Technical Note of Coin Manganese Dioxide Lithium Battery

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1. Principle, composition and structure of Coin Manganese Dioxide Lithium Battery

1.1 Principle of Coin Manganese Dioxide Lithium Battery

Manganese dioxide lithium battery uses manganese dioxide for the cathode electrode and lithium metal for the anode electrode, and the discharge function is exhibited by the chemical reaction (oxidation-reduction reaction) of both electrodes.

1.2 Composition of Coin Manganese Dioxide Lithium Battery

Manganese dioxide battery is composed of anode electrode (lithium metal), cathode electrode (manganese dioxide), electrolytic solution in which lithium salt is dissolved in an organic solvent, and a separator.

1.3 Structure Standard of Coin Manganese Dioxide Lithium Battery

The nominal voltage of battery is determined by the difference in reaction potential between cathode electrode active material and anode electrode active material. The theoretical electromotive force depends on the electrode active material, and this value can be calculated from the standard free energy change (⊿G0). The theoretical value of manganese dioxide lithium battery is as follows.

$$Li + Mn^{IV}O_2 \rightarrow Mn^{III}O_2(Li^{+})$$

Voltage = 3.50V, theoretical capacity = 3.50g / Ah (286Ah / kg)
(Referred Latest Battery Handbook 1996))

The battery capacity (mAh) is determined by the amount of anode electrode lithium metal that releases lithium ions and the amount of manganese dioxide that can receive lithium ions. Therefore, in order to generate large battery capacity (mAh), the point is how much lithium metal that releases a lot of lithium ions and manganese dioxide that stores lithium ions can be packed in a unit volume. In lithium manganese dioxide battery, there is electrolyte solution in which lithium ions are dissolved in organic solvent between the cathode electrode and the anode electrode as a “transport medium of lithium ions”. The electrolyte uses organic solvent with lithium salt dissolved. Oxidation and reduction reactions does not occur easily with organic solvents. (The potential window is wide) In addition, electrolytes that easily dissociate and have high conductivity are used.

In addition, material with a hole called separator is placed between the cathode and anode electrodes in order to prevent physical contact while keeping electrochemical reaction. If the thickness of the separator is thin, the distance between the cathode and anode electrodes will be shorter.また If the porosity of the separator is large, lithium ions can be transported, and the internal resistance between the cathode and anode electrodes will be low, so a high-power lithium manganese dioxide battery can be realized.

1.4 Materials for Coin Manganese Dioxide Lithium Battery

Murata Manganese Dioxide Lithium Battery consists of manganese dioxide with special treatment for the cathode electrode active material and high voltage / high activity lithium metal for the anode electrode active material. In addition, by selecting the most suitable electrolyte and separator to match them, the discharge voltage is about 3V, and the battery voltage is stable and the internal resistance is low.

Anode reactions : $Li \rightarrow Li^{+} + e^{-}$
Cathode reactions : $Mn^{IV}O_2 + Li^{+} + e^{-} \rightarrow Mn^{III}O2(Li^{+})$
All battery reactions : $Li + Mn^{IV}O_2 \rightarrow MnO_2(Li^{+})$

Total reaction formula of lithium manganese dioxide battery

Unlike capacitors, it discharges and stores lithium ions, so it has the characteristic of small self-discharge.

1.5 Structure of Coin Manganese Dioxide Lithium battery

Murata's lithium manganese dioxide batteries are coin type. The cathode electrode is made into pellet-shaped electrodes by kneading, rolling and denting special manganese dioxide. The anode electrode is made by rolling lithium metal. The created electrode is inserted into cathode electrode can (plus terminal can) and anode electrode can (minus terminal can), and a separator is interposed between the cathode electrode and the anode electrode to prevent short circuit due to physical contact between the electrodes.

Then, it is created by injecting the electrolyte into the element consisting of the electrode group and the case, and then sealing.

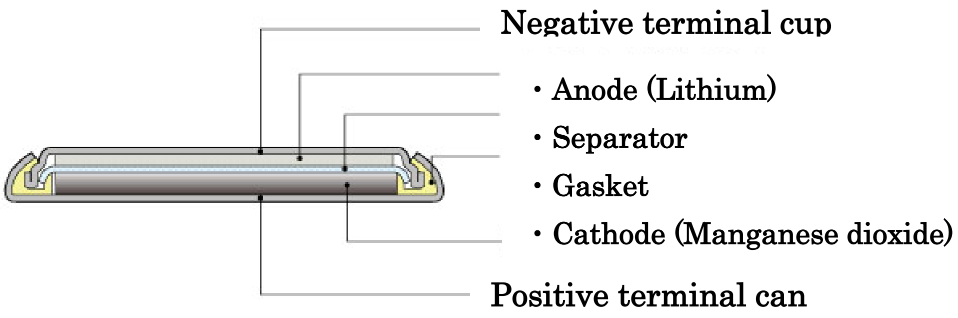


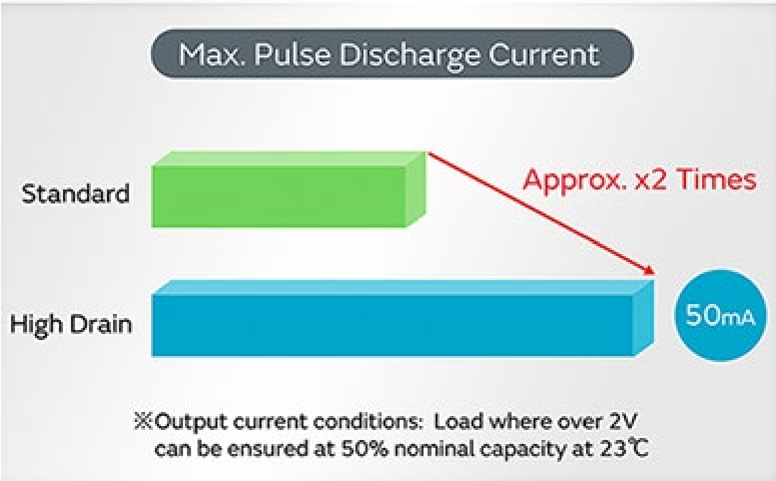
Fig.1 Cross-section structure of coin manganese dioxide lithium battery.

2. Characteristics and benefits of Murata Coin Manganese Dioxide Lithium battery

Murata's Coin manganese dioxide lithium batteries have products specialized for "high drained " and "heat resistance".

「For High drained((hereinafter, large current type)」

Murata's original technology lowered the internal resistance of the battery and enabled high-current pulse discharge. The high-current type has the maximum pulse discharge current *1 increased to 50mA, which is about twice that of conventional products.



※Output current condition: A load that can secure a voltage of 2 V or higher at 50% of the nominal capacity (under 23 ° C environment)

Fig.2 Standard product and high current type discharge current

The internal resistance of battery mainly depends on the contact resistance (contact between electrodes, contact between electrodes and cases) and material resistance (electrode active material, electrolyte, separator).

We have succeeded in reducing the internal resistance by 30% compared to the standard product by reviewing the contact resistance and selecting the material for the high drained type.

Since coin manganese dioxide lithium battery has large internal resistance, the voltage drop due to the high current causes the minimum drive voltage of the device to drop, and the problem is that the device does not operate even if the battery capacity is sufficient. High drained type reduces the voltage drop by lowering the internal resistance, and can ensure stable operation stability even with LPWA communication devices (LoRa, Sigfox, etc.) and RKE that requires peak current of 30 mA or more.

*1Maximum current value that can be pulse-discharged (3 seconds) with voltage of 2 V or higher under 23 ° C environment with 50% of the nominal capacity discharged.

