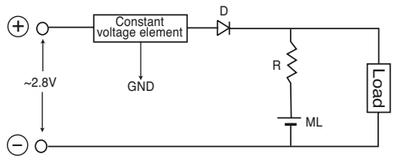
* Consult with Panasonic concerning constant-current charging systems.

Reference: Examples of charging circuits



When Charging using another battery

ML-414

REG	D	R
3.2V	MA2J728	4.7kΩ
3.1V	MA2J728	3.9kΩ

ML-421

REG	D	R
3.2V	MA2J728	6.2kΩ
3.1V	MA2J728	5.1kΩ

ML-614

REG	D	R
3.2V	MA2J728	1.8kΩ
3.1V	MA2J728	1.5kΩ

ML-621

REG	D	R
3.2V	MA2J728	910Ω
3.1V	MA2J728	750Ω

ML-920

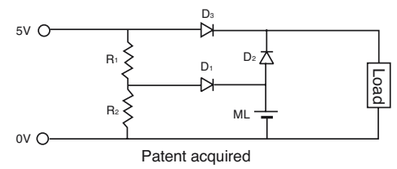
REG	D	R
3.2V	MA2J728	470Ω
3.1V	MA2J728	390Ω

ML-1220

REG	D	R
3.2V	MA2J728	470Ω
3.1V	MA2J728	390Ω

ML-2020

REG	D	R
3.2V	MA2J728	180Ω
3.1V	MA2J728	150Ω

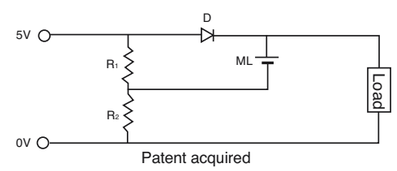


Patent acquired

Standard circuits

For D_2, select a diode of small inverse current
D_1, D_2: MA3X716 (Diode type code)
D_3: MA3X704, MA2J728 (Ir=1μA/5V)

	R_1	R_2
ML-414	5.1kΩ	9.1kΩ
ML-421	5.1kΩ	9.1kΩ
ML-614	2.7kΩ	5.1kΩ
ML-621	1.1kΩ	2.0kΩ
ML-920	680Ω	1.3kΩ
ML-1220	680Ω	1.3kΩ
ML-2020	180Ω	330Ω



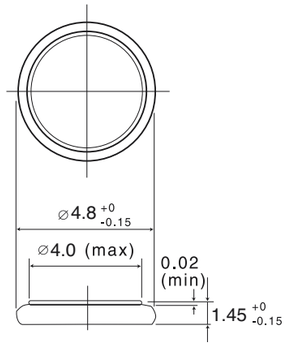
Patent acquired

Simple economical circuits

Load	100μA below	
D,Vf	0~0.2V	
	R_1	R_2
ML-414	9.1kΩ	5.6kΩ
ML-421	10kΩ	5.1kΩ
ML-614	5.1kΩ	2.7kΩ
ML-621	2.4kΩ	1.3kΩ
ML-920	1kΩ	510Ω
ML-1220	1kΩ	510Ω
ML-2020	330Ω	180Ω

VF of D will be different from the value given above if a current in excess of 10μA flows to the load during operation. Compensation must be provided by the resistors in such cases.

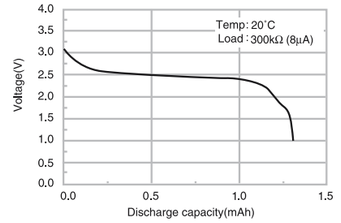
ML-414



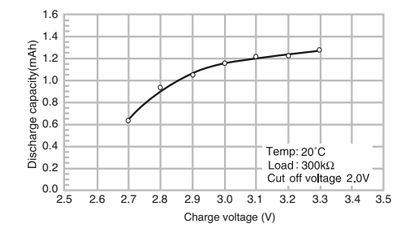
SPECIFICATIONS

Name	ML-414
Nominal voltage (V)	3
Nominal capacity (mAh)	1.2
Continuous drain (mA)	0.005
Operating temperature (°C)	-20 to +60
Weight (g)	0.09

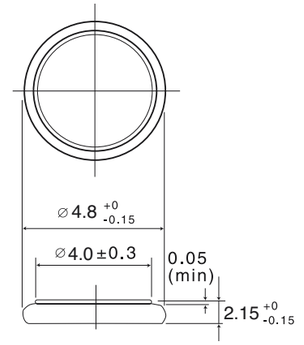
DISCHARGE CHARACTERISTICS



CHARGE VOLTAGE VS. DISCHARGE CAPACITY



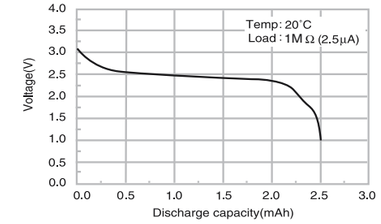
ML-421



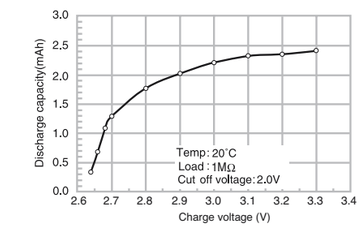
SPECIFICATIONS

Name	ML-421
Nominal voltage (V)	3
Nominal capacity (mAh)	2.3
Continuous drain (mA)	0.005
Operating temperature (°C)	-20 to +60
Weight (g)	0.11

DISCHARGE CHARACTERISTICS



CHARGE VOLTAGE VS. DISCHARGE CAPACITY



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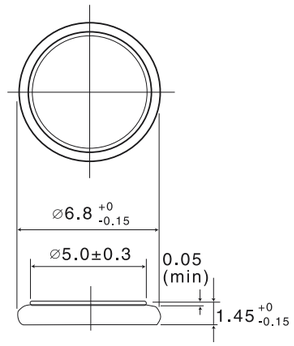
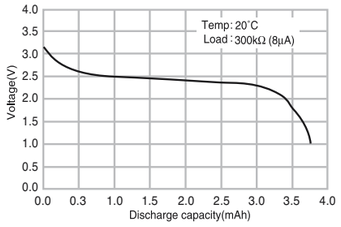
ML-614



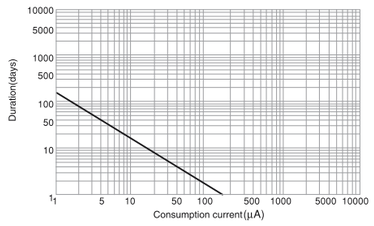
SPECIFICATIONS

Name	ML-614
Nominal voltage (V)	3
Nominal capacity (mAh)	3.4
Continuous drain (mA)	0.01
Operating temperature (°C)	-20 to +60
Weight (g)	0.16

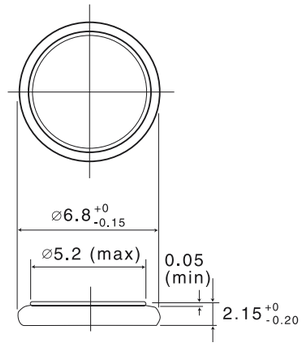
DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