「For heat resistance (hereinafter heat resistant type)」

The following lineups are available depending on the operating temperature range. -40 to + 125 ℃: Heat resistant type (W series)

-40 to + 85 ° C: Semi-heat resistant type (X series)

Heat resistant type (W series)

This product is ideal for devices used in harsh environments such as in-vehicle equipment.

When standard type of coin manganese dioxide lithium battery is exposed to high temperature environment (+ 70 ° C or higher), the electrolyte volatilizes and the internal pressure of the battery rises. When the internal pressure of the battery rises, the internal resistance of the battery rises and the battery capacity decreases. The battery swells due to the increase in internal pressure as well. In the worst case, lithium manganese dioxide batteries can burst.

In response to these problems, we adopted electrolytic solutions that is difficult to volatilize and proprietary sealing technology to prevent the internal pressure of the battery from rising. We have succeeded in streng Temperature characteristics battery, suppressing the swelling of the battery at high temperatures, suppressing the deterioration of the battery, and preventing the battery from bursting.

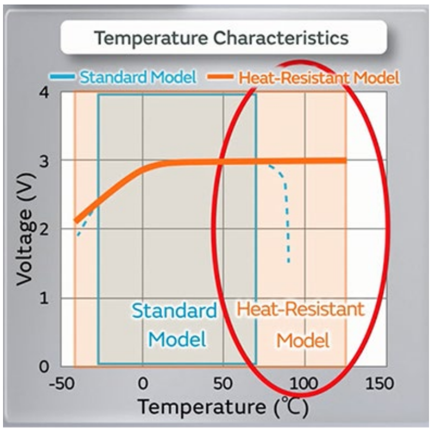


Fig 3 Temperature characteristics of standard model and heat resistant model

The semi-heat resistant type is product that covers the upper temperature limit up to + 85 ° C and realizes lower cost than the heat resistant type (W series).

Fig 4 Comparison of voltage between standard model and extended temperature model after storage at 85 ℃.

The standard type had upper limit temperature of + 70 ° C, so when used above + 70 ° C, W type is chosen, resulting in excessive quality and increased costs.

It is suitable for RTC applications of in-vehicle accessories (drive counter, ETC reader) and industrial equipment (smart meter, FA equipment) used in high temperature environment.

3 Murata Coin Manganese Dioxide Lithium Battery Lineup

Murata Manufacturing has four types of coin manganese dioxide lithium batteries (standard type, heat resistant type, semi-heat resistant type, high drain type).

3.1 Standard type

品名 Model	電気特性 Electrical characteristic					寸法 Dimensions		質量 Mass (g)
	公称電圧 Nominal Voltage (V)	*公称容量 Nominal Capacity (mAh)	標準放電電流 Standard Discharge Current (mA)	最大パルス放電電流 Maximum Pulse Discharge Current (mA)	使用温度範囲 Operating Temeprature Range (℃)	直径 Diameter (mm)	高さ Height (mm)	
CR1216	3	30	0.1	10	-30～70	12.5	1.6	0.7
CR1220	3	40	0.1	10	-30～70	12.5	2.0	0.8
CR1616	3	60	0.1	15	-30～70	16	1.6	1.1
CR1620	3	80	0.1	15	-30～70	16	2.0	1.2
CR1632	3	140	0.1	15	-30～70	16	3.2	1.9
CR2016	3	90	0.1	20	-30～70	20	1.6	1.8
CR2025	3	160	0.2	20	-30～70	20	2.5	2.6
CR2032	3	220	0.2	20	-30～70	20	3.2	3.1
CR2430	3	300	0.2	20	-30～70	24	3.0	4.4
CR2450	3	610	0.4	20	-30～70	24	5.0	6.5
CR2477	3	1000	0.4	20	-30～70	24	7.7	10

＊The maximum pulse discharge current is the maximum current that can be discharged

under the following conditions.
(DOD: 50%, 23 ℃, pulse width: 2 seconds, cut-off voltage: 2V)

＊Nominal capacity is the capacity when discharged at standard discharge current up to 2.0V at 23 ℃.

＊Tabs and tubes are also available. Please refer to our web page for details
Applications:
Consumer equipment (calculator, electronic notebook, RTC backup)
In-vehicle (remote keyless entry (RKE, Keyfob))

3.2 High Drain type

品名 Model	電気特性 Electrical characteristic					寸法 Dimensions		質量 Mass (g)
	公称電圧 Nominal Voltage (V)	*公称容量 Nominal Capacity (mAh)	標準放電電流 Standard Discharge Current (mA)	最大パルス放電電流 Maximum Pulse Discharge Current (mA)	使用温度範囲 Operating Temeprature Range (℃)	直径 Diameter (mm)	高さ Height (mm)	
CR2032R	3	200	3	50	-30～70	20	3.2	3.0
CR2450R	3	500	3	50	-30～70	20	5.0	6.2

＊Nominal capacity is the capacity when discharged at standard discharge current up to 2.0V at 23 ℃.
＊The maximum pulse discharge current is the maximum current that can be discharged under the following conditions.
(DOD: 50%, 23 ℃, pulse width: 2 seconds, cut-off voltage: 2V)
＊Tabs and tubes are also available. Please refer to our web page for details

Applications:
In-vehicle equipment, IoT equipment (high load communication (instantaneous pulse discharge less than 50mA))
Remote keyless entry (RKE, Keyfob))
IoT devices (tracking device, sensor node)

3.3 Heat resistance Type

品名 Model	電気特性 Electrical characteristic					寸法 Dimensions		質量 Mass (g)
	公称電圧 Nominal Voltage (V)	*公称容量 Nominal Capacity (mAh)	標準放電電流 Standard Discharge Current (mA)	最大パルス放電電流 Maximum Pulse Discharge Current (mA)	使用温度範囲 Operating Temeprature Range (℃)	直径 Diameter (mm)	高さ Height (mm)	
CR2032X	3	220	1	30	-40～85	20	3.2	3.0
CR2450X	3	600	1	30	-40～85	24	5.0	6.2
CR2477X	3	1000	1	30	-40～85	24	7.7	9.5

＊Nominal capacity is the capacity when discharged up to 2.0V at standard discharge current at 23 ℃.

＊The maximum pulse discharge current is the maximum current that can be discharged under the following conditions.

(DOD: 50%, 23 ℃, pulse width: 2 seconds, cut-off voltage: 2V)

＊Tabs and tubes are also available. Please refer to our web page for details.

Applications:

In-vehicle equipment（Tire Pressure Monitoring System(TPMS)））

3.4 Extended temperature Type

品名 Model	電気特性 Electrical characteristic					寸法 Dimensions		質量 Mass (g)
	公称電圧 Nominal Voltage (V)	*公称容量 Nominal Capacity (mAh)	標準放電電流 Standard Discharge Current (mA)	最大パルス放電電流 Maximum Pulse Discharge Current (mA)	使用温度範囲 Operating Temeprature Range (℃)	直径 Diameter (mm)	高さ Height (mm)	
CR2032W	3	210	1	30	-40～125	20	3.2	3.1
CR2050W	3	345	1	30	-40～125	20	5.0	4.2
CR2450W	3	550	1	30	-40～125	24	5.0	6.7
CR2477W	3	1000	1	30	-40～125	24	7.7	11

＊Nominal capacity is the capacity when discharged at standard discharge current up to 2.0V at 23 ℃.

＊The maximum pulse discharge current is the maximum current that can be discharged under the following conditions.

(DOD: 50%, 23 ℃, pulse width: 2 seconds, cut-off voltage: 2V)

＊Tabs and tubes are also available. Please refer to our web page for details.

Applications
In-vehicle accessory equipment (drive counter, ETC reader)
IoT devices (RTC applications for smart meters), FA devices (RTC applications), etc.

4 Comparison with other batteries (merits and demerits of other batteries)

4.1 Comparison with Alkaline Manganese Battery ・Alkaline Battery

4.1.1 High Energy Density

The voltage, capacity, and volume energy density of coin alkaline manganese batteries / alkaline batteries (coin alkaline manganese batteries (abbreviation: LR), silver oxide batteries (abbreviation: SR)) and coin manganese dioxide lithium batteries (abbreviation: CR), respectively are summarized in Table 1.

Type	V	mAh	wh/I
Coin Alkaline manganese batteries	1.5	4~150	60
Alkaline manganese batteries AA, AAA	15	850, 2000	
Coin manganese dioxide lithium batteries	3	30 ~ 2000	400

Table 1 Summary of voltage, capacity and energy density of various batteries

Coin manganese dioxide lithium batteries has higher withstand voltage and higher energy density than alkaline batteries and coin alkaline manganese batteries because the potential range between the anode and cathode electrodes are widened by using lithium metal for the anode electrode. (Refer to the table 1)

As shown in Fig. 5, coin manganese dioxide lithium batteries are rich in types and has wide lineup of 30 to 2000 mAh.

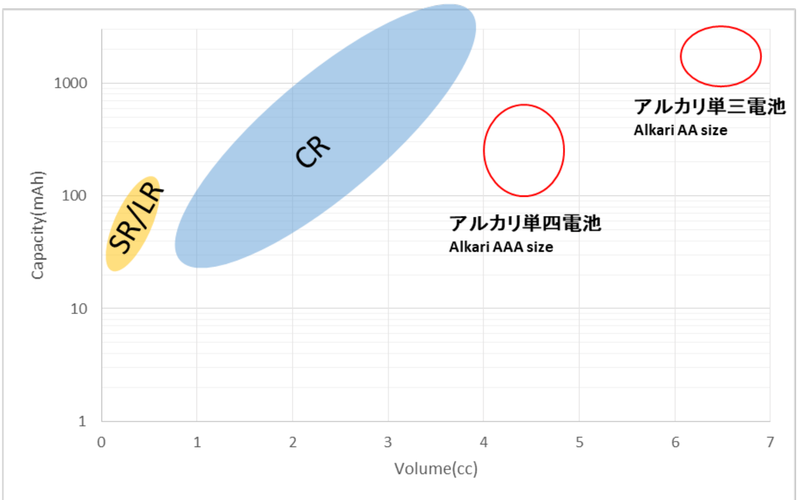


Fig.5 Relationship between size and capacity of various batteries

4.1.2 Low self-discharge (low deterioration)

Coin alkaline manganese batteries and coin manganese dioxide lithium batteries will cause the following phenomena if they are left for a long time.

In coin alkaline manganese batteries, zinc in anode electrode forms zinc oxide by causing chemical reaction with oxygen dissolved in the electrolyte or small amount of oxygen generated on the cathode electrode. This causes degradation. (Capacity decreases and internal resistance increases. Deterioration is proportional to temperature, and if it exceeds the normal temperature, it will deteriorate at an accelerated rate.

・In coin manganese dioxide lithium battery, oxygen contained in the electrolytic solution inside the battery does not chemically react with anode electrode, so it does not cause deterioration at normal temperature. However, water in the air penetrates from the encapsulant and causes electrolysis of the water, so if they are left under high humidity environment, the capacity will deteriorate. Under high temperature (more than 60 ℃) and high humidity environment, deterioration occurs due to the effect of volatilization of the electrolyte, so if the humidity is low and it is in a normal temperature environment ,deterioration does not occur. Compared to other batteries, CR (Coin manganese dioxide lithium batteries) is characterized by long-term storage. Figure 6 shows the self-discharge (capacity loss rate / year) by temperature of coin manganese dioxide lithium battery (CR) and silver oxide battery (SR).

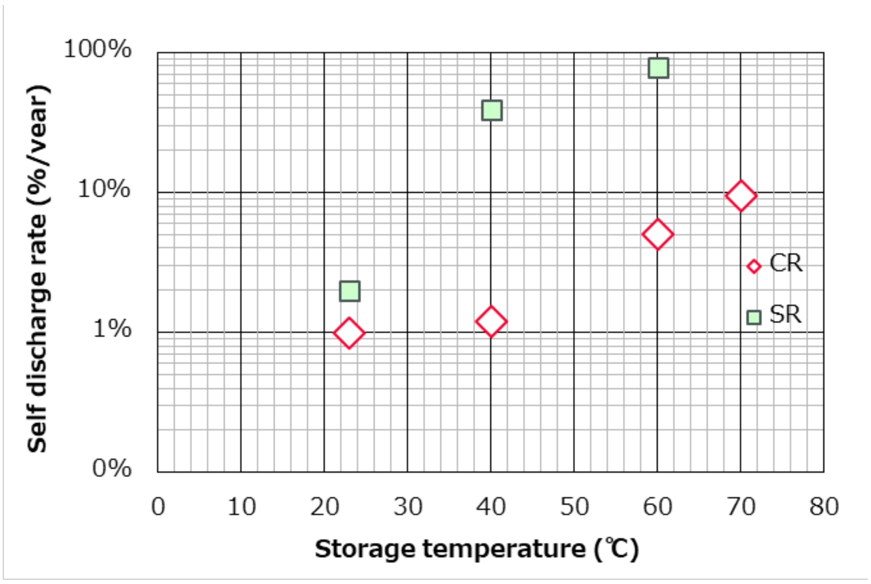


Fig.6 Self discharge by temperature of CR and SR (capacity loss rate / year)

5 Battery characteristics of Murata Manufacturing Co., Ltd.

5.1. Battery characteristics

The battery characteristics of each CR2032 series are summarized.
Fig.7 Discharge temperature characteristics, Fig.8 Continuous pulse characteristics, Fig.9 Closing voltage characteristics, Fig.10 Internal resistance, Fig.11 Capacity loss rate after storage. (they are reference data values)