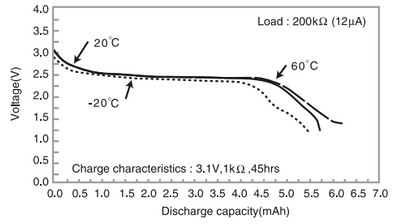
ML-621



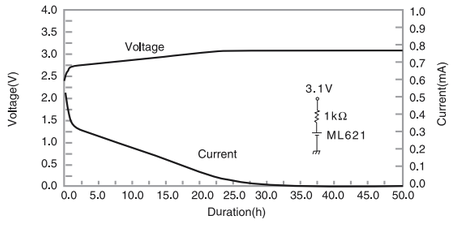
SPECIFICATIONS

Name	ML-621
Nominal voltage (V)	3
Nominal capacity (mAh)	5.0
Continuous drain (mA)	0.01
Operating temperature (°C)	-20 to +60
Weight (g)	0.23

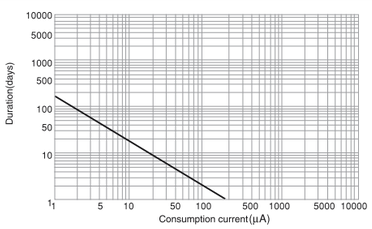
DISCHARGE CHARACTERISTICS



CHARGE CHARACTERISTICS

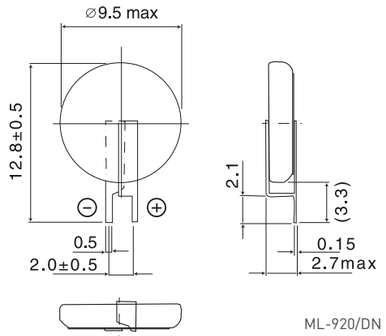


CONSUMPTION CURRENT VS. DURATION TIME



The data in this document are for descriptive purposes only and are not intended to make or imply any guarantee or warranty.

ML-920

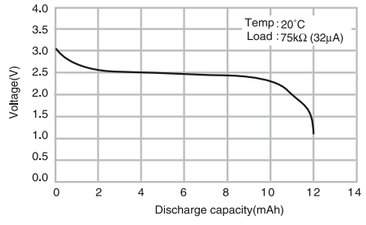


ML-920/DN

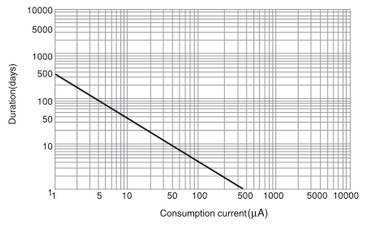
SPECIFICATIONS

Name	ML-920
Nominal voltage (V)	3
Nominal capacity (mAh)	11.0
Continuous drain (mA)	0.03
Operating temperature (°C)	-20 to +60
Weight (g)	0.4

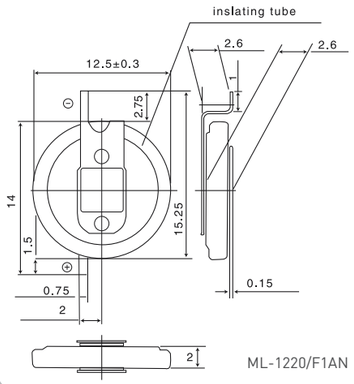
DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



ML-1220

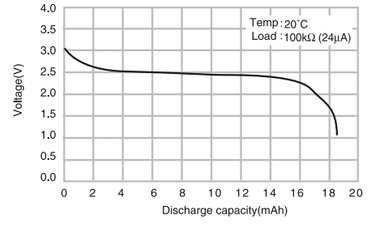


ML-1220/F1AN

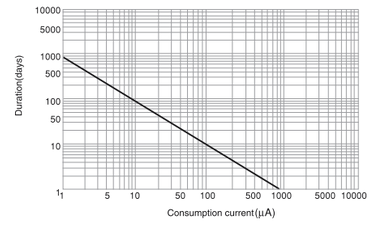
SPECIFICATIONS

Name	ML-1220
Nominal voltage (V)	3
Nominal capacity (mAh)	17.0
Continuous drain (mA)	0.03
Operating temperature (°C)	-20 to +60
Weight (g)	0.8

DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



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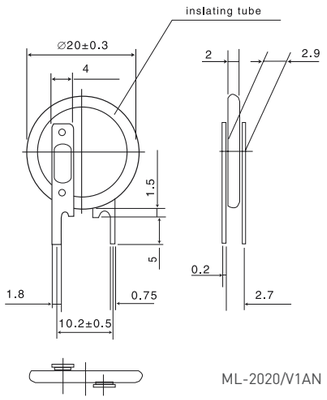
ML-2020

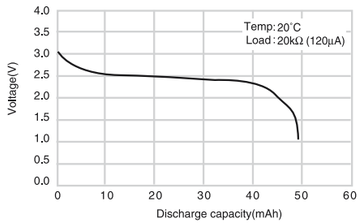


ML-2020/V1AN

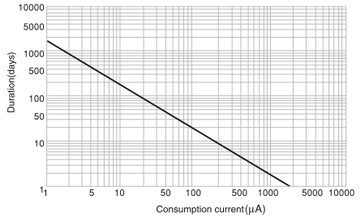
SPECIFICATIONS

Name	ML-2020
Nominal voltage (V)	3
Nominal capacity (mAh)	45
Continuous drain (mA)	0.12
Operating temperature (°C)	-20 to +60
Weight (g)	2.2

DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



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NIOBIUM RECHARGEABLE LITHIUM BATTERIES (NBL SERIES) – COIN TYPE RECHARGEABLE LITHIUM BATTERIES

The NBL series eliminates the need for a voltage boosting circuit since they can be charged at a low voltage. They help to simplify charging circuits.

GENERAL SPECIFICATIONS

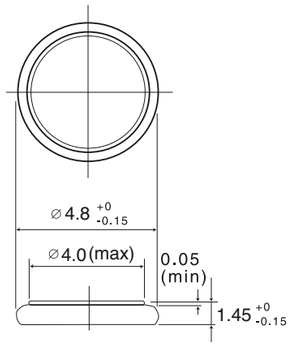
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
NBL-414	2	1	0.008	4.8	1.4	0.08	–	–
NBL-621	2	4	0.010	6.8	2.1	0.22	–	–

Applications

- Memory back-up power supplies for mobile phones using ICs which are driven at 2.5V or below

*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

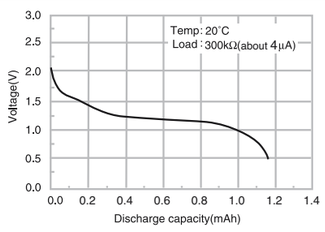
NBL-414



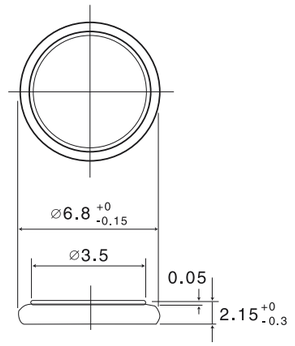
SPECIFICATIONS

Name	NBL-414
Nominal voltage (V)	2
Nominal capacity (mAh)	1.0
Continuous drain (mA)	0.008
Operating temperature (°C)	-20 to +60
Weight (g)	0.08