5.1.1 Discharge temperature characteristics

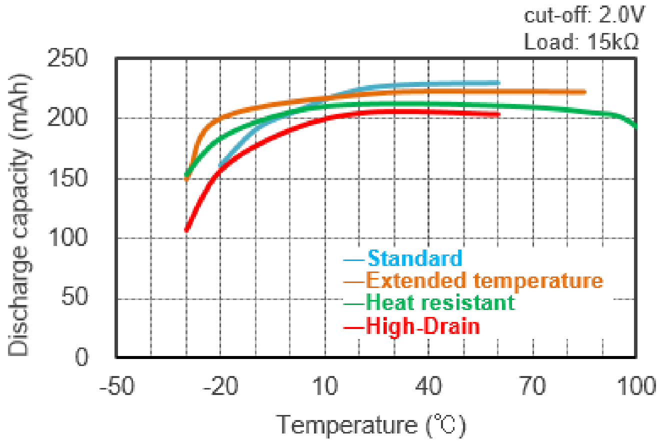


Fig.7 Discharge temperature characteristics

5.1.2 Continuous pulse characteristics

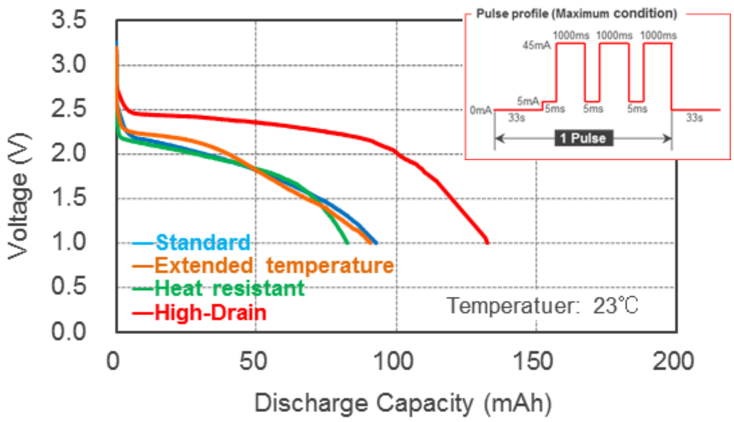


Fig.8 Continuous pulse characteristics

5.1.3 Circuit voltage characteristics

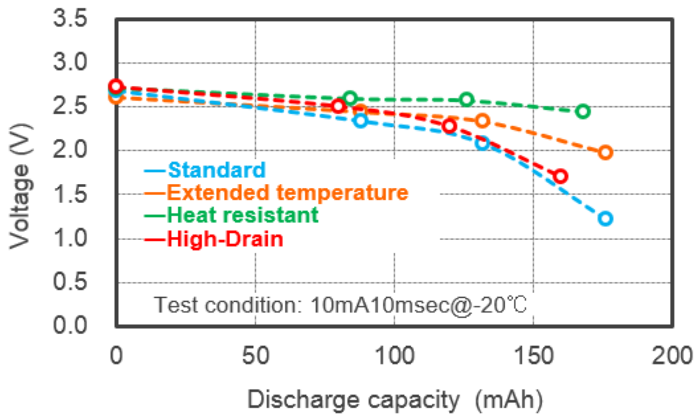


Fig.9 Closing voltage characteristics

5.1.4 Internal resistance

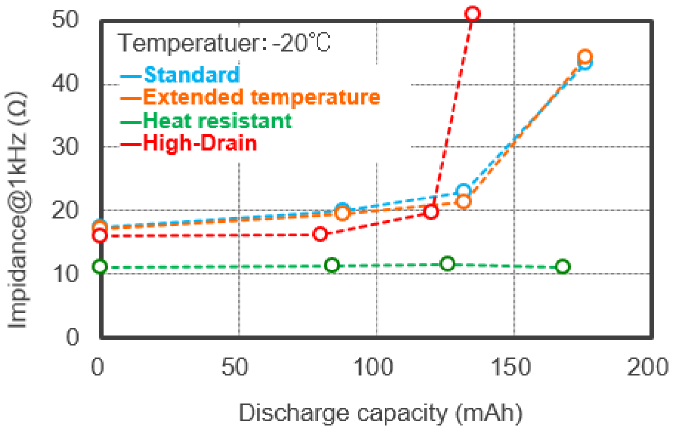


Fig.10 Internal resistance

5.1.5 Capacity loss rate after storage

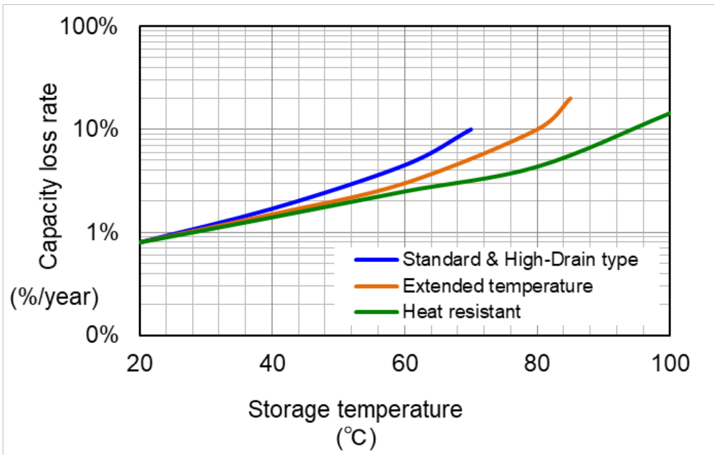


Fig.11 Capacity loss rate after storage at each temperature (% / year)

For other data, please refer to the data sheet or contact us.
https://www.murata.com/ja-jp/products/batteries/micro/cr

6. Battery usage rate

The utilization rate of coin manganese dioxide lithium battery with respect to the theoretical capacity depends on the ambient temperature and the discharge current

6-1 Relationship between discharge current and battery utilization

Coin manganese dioxide lithium battery has its own internal resistance. The internal resistance of the battery depends on the battery size and type. Generally, when high drain (more than 10 mA) is discharged from battery, the voltage drop becomes large as shown in Fig.12. Even if the battery capacity is sufficient, the voltage drop may cause the minimum drive voltage of the device to drop and the device may become inoperable. This voltage drop must be taken into account when discharging batteries with high drain.

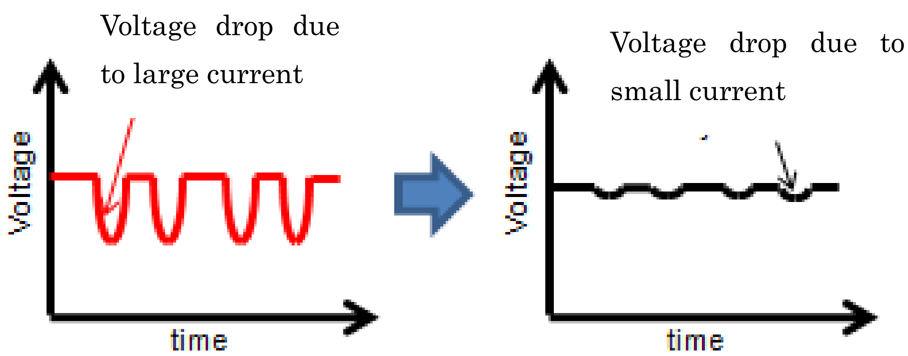


Fig.12 Image of battery voltage drop at high current and voltage drop at low current

6-2 Relationship between ambient temperature and battery utilization

Generally, when using coin manganese dioxide lithium battery at high temperature (70 ℃ or higher) or low temperature (0 ℃ or lower), the following phenomena occur.

○Battery behavior under high temperature (70 ℃) environment

・The internal resistance of the battery decreases as the viscosity of the electrolyte inside the battery decreases. Therefore, the voltage drop of the battery at 70℃ is smaller than that at normal temperature.

・Battery deterioration (increased internal resistance and decreased capacity) will occur. For details, please refer to 2. Characteristics and Benefits of Murata Battery

○Battery behavior under low temperature (0 ℃) environment

・As the viscosity of the electrolyte inside the battery increases, the internal resistance of the battery increases. Therefore, the voltage drop of the battery at 0℃ is larger than that at normal temperature.

・Battery deterioration (increased internal resistance and decreased capacity) is less likely to occur. For details, please refer to 2. Features and Benefits of Murata Battery.

6.3 Battery usage ratio in case of constant current discharge and 6.4 Battery usage ratio in case of pulse discharge are summarized as below.

6.3 In case of constant current discharge

The usage rate calculation of coin manganese dioxide lithium battery under constant current conditions is as follows. The amount of charge (Q) required for the load is calculated by the Coulomb formula below.

$Q = I \times T$ ・・・(1)

Q: Charge（C）, I: Average current（A）, T: Time（sec）

On the other hand, the charge (Q) of the battery can be calculated by the following formula.

$Q = C \times 3600$ ・・・(2)

C: Capacity of battery（mAh）

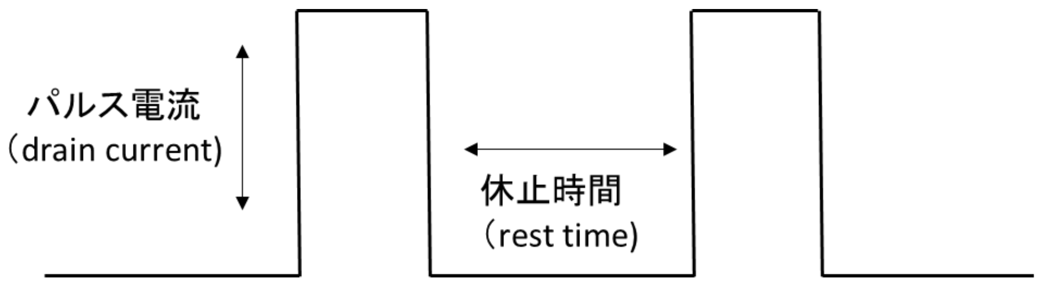
From figures of (1) and (2), the battery utilization rate is calculated by the following formula.

T=C×3600÷I・・・(3)

However, (3) is a calculation formula assuming an ideal battery. Deterioration due to internal resistance and temperature specific to the battery (see 6-1 Relationship between discharge current and battery utilization rate and 6-2 Relationship between ambient temperature and battery utilization rate) is not taken into consideration. Please refer to 5.1.1 to 5.1.5 and carefully consider the effects when designing.

6.4 In case of pulse discharge

The battery utilization rate by pulse discharge depends on the ambient temperature, discharge current, and pulse discharge interval (pause time).



A voltage drop occurs due to the influence of the internal resistance of the battery and the discharge current. (Refer to 6-1 Relationship between discharge current and battery utilization, 6-2 Relationship between ambient temperature and battery utilization)
Also, since the internal resistance of the battery increases at low temperatures, if the current value of the discharge current is large, the voltage drop will be large and the drive voltage of the equipment may not be output. Care must be taken when using in low temperature environment. Below is a summary of pulse discharge battery utilization rates.

○Battery utilization of pulse discharge

See the figure below for the battery utilization rate in pulse discharge.
It is the relation between the current value of pulse discharge at normal temperature (25 ℃) and the battery utilization rate during the rest time.
(It is not a guaranteed value but a reference value.)

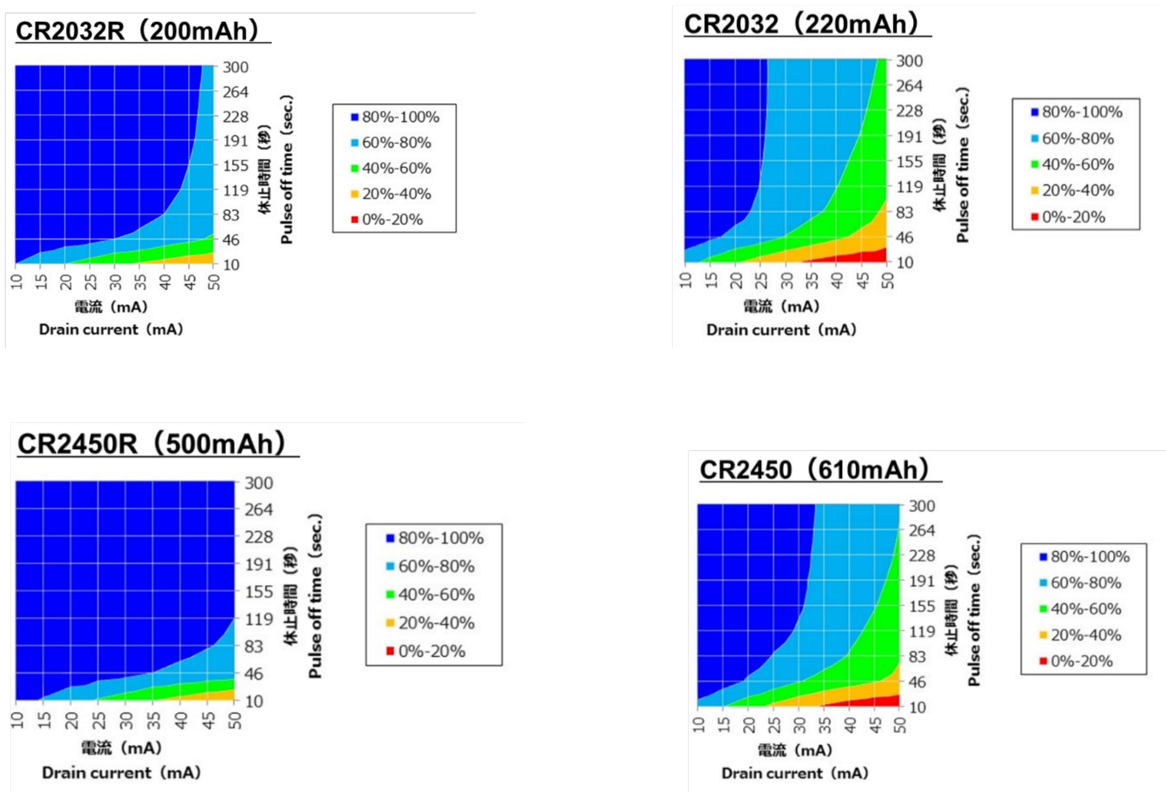


Fig.13 Battery utilization of pulse discharge

If you use a battery at a low temperature, the voltage drop may increase due to the inherent internal resistance, and it may not be possible to reach the lowest limit voltage of the device. In addition, the device's leakage current may reduce the battery utilization rate.

7. Safeness

7.1 Safeness test（According to IEC-60086-4）

Table 2 summarizes the IEC60086-4 safety test items.

Table.2 Safety test items of CR

Test item F (Impact), L (Incorrect installation) and M (Over discharge) are for secondary batteries. Primary batteries (CR) are excluded.