DISCHARGE CHARACTERISTICS



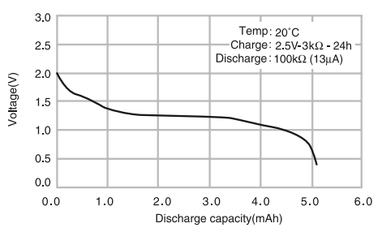
NBL-621



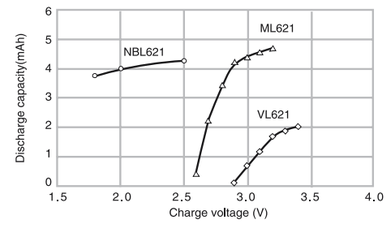
SPECIFICATIONS

Name	NBL-621
Nominal voltage (V)	2
Nominal capacity (mAh)	4.0
Continuous drain (mA)	0.01
Operating temperature (°C)	-20 to +60
Weight (g)	0.22

DISCHARGE CHARACTERISTICS



CHARGE VOLTAGE VS. DISCHARGE CAPACITY



TITANIUM RECHARGEABLE LITHIUM BATTERIES (MT SERIES) – COIN TYPE RECHARGEABLE LITHIUM BATTERIES

These Coin Type Manganese Titanium Rechargeable Lithium Coin batteries use a Lithium-Manganese complex oxide for the positive pole and a special Lithium-Titanium complex oxide for the negative pole. They provide a capacity which is more than 10 times that of capacitors of the same size.

GENERAL SPECIFICATIONS

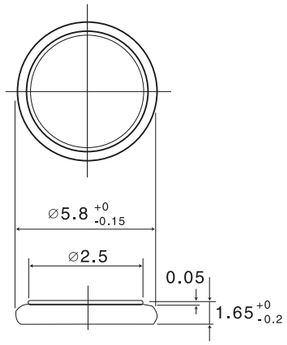
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	JIS	IEC
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
MT-516	1.5	1.8	0.4	5.8	1.6	0.15	–	–
MT-621	1.5	2.5	0.4	6.8	2.1	0.25	–	–
MT-920	1.5	5.0	0.4	9.5	2.0	0.50	–	–

Applications

- Main power supplies in compact products such as rechargeable watches
- Memory back-up power supply for pagers, timers, etc.

*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.

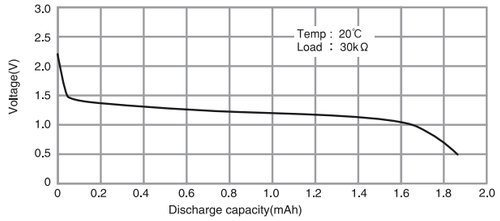
MT-516



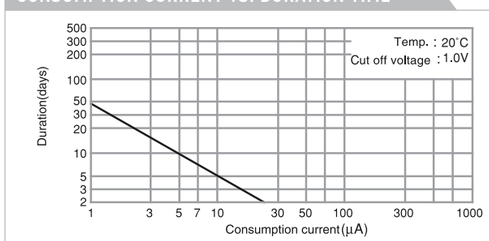
SPECIFICATIONS

Name	MT-516
Nominal voltage (V)	1.5
Nominal capacity (mAh)	1.8
Continuous drain (mA)	0.04
Operating temperature (°C)	-10 to +60
Weight (g)	0.15

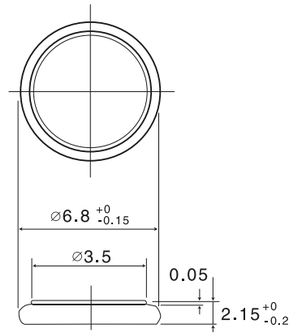
DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



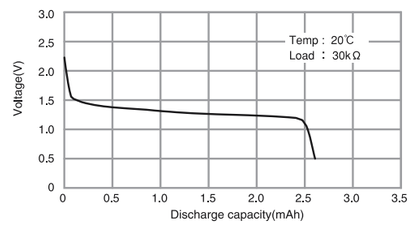
MT-621



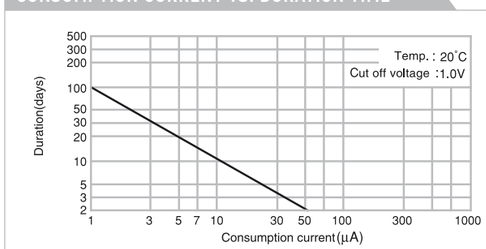
SPECIFICATIONS

Name	MT-621
Nominal voltage (V)	1.5
Nominal capacity (mAh)	2.5
Continuous drain (mA)	0.04
Operating temperature (°C)	-10 to +60
Weight (g)	0.25

DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



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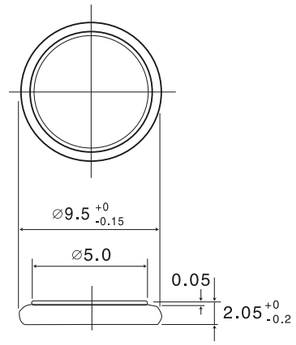
TITANIUM RECHARGEABLE LITHIUM BATTERIES (MT SERIES) 3

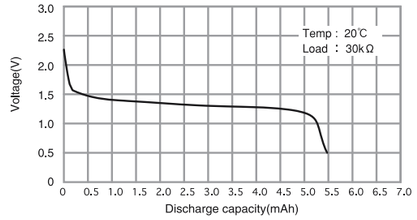
MT-920



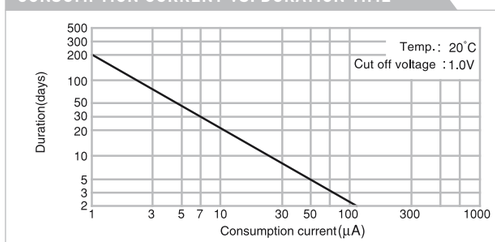
SPECIFICATIONS

Name	MT-920
Nominal voltage (V)	1.5
Nominal capacity (mAh)	5.0
Continuous drain (mA)	0.04
Operating temperature (°C)	-10 to +60
Weight (g)	0.50

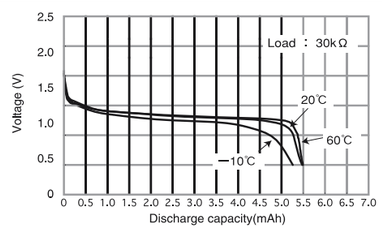
DISCHARGE CHARACTERISTICS



CONSUMPTION CURRENT VS. DURATION TIME



DISCHARGE TEMPERATURE CHARACTERISTICS



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REFLOWABLE* MANGANESE RECHARGEABLE LITHIUM BATTERIES (ML-R SERIES) – REFLOWABLE COIN TYPE RECHARGEABLE LITHIUM BATTERIES

These batteries are able to use the reflow soldering process for automatic mounting, by adopting four high heat-resistant materials. ML-R series feature large capacity close to non-reflowable ML series.

GENERAL SPECIFICATIONS

Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	Reflowable temperature	Operating temperature
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
ML-414RM*2	3	1.0	0.005	4.8	1.4	0.07	Max. 260°C	-20°C to +60°C

Applications

- Memory back-up power supplies for mobile phones, memory cards, pagers and other compact communications equipment, data terminals and office automation equipment

* The soldering method which applies solder cream(paste-like thing which added flux to solder powder), on to the board and solder the part and overheat.
*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.
*2 Indicates terminal specification. Note: Only battery with terminal are handled. Lead free re-flow corresponded (please consult about temperature range.)