Test Item	Test Condition	Temperature	n
Altitude (Test A)	Stored at a pressure of 11.6kPa or less for at least 6 h.	20±5℃	Each 10 (Fully discharged, Undischarged)
Thermal cycling (Test B)	The test shall be conducted using the test cells previously subjected to the Altitude test. 72℃6h←→-40℃6h 10 times repeated. Interval between test temp. is max. 30 min.	72℃6h ↓ (within 30min.) -40℃6h	Each 10 (Fully discharged, Undischarged)
Vibration (Test C)	The test shall be conducted using the test cells previously subjected to the Thermal cycling test. Duration of Logarithmic Sweep Cycle 7Hz →200H→7Hz 15min. (1 cycle) Axis: X, Y, Z each 12 cycles Total 36cycles Each direction : 3h Total 9h	20±5℃	Each 10 (Fully discharged, Undischarged)
Shock (Test D)	The test shall be conducted using the test cells previously subjected to the Vibration test. Wave form : Half sine Peak acceleration : 150gn Pulse duration : 6ms Number of shocks per half axis : 3 Each test cell shall be subjected to 3 shocks in each direction of three mutually perpendicular mounting positions of the cell for a total 18 shocks.	20±5℃	Each 10 (Fully discharged, Undischarged)
External short-circuit (Test E)	The test shall be conducted using the test cells previously subjected to the Shock test. The test cell shall be stabilized at an external case temperature of 55 °C and then subjected to a short-circuit condition with a total external resistance of less than 0,1 Ω at 55 °C. This short-circuit condition is continued for at least 1 h after the cell of external case temperature has returned to 55℃. The test sample shall be observed for a further 6 h.	55±2℃	Each 10 (Fully discharged, Undischarged)
Impact (Test F)	This test is not applicable to Coin shaped battery. Round stick with 7.9mm diameter is placed across on the center of battery on the flat plate. Drop 9.1kg weight on the battery from 61cm height.	20±5℃	N/A
Crush (Test G)	Each test cell is to be subjected to one crush only. 1) The applied force reaches 13 kN ± 0,78 kN; EXAMPLE: The force can be applied by a hydraulic ram with a 32 mm diameter piston until a pressure of 17 MPa is reached on the hydraulic ram. 2) The voltage of the cell drops by at least 100 mV; or 3) The cell is deformed by 50 % or more of its original thickness. As soon as one of the above conditions has been obtained , the pressure shall be released. A prismatic or flexible cell shall be crushed by applying the force to the side with the largest surface area. A coin cell shall be crushed by applying the force on its flat surfaces.	20±5℃	Each 5 (Fully discharged, Undischarged)
Forced discharge (Test H)	This test shall be conducted with fully discharged test cells that have not previously been subjected to other tests. Each cell shall be force discharged at ambient temperature by connecting it in series with a 12 V direct current power supply at an initial current equal to the maximum continuous discharge current specified by the manufacturer. The specified discharge current is obtained by connecting a resistive load of appropriate size and rating in series with the test cell and the direct current power supply. Each cell shall be force discharged for a time interval equal to its rated capacity divided by the initial test current.	20±5℃	10 (Fully discharged)
Abnormal charging (Test I)	Each test cell shall be subjected to a charging current of three times charging current Ic specified by the battery manufacturer by connecting it in opposition to a d.c. power supply for setting the current, the specified charging current shall be obtained by Unless the power supply allows connecting a resistor of the appropriate size and rating in series with the battery. The test duration shall be calculated using the formula: td = 2,5 × Cn / (3 × Ic) where d is the test duration. In order to expedite the test, where tit is permitted to adjust the test parameters such that td does not exceed 7 days; Cn is the nominal capacity; Ic is the abnormal charging current Ic specified by the battery manufacturer by connecting it.	20±5℃	5 (Undischarged)
Free Fall (Test J)	The test shall be conducted with undischarged test cells. The test cell shall be dropped from a height of 1m onto a concrete face. Each test cell shall be dropped six times, a prismatic battery once from each of its six faces, round battery twice in each of the three axes.	20±5℃	5 (Undischarged)
Thermal abuse (Test K)	A test cell shall be placed in an oven and the temperature raised at a rate of 5 °C/min to a temperature of 130 °C at which the battery shall remain for 10min.	5℃/min to 130℃	5 (Undischarged)
Incorrect installation (Test L)	A test cell is connected in series with three undischarged additional single cell batteries of the same brand an type in such a way that the terminals of the test battery are connected in reverse. The resistance of the interconnecting circuit shall be no greater than 0.1Ω. The circuit shall be completed for 24h or until the battery case temperature has returned to ambient.	20±5℃	N/A
Over discharge (Test M)	Each test cell shall be predischarged to 50 % depth of discharge. It shall then be connected in series with three undischarged additional single cell batteries of the same type. A specified resistive load R1 is connected in series. (Ex. CR123A/CR2:8.2Ω) The test shall be continued for 24 h or until the battery case temperature has returned to ambient. The test shall be repeated with 75% predischarged test cells.	20±5℃	N/A

8. Usage precautions

8.1 Storage conditions

Proper storage temperature is +5℃~+35℃.

Proper storage humidity is 45～85%RH

8.2 Handling Precautions

This CR Batteries contain flammable materials, such as lithium and organic solvent. Improper battery handling may cause leakage, overheating, explosion or ignition of batteries, which may lead to injury or product failure.

◎Danger

・Keep batteries away from children. Swallowing a battery can cause chemical burn or penetration of the mucous membrane tissue, in the worst case, may result in death. If infant happens to swallow a battery, seek medical attention immediately to take it out.

◎Warning

- Do not charge this battery. When charged, the electrolyte in the battery is heated and the internal pressure rises due to the generation of gas, which may cause the battery to leak, heat, burst, or catch fire.
- Do not put the battery in a fire, heat or disassemble. It may damage the insulations and it causes leakage, overheat, explode, or catch fire。
- Do not use the battery (+) and (-) in opposite. An abnormal reaction may occur due to charging or short circuit, causing the battery leakage, overheat, explode, or catch fire.
- If the electrolyte gets into your eyes, it may harm your eyes. Wash your eyes with clean water such as tap water without rubbing, and then consult a doctor immediately
- If you lick the electrolyte by mistake, gargle immediately and consult a doctor.
- Do not connect (+) (-) of the battery with wires, and do not carry or store it with a metal necklace or hairpin. The battery may become short-circuited, excessive current may flow, and the battery may leak, overheat, explode, or catch fire.
- If the battery has leakage or strange smell, the leaked electrolyte may catch fire, so keep it away from fire immediately.

- Do not solder directly to the battery. The heat may damage the insulation, causing the battery leakage, overheat, explode, or catch fire.

- When storing or disposing of this battery, insulate the terminals with tapes. Mixing the battery with other batteries or metal objects may cause short circuit in the battery, resulting in leakage, overheating, rupture or ignition.

- Do not mix used batteries, old batteries, or different brands or types of batteries with new batteries. Due to the difference in characteristics, the battery may leak, overheat, explode, or catch fire.

- Do not attach the battery to the skin with cellophane tape. It may cause skin damage.

@ Precautions

・Do not drop, apply strong force to nor deform batteries. Leakage, heating, explosion or ignition may result.

・Do not store, use nor leave batteries at high-temperatures or high-humidity such as inside of cars in the sun. Avoid exposure to direct sunlight to prevent leakage, heating, explosion or ignition.

・Do not wet batteries with water. This may cause ignition of batteries.

・Depending on types of devices, batteries positive (+) and negative (–) terminals may contact with metallic part at entrance of battery compartments. Insert batteries into devices in the way not to cause short-circuit.

・Depending on types of devices, batteries may not be suitable for use on certain specification or performance. Use suitable batteries correctly on devices in accordance with devices' instruction manuals and handling precautions.

・Do not store nor use batteries in high temperature and high humidity location and where batteries are exposed to direct sunlight. Storage in high temperature and high humidity location may cause leakage, heating, explosion or ignition and in some cases, batteries' performance and life may be deteriorated.

・When abnormality such as heating or deformation is found on batteries during use or storage, stop using the batteries. This may cause leakage, heating and explosion.

・This battery is supposed to be discarded as general non-burnable waste. If there are local regulations, please dispose of them according to those regulations.

・Be sure to provide an appropriate fail-safe function on your product to prevent a second damage that may be caused by the abnormal function or the failure of our product.

・Please contact us before using our products for the applications listed below which require especially high reliability for the prevention of defects which might directly cause damage to human life or property.
①Aircraft equipment, ②Aerospace equipment, ③Undersea equipment
④Power plant control equipment, ⑤Medical equipment
⑥Transportation equipment(vehicles, trains, ships, etc.)
⑦Traffic signal equipment ⑧Disaster prevention / crime prevention equipment
⑨Data-processing equipment
⑩Application of similar complexity and/or reliability requirements to the applications listed in the above.

8.3 Precautions in Designing

To use batteries efficiently, observe the following precautions.

・Do not solder batteries directly. Excessive heating may cause deformation of batteries and components such as gaskets, which may lead to swelling, leakage, explosion or ignition of batteries.

・Observe soldering conditions for tabbed batteries to be specified by manufacturers. Use tabbed batteries if soldering is required. Excessive heating may cause deformation of gaskets, leakages or performance deterioration of batteries. Be sure not to allow battery temperature to exceed guaranteed temperature during soldering.

・Use nickel-plated iron or stainless steel for the terminals that contact batteries.

・Make sure that terminal contact pressure is 100gf minimum for stable contact.

・Keep batteries and contact terminal surfaces clean and free from moisture and foreign matter.

・Before inserting batteries, check batteries' contact terminals if they are normal, not bent or damaged. Bent terminals may not make good contact with batteries or may cause short-circuit.

・Do not force discharge the battery by external discharge. If the voltage becomes 0 V or less. It may lead to reversed polarity and gas generate. It may cause ignition, heating, leakage or explosion.