CHARGING

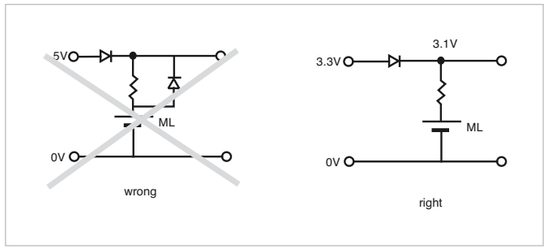
Charging circuits

Charging/discharging cycle	Approx. 350 times at 10% discharge depth to nominal capacity
Charging system*	Constant-voltage charging (Please strictly adhere to the specified charge voltage)
Operating temperature	-20°C to +60°C

The charging circuit is crucial in terms of ensuring that full justice will be done to the battery characteristics. Consider it carefully as the wrong charging circuit can cause trouble.

Precautions regarding the charge voltage setting

Under no circumstances should trickle charging, which is used for Nickel-Cadmium batteries, be used. Ignoring this precaution will cause the battery voltage to rise to about 5V, resulting in a deterioration of performance.



Charge voltage range

If a fixed-charging method is applied, please adhere to the specified charging voltage. Guaranteed voltage is 2.8V to 3.2V at the temperature of -20°C to +60°C.

- If the charging voltage exceeds the specifications, the internal resistance of the battery will rise and may cause battery deterioration. Also, with a charge voltage around 4V, corrosion of the ⊕ terminal (case) may occur, causing leakage. ('Influence of the charge voltage on ML batteries' at page 63.)
- It is not possible for the battery capacity to recover completely when the charging voltage is below the specification.

Recommended charging circuits

Basic conditions

Fixed-voltage charge

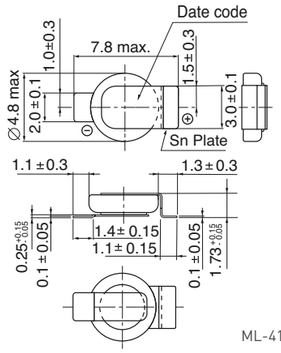
Charge voltage:	2.8 to 3.2V (Standard voltage:3.1V)
Charge current:	For a battery voltage of 2.5V
ML-414RM	Approx. 0.06mA or below

Mixed usage of batteries

Do not use these batteries and Lithium primary batteries or other rechargeable batteries together, and do not use new batteries and old batteries together even if they are of the same type.

* Consult with Panasonic concerning constant-current charging systems.

ML-414RM

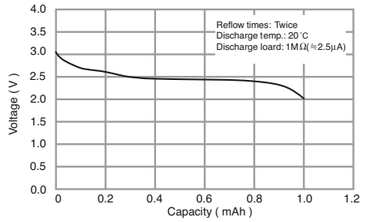


ML-414RM/AN

SPECIFICATIONS

Name	ML-414RM
Nominal voltage (V)	3
Nominal capacity (mAh)	1.0
Continuous drain (mA)	0.005
Operating temperature (°C)	-20 to +60
Weight (g)	0.07

DISCHARGE CHARACTERISTICS



REFLOWABLE* NIOBIUM RECHARGEABLE LITHIUM BATTERIES (NBL-R SERIES) REFLOWABLE COIN TYPE RECHARGEABLE LITHIUM BATTERIES

The NBL-R series eliminates the need for a voltage boosting circuit since they can be charged at a low voltage. They help to simplify charging circuits.

GENERAL SPECIFICATIONS

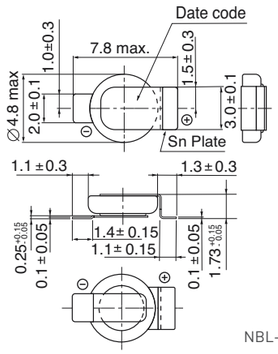
Model number	Electrical Characteristics at 20 °C			Dimensions (mm)		Approx. Weight (g)	Reflowable temperature	Operating temperature
	Nominal Voltage (V)	Nominal Capacity (mAh)*1	Continuous Standard Drain (mA)	Diameter	Height			
NBL-414L*2	2	0.5	0.005	4.8	1.4	0.08	Max. 230°C	-20°C to +60°C

Applications

- Memory back-up power supplies for mobile phones using ICs which are driven at 2.5V or below

* The soldering method which applies solder cream(paste-like thing which added flux to solder powder), on to the board and solder the part and overheat.
*1 Based on standard drain and cut off voltage down to 2.0V at 20°C.
*2 Indicates terminal specification. Note: Only battery with terminal are handled.

NBL-414L

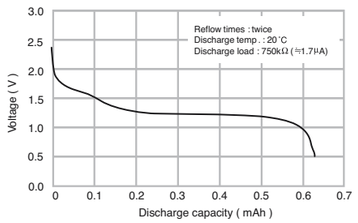


NBL-414L/AN

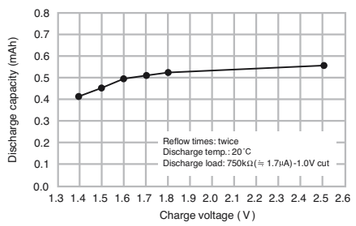
SPECIFICATIONS

Name	NBL-414L
Nominal voltage (V)	2
Nominal capacity (mAh)	0.5
Continuous drain (mA)	0.005
Operating temperature (°C)	-20 to +60
Weight (g)	0.08

DISCHARGE CHARACTERISTICS



CHARGE VOLTAGE VS. DISCHARGE CAPACITY



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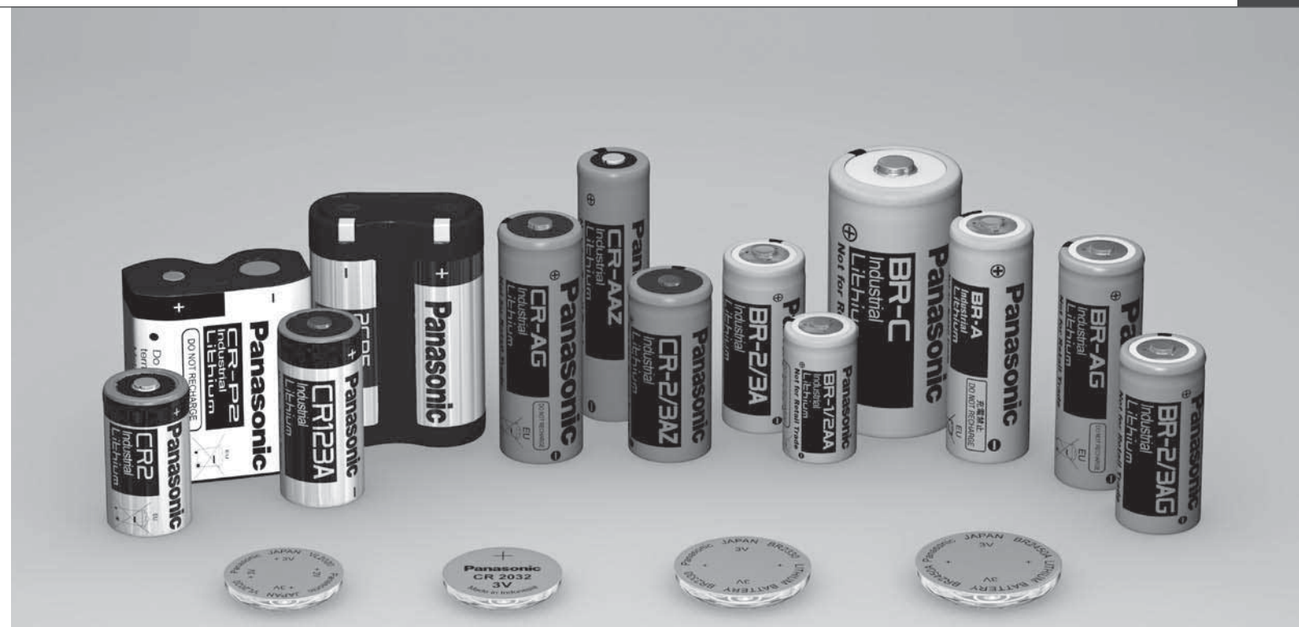