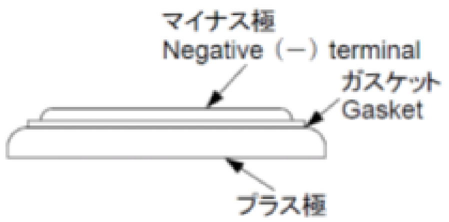
・Design equipment so that infants cannot easily remove batteries and swallow them.

・Consult sales representatives, when series or parallel connection of several batteries is required.

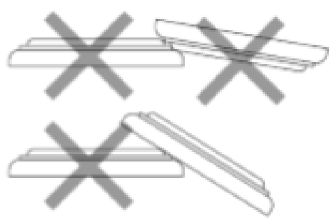
8.4 Precautions for Mounting

Unlike other electronic components, Coin CR Batteries may be externally short-circuited before and after they are installed in circuit boards and without the power being turned on. This causes power drainage. As a result, batteries may lose their capacity before the equipment are even used. As short-circuits tend to occur in the following cases, please take care when handling batteries.

・Overlapping Batteries
Coin Manganese Dioxide Lithium Batteries are shaped as shown below. They have exposed positive (+) and negative (–) metallic surfaces with a thin cylindrical seal, called the gasket, in between them. When batteries are overlapped or mixed together in a disorderly way, their positive (+) and negative (–) terminals touch each other and may result in short-circuit.



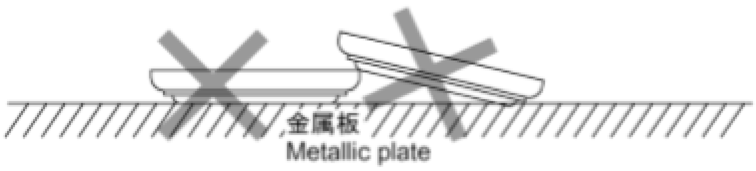
【Battery shape of Coin Manganese Dioxide Lithium Battery】



【Battery overlap】

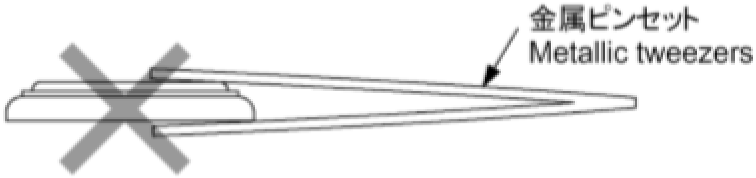
・Batteries in Metallic Container or on Metallic Plate

Similar to the overlapping battery problem, when batteries are put in a metallic container or on a metallic plate, their positive (+) and negative (–) terminals may short-circuit through the conductive surface, depending on how the batteries are positioned.



・When Held with Metallic Tweezers

When held with a pair of metallic tweezers as shown, batteries may short-circuit through the tweezers.



・Short-circuits through Piled Circuit Boards

When circuit boards with batteries are piled on top of one another, their conductive traces may touch and form a battery discharge circuit that consumes batteries' power.

・Discharge through Conductive Electrostatic Prevention Mats

Conductive mats are widely used to prevent static electricity from destroying semiconductors. If a circuit board with mounted battery is put on a conductive mat, the soldered conductors may touch the mat, providing a discharge path for batteries.

・Battery Handling by Naked Hand

If batteries are touched by naked hand, surface resistance may be increased due to sweat or sebum; contact performance may be deteriorated.

・Improper Battery Mounting Polarity

When batteries' positive (+) and negative (–) terminals are reversed with respect to the battery mounting's polarity marks, batteries may be discharged, depending on the type of electric circuit.

・Conductive Materials to prevent Static Electricity

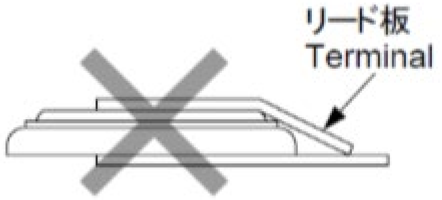
Various protective materials are used to prevent static electricity. Most of these protective materials consist of particular combination of carbon, aluminum and other materials; it makes conductive performance effective. If both battery's positive (+) and negative (–) terminals touch these protective materials at the same time, batteries may discharge.

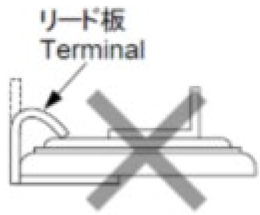
・Electrical characteristics after short-circuit

Coin Manganese Dioxide Lithium Batteries may require considerable time to regain its normal voltage even after a slight short-circuit.
When batteries are short-circuited, wait an adequate time for batteries to recover before measuring electrical characteristics. Use a high impedance (1MΩ or higher) voltmeter to measure battery voltage.

・When Batteries Lead Plates Touch Each Other

When batteries lead plates bend and touch each other or either terminal, batteries may short-circuit.





・Solder Bridges

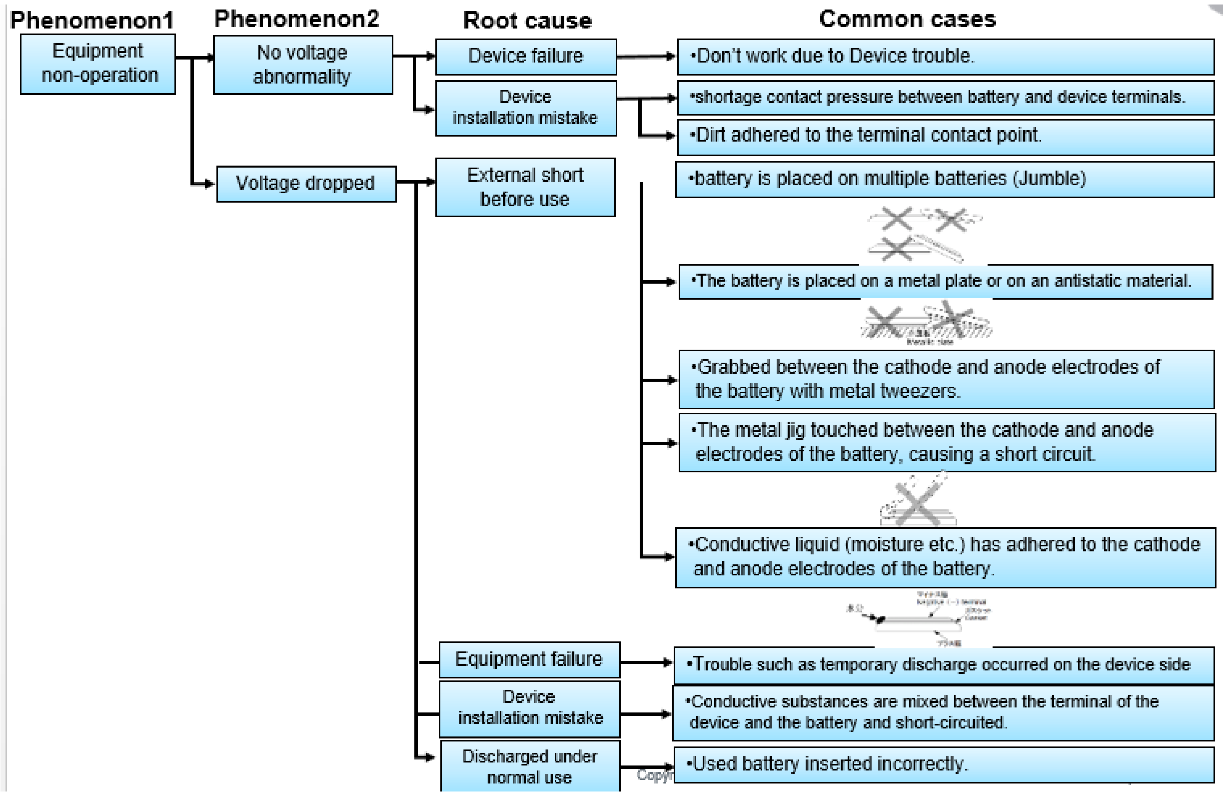
Solder may bridge between circuit board conductors, causing short-circuits and draining batteries.