	Page
Batteries with Terminals	80
Soldering Lithium batteries	80

BATTERIES WITH TERMINALS

High reliable terminal

➜ Terminal welding

For terminal welding on the battery, it is quite important to establish the best welding method and its best conditions in order to keep the strong weld strength without any damages on the battery performances. Panasonic mainly use the Laser welding method which is applicable to attach terminals on even quite small batteries that the spot welding hardly to do for. Therefore, our products can correspond exactly and flexibly to various applications. Also, we have established our own high reliable welding capability with a lot of amount of testing data to search the best weld condition for each various combinations of various battery sizes and terminal shapes, which can be provided for widespread equipments and devices.

➜ Soldering on PCB

On the edge of all terminal, Tin plating is applied for increasing the reliability of soldering instead of the solder plate in order to consider influences on environments.

Complete Line-up

Panasonic offers a full range of batteries with terminals for various PCB mounting. Since the terminals come in a variety types, please contact Panasonic for further details. On the other hand, we also provide battery holders for some limited sizes.

SOLDERING LITHIUM BATTERIES

➜ Using a soldering iron

Do not allow the soldering iron to make direct contact with the bodies of the batteries. Proceed with the soldering quickly within 5 seconds while maintaining the iron tip temperature at about 350°C, and do not allow the temperature of the battery bodies to exceed 85°C. (Heat resistance BR type is 125°C)

➜ Automatic dip-soldering bath

Soldering with a dip-soldering bath can be used by condition but do not allow the temperature of the battery bodies exceed 85°C. It is important to note, depending on the temperature conditions inside the dipping device,that the battery body temperature may rise after dipping due to the residual heat retained. When a post-dipping temperature rise is observed, review the temperature conditions and consider a dipping time reduction or a way of forcibly cooling the batteries after dipping.

Basic conditions

Solder dipping bath temperature	Not exceed 260°C
Dipping duration	Within 5 sec.
Number of dipping	Within 2 times

⚠ Never Use Reflow Soldering

Please do not carry out re-flow welding except for the re-flow corresponding batteries (ML-R and NBL-R). Never use reflow soldering since doing so directly heats the battery surface to high temperatures, causing electrolyte leakage, deterioration of battery characteristics and risking bursting or ignition.

Cautions

Example where the terminals were soldered straight onto a coin-type Lithium battery, the terminals were connected to a PC board or other electronic components, and the heat generated by the soldering adversely affected the battery, resulting in a deterioration of the battery characteristics:

The heat generated when terminals are mounted using solder causes Lithium to melt.

↓

The separator melts and becomes perforated.

↓

The positive and negative poles are welded together, causing 'internal shorting.'

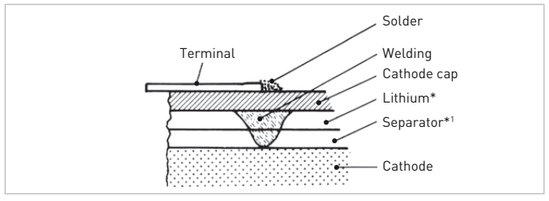
↓

In terms of the battery characteristics, the open-circuit voltage and electrical capacity are both reduced.

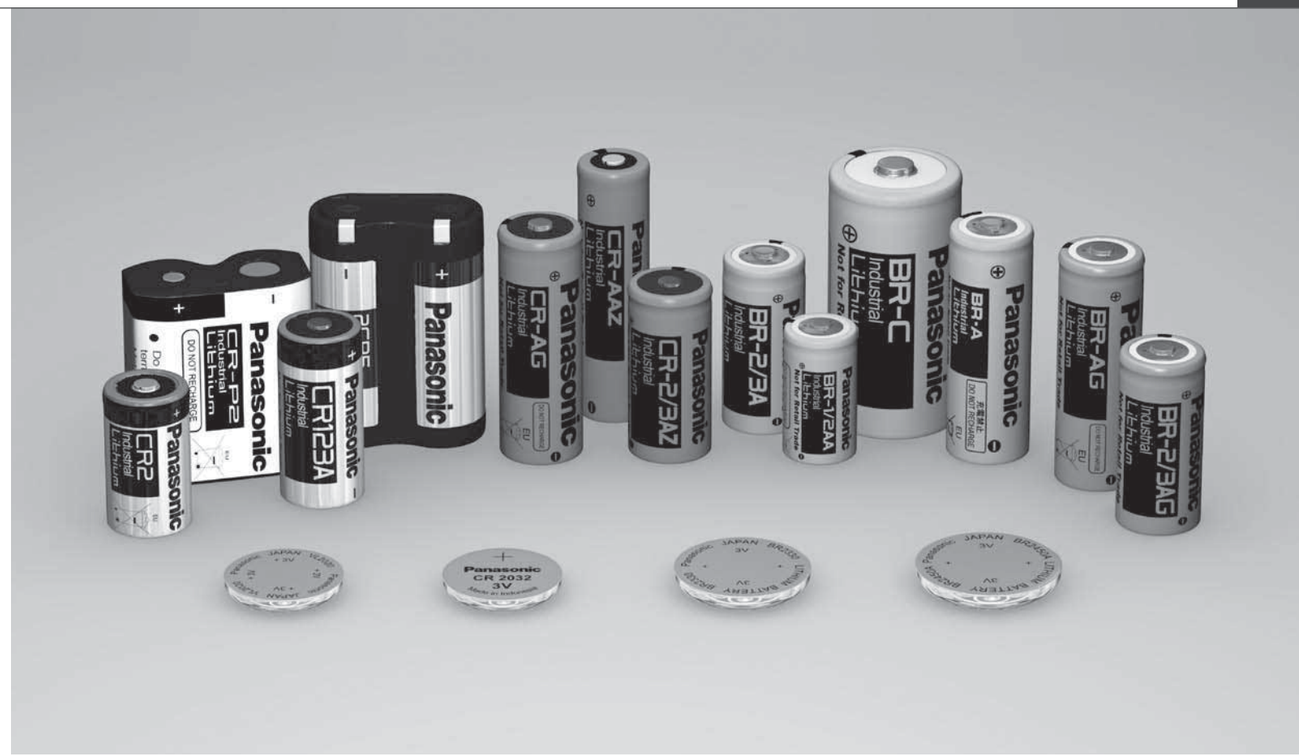
↓

The battery loses its functions or it bursts in rare cases.

Soldering



* Metal whose melting point is about 180°C
*1 Non woven cloth of polypropylene whose melting point is about 165°C



	Page
ISO9001 Approval	82
Transporting Lithium batteries	82
Security Export Control	82

ISO9001 APPROVAL

Three factories in Osaka, Japan and abroad of the Lithium & Micro battery Division has acquired certification under ISO9000 series, the international standard for quality assurance, for its Cylindrical Type Lithium batteries and Coin Type Lithium batteries.

(Moriguchi factory, Osaka)

TRANSPORTING LITHIUM BATTERIES

Based on the United Nations recommendation, regulations have been placed on the transportation of Lithium metal batteries and Lithium-Ion batteries by the International Civil Aviation Organization (ICAO), the International Air Transport Association (IATA), the International Maritime Organization (IMO). Packing and transportation are formally regulated according to the amount of Lithium contained in Lithium batteries. Transportation of Lithium batteries must conform to these regulations. Lithium batteries that have part numbers beginning with BR, CR, ML, NBL and/or VL are classified as 'Lithium metal batteries (UN3090 or UN3091)*' Since Panasonic Lithium metal batteries (except BR-C*[1]) meet the below 3 criteria, they can be treated as exempt from UN3090 or 3091 and shipped as non-dangerous goods.

1. for cells, the Lithium content is not more than 1g
2. for batteries, the aggregate Lithium content is not more than 2g
3. each cell or battery is of the type proven to meet requirements of each test in the UN Manual of Tests and Criteria, Part III, sub-section 38.3

Transporting condition

Actual content of packaging label and shipping documents varies among Shipping companies. Make sure to confirm in advance with your shipping company. For marine or air shipment, except for packages containing no more than 4 cells installed in equipment or no more than 2 batteries installed in equipment, each package shall meet the following:

1. Each consignment shall be accompanied with a document including the following:

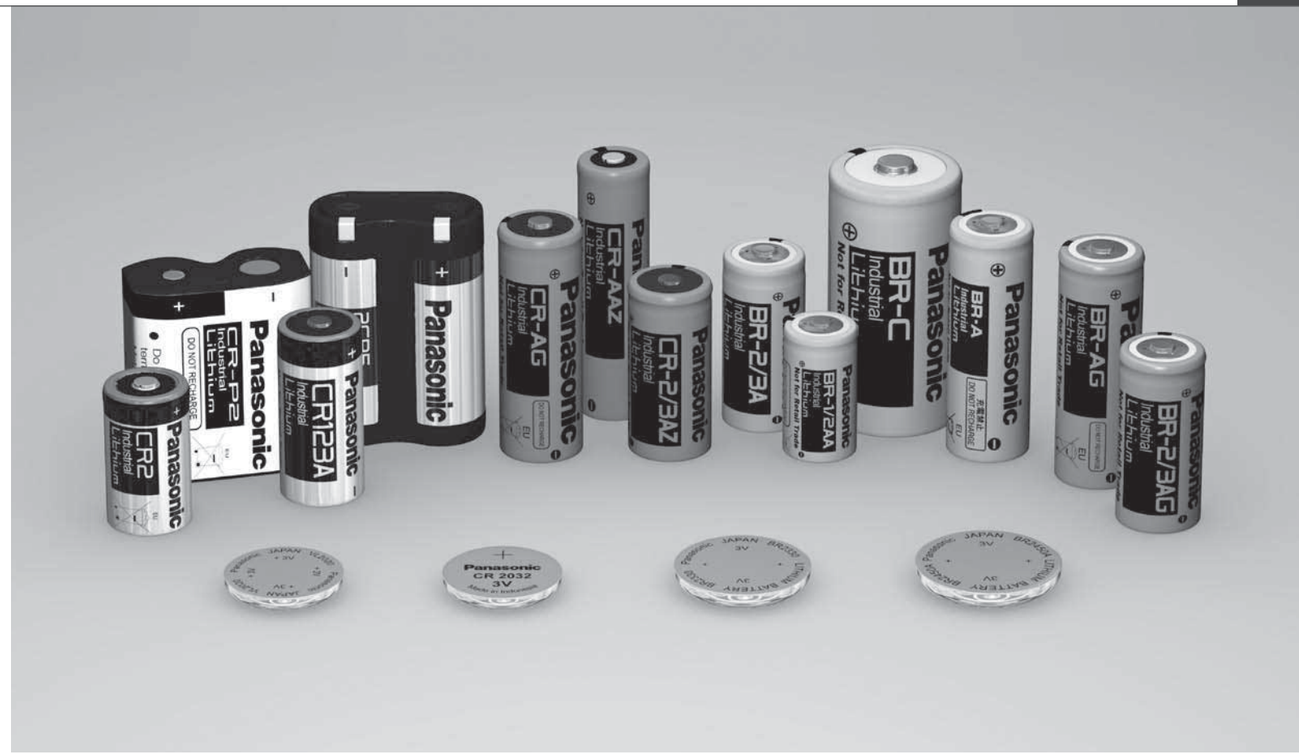
(a) the package contains Lithium metal cells or batteries;
(b) the package shall be handled with care and that a flammability hazard exists if the package is damaged;
(c) special procedures should be followed in the event the package is damaged, to include inspection and repacking if necessary; and
(d) a telephone number for additional information.

2. Each package shall be marked with the previous (a) to (d). For air shipment, each package shall be labeled with a Lithium battery handling label provided by IATA.
3. Except when Lithium batteries are installed in equipment, each package shall be capable of withstanding a 1.2m drop test in any orientation without damage to cells or batteries contained therein, without shifting of the contents so as to allow battery to battery (or cell to cell) contact and without release of contents
4. Except when Lithium batteries are installed in or packed with equipment, packages shall not exceed 30kg gross mass for marine shipment or 2.5kg gross mass for air shipment. (Except when Lithium batteries are installed in or packed with equipment. Air shipment prohibition with passenger plane in the United States.)

SECURITY EXPORT CONTROL

'Security export control' entails observing the legislation provided to maintain international peace and safety by preventing the proliferation of weapons of massive destructions (nuclear weapons, chemical warfare weapons, biological weapons and missiles) and the excessive buildup of conventional weapons. COCOM, the committee that imposed controls on exports to the Communist bloc, was disbanded on March 31, 1994. Later, as part of a new export control regime, Russia and Eastern European countries joined with the previously affiliated nations of COCOM (Japan, America and Europe) and established the Wassenaar Arrangement for dual-use goods & technologies related to conventional weapons. According to the Export Trade Control Order revised by the Japanese Ministry of Economy, Trade & Industry in May 2008, batteries listed in this catalog are classified as 'batteries' not 'cells', and will therefore not be controlled by (7) in annex Table1 to the Order. The above notwithstanding, these batteries may be subject to the regulations depending on their ultimate destination, application and other conditions. When a certificate of classification is required for exportation, etc. or if you have any queries, contact a Panasonic sales representative.

* The Lithium batteries contained in equipment or packed with equipment are classify into UN3091.
*[1] The Lithium content of the cylindrical BR-C Lithium battery exceeds 1g, and must be shipped as dangerous goods for both air and sea transport.



	Page
Avoiding Hazards	84
Preventing Quality Problems	85 – 87

AVOIDING HAZARDS

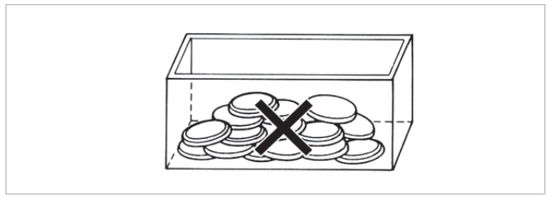
Case Study and Explanation

To store batteries, place each of the batteries in the sections provided on the designated tray in such a way that they will not make contact with one another.

Ignition

2,000 new batteries were taken out from the 20-piece tray containers and thrown randomly into a cardboard box where they were stacked on top of one another. About 30 minutes later, smoke was seen emanating from the batteries followed by ignition several minutes after that.

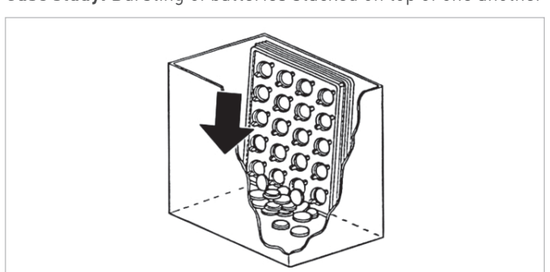
Case study: Ignition of batteries stacked together



Rupture

This particular case involves batteries which were packed in trays and destined for OEMs. The batteries were packed in an intermediate package consisting of 10 trays with each tray containing 20 (or 40) batteries, and the trays were stacked on top of each other. The intermediate package (of the 10 trays) was opened at the distribution stage of our operations, and five of the trays were delivered to one customer. Since the trays were stored at an angle inside the box, the batteries fell out of their positions on the trays and became stacked up on the bottom inside the small box. As a result, some of the batteries burst.

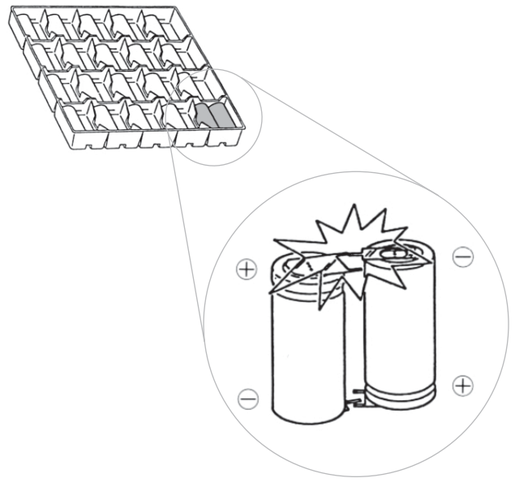
Case study: Bursting of batteries stacked on top of one another



Generating Heat

21 Cylindrical Type Lithium batteries with tab terminals were placed in a 20 piece tray – one battery more than the capacity of the 20-piece tray. Two of the batteries were placed together with their poles reversed. As a result, the tab terminals came into contact with each other, causing external shorting, and the temperature of the two batteries rose dramatically, generating heat and causing the tubes to burst.

Since two batteries were placed in a space (indicated by the arrow) allocated to one battery, their terminals made contact with each other, and external shorting resulted.



Generating heat and deterioration of capacity

To store batteries, place each of the batteries in the sections provided on the designated tray in such a way that they will not make contact with one another.

PREVENTING QUALITY PROBLEMS

Reduction of battery Voltage and Deterioration of Capacity

(1) Reduction of battery voltage and deterioration of capacity through contact with antistatic conductive materials

Incidents have been reported where terminal-mounted batteries for memory back-up or Coin Type Lithium batteries have come into contact with antistatic conductive materials, thus forming external discharge circuits and leading to voltage drops or capacity deterioration.

In manufacturing plants using ICs, LSI and other semiconductor components, thoroughgoing antistatic measures are taken. Various protective materials are used to prevent static: most of them have special compounds of carbon, aluminum foil and other metals and are therefore conductive. These protective materials are used, for example, in the form of packaging bags, trays, mats, sheets, films, corrugated boards and resin cases.

A protective material may have a resistance ranging from 103 to 106Ω/cm, for instance. This means that if the ⊕ and ⊖ terminals of a battery come into contact with this material, a current ranging from several milliamperes to several microamperes will flow and the battery will discharge, causing voltage drop and capacity deterioration.

When batteries are to be used near protective materials, take every possible care to ensure that the ⊕ and ⊖ terminals of the batteries or PC boards, etc. on which batteries are mounted do not touch these protective materials directly.

Fig. 1 A terminal-mounted battery was inserted into a conductive mat. The battery charge was exhausted in several days.

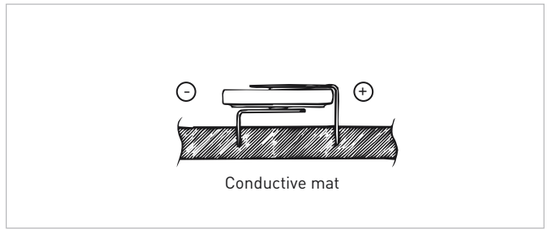


Fig. 2 Battery-mounted PC boards were inadvertently brought into contact with spacers and a conductive rubber sheet. The battery charge was exhausted.

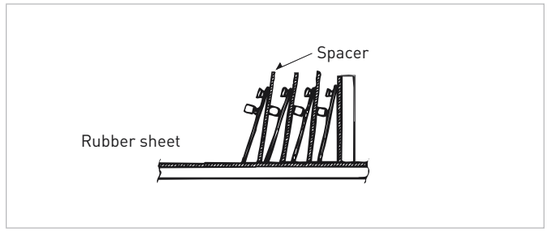


Fig. 3 A battery-mounted PC board was inadvertently brought into contact with a conductive resin case. The battery charge was exhausted.

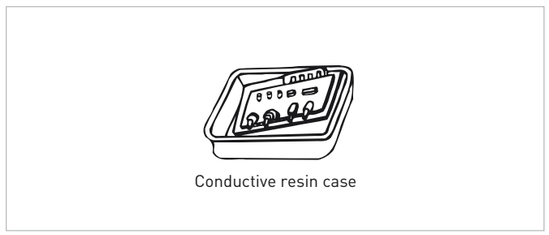
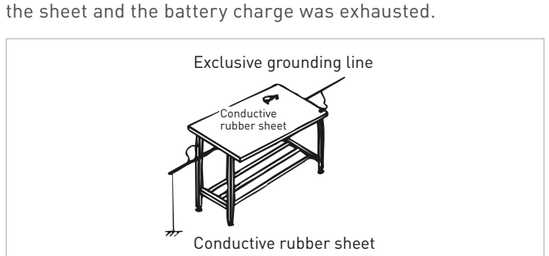


Fig. 4 A battery was placed directly on a rubber sheet spread over a worktable. The ⊕ and ⊖ terminals were in contact with the sheet and the battery charge was exhausted.



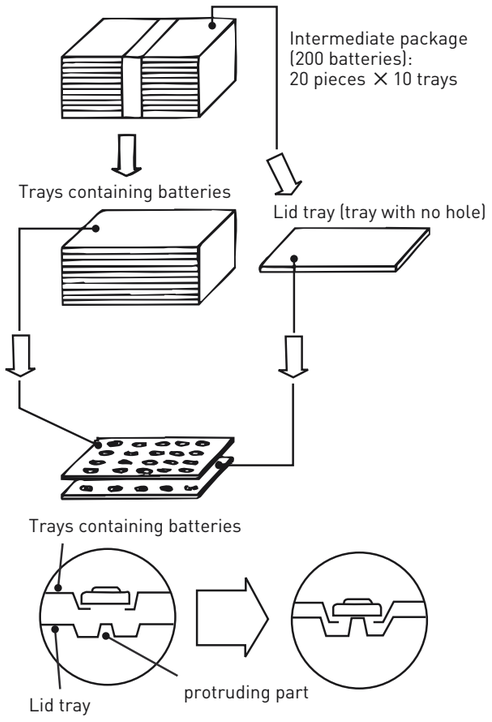
(2) Reduction of battery voltage and deterioration of capacity through contact between batteries

Incidents have been reported where terminal-mounted batteries for memory back-up or Coin Type Lithium batteries have come into contact each other, thus forming discharge circuits (shorted state) and leading to voltage drops or capacity deterioration. Observe the following precautions.

1. Remove the batteries from the tray one at a time. If the tray is turned upside down, the batteries will come into contact with each other, forming discharge circuits.
2. Do not place batteries randomly in a parts box or other container. Discharge circuits will be formed by multiple batteries coming into contact numbers of the batteries, causing the batteries to discharge and drain.

○ Recommended procedures

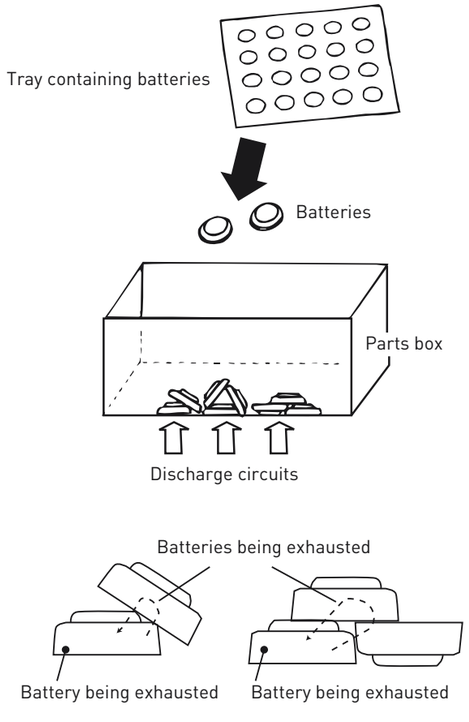
Utilize the tray lid in taking out batteries



Lay a tray lid flat and place a tray containing batteries on top of it: batteries are pushed up by protrusions of the lid tray so that they can be easily picked up with fingers.

× Prohibited procedures

Do not throw batteries randomly into a parts box by turning over trays containing batteries.



Contact of batteries with each other forms discharge circuits, thus the batteries are drained.

Memory Erasure Problems

Coin-type Lithium batteries are often used as the power supplies for memory back-up in various equipment. However problems with the erasure of valuable data in the memory due to improper contact between the batteries and equipment have been reported.

1. When batteries are to be used continuously for a prolonged period.

➜ Select tab terminal-mounted batteries, and solder the tabs to the battery connection terminals of the equipment. (See Fig. 1)

➜ When batteries need to be replaced, use a battery holder (see Fig. 2) or battery with lead wire connectors (see Fig. 3). Battery holders made by Panasonic (exclusively for the CR-2032 and BR-2032, see Fig. 2) are available for use.

2. When batteries need to be replaced in the short term, select batteries with no terminals or lead wire connectors.

➜ Use of Y-shaped terminals (2-point contact) for both the and poles as the shape of the connection terminals in the equipment helps to achieve a more stable contact. (See Fig. 4)

The contact pressure of the contacts should be no less than 2 to 10N (approx. 200 to 1000 gf). (See Fig. 5)

➜ To prevent momentary contact failure of several milliseconds in the circuit, the use of a tantalum capacitor, etc. with a capacitance of several microfarads is effective. (See Fig. 6)

➜ For the connection terminals of the equipment, use iron or stainless steel with nickel plating at the very least. Gold-plating is more suitable when the contact resistance must be reduced.

Note: Do not touch batteries with bare hands because perspiration (salt), body oil, etc. will increase the surface resistance which may lead to defective contact.

Reference samples see Fig. 1-6

Fig. 1 Soldering

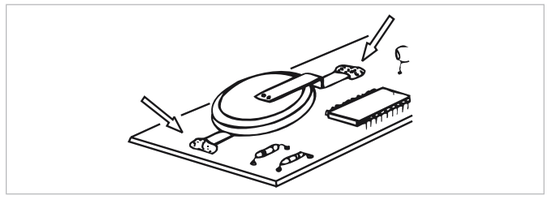


Fig. 2

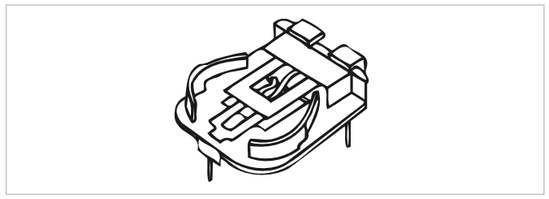


Fig. 3

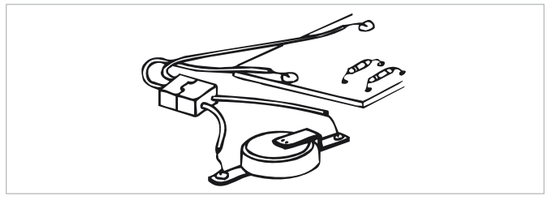


Fig. 4

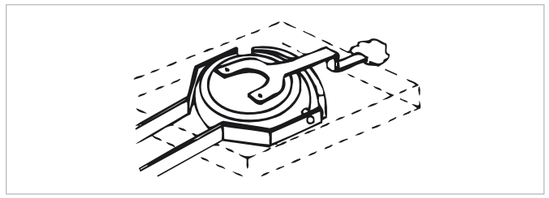


Fig. 5 Excessive load

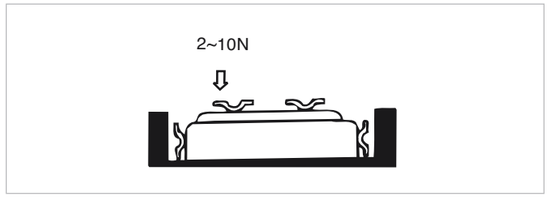
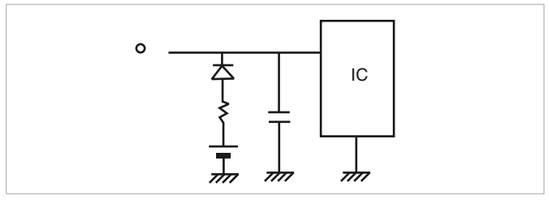


Fig. 6



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