・Short-circuits through Soldering Irons

Similar to solder bridging, when circuit board wiring is short-circuited by a soldering iron for an extended period, batteries may be drained and consumed.
Complete manual soldering within 5 seconds.

Typical failure modes of CR battery for the above contents are summarized in Fig.14.

Fig 14: Typical Failure Tree of CR batteries



8.5 Mounting Conditions

Heating by manual soldering
Soldering iron temperature：380±10℃
Heating time：3～4sec.
＊When soldering in the automatic solder dip bath, set the temperature environment and time so that the temperature of the battery does not exceed the operating temperature range of the battery, including preheating, dipping in the solder bath and residual heat after dipping.

Flow soldering conditions

Soldering temperature：260±3℃
Heating time：5sec. or less

8.6 Other Precautions

Precautions when designing a backup circuit（RTC・memory protection ）

A primary lithium battery is not rechargeable.　When using in a backup circuit, be sure to use a reverse current prevention diode and a protection resistor to control the charging of the manganese dioxide lithium battery from the main power supply. However, the diode leakage current charged the battery slightly. Thus, select a diode and design the circuit so that the amount of charging due to leakage current does not exceed 2% of the nominal battery capacity over the total period of use.

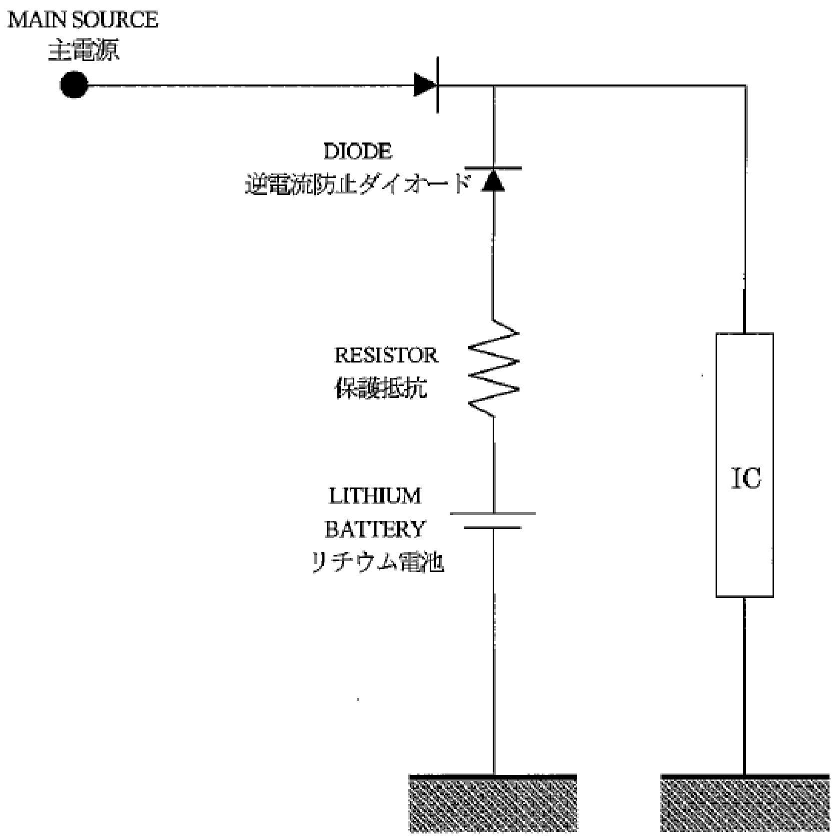


Fig.15 Recommendable circuit of backup

Maximum charging current CR batteries

Standard Type		Heat-resistant type		Extended temperature type		High-Drained Type	
Model	Maximum charging current	Model	Maximum charging current	Model	Maximum charging current	Model	Maximum charging current
CR1216	3.5mA	CR2032W	10mA	CR2032X	10mA	CR2032R	10mA
CR1220	10mA	CR2050W	10mA	CR2450X	15mA	CR2450R	15mA
CR1616	4mA	CR2450W	15mA	CR2477X	10mA		
CR1620	2.5mA	CR2450W	15mA	CR3677X	10mA		
CR1632	4mA	CR2477W	10mA				
CR2016	10mA						

CR2025	5mA						
CR2032	10mA						
CR2430	15mA						
CR2450	20mA						
CR2477	10mA						

8.7 Packing

The packing forms for bulk cell products and tab products are shown below.

Table.4 Bulk CR cell

Type	Model name	Package (Ship mode)	Master Carton QTY (pcs)	Size L master carton (mm)	Size H master carton (mm)	Size W master carton (mm)
Standard	CR1216	Air & Boat	2000	342	150	183
	CR1220	Air & Boat	2000	342	150	183
	CR1616	Air & Boat	1200	342	150	183
	CR1620	Air & Boat	1200	342	150	183
	CR1632	Air & Boat	1200	342	150	183
	CR2016	Air & Boat	1200	342	150	183
	CR2025	Air & Boat	700	342	150	183
		Boat	1400	342	150	183
	CR2032	Air & Boat	700	342	150	183
		Boat	1400	342	150	183
	CR2430	Air & Boat	500	342	150	183
		Boat	1500	342	150	183
	CR2450	Air & Boat	300	342	150	183
		Boat	900	342	150	183
	CR2477	Air & Boat	200	342	150	183
		Boat	600	342	150	183
Extended Temp.	CR2032X	Air & Boat	700	342	150	183
		Boat	1400	342	150	183
	CR2450X	Air & Boat	300	342	150	183
		Boat	900	342	150	183
	CR2477X	Air & Boat	200	342	150	183
		Boat	600	342	150	183
Heat-resitant	CR2032W	Air & Boat	700	342	150	183
	CR2050W	Air & Boat	500	342	150	183
	CR2450W	Air & Boat	300	342	150	183
	CR2477W	Air & Boat	200	342	150	183
High Drain	CR2032R	Air & Boat	700	342	150	183
		Boat	1400	342	150	183
	CR2450R	Air & Boat	300	342	150	183
		Boat	900	342	150	183

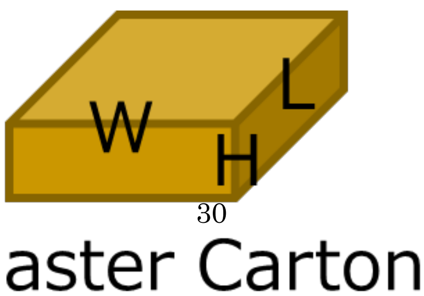


Table.5　Tab-welded CR

Type		Model name	Package (Ship mode)	Master Carton QTY (pcs)	Size L master carton (mm)	Size H master carton (mm)	Size W master carton (mm)	Master carton G Weight (kg)
Tab-welder	Standard	CR2032-HE1	Air & Boat	250	363	150	185	1.6
		CR2032-HE8	Air & Boat	250	363	150	185	1.6
		CR2032-HO6	Air & Boat	250	363	150	185	1.6
		CR2032-VE3	Air & Boat	250	363	150	185	1.6
		CR2430-HE1	Air & Boat	250	363	150	185	1.9
		CR2430-HE2	Air & Boat	250	363	150	185	1.9
		CR2430-HO1	Air & Boat	250	363	150	185	1.9
		CR2430-VE1	Air & Boat	200	363	150	185	1.6
		CR2450-HE5	Air & Boat	200	381	218	196	2.3
		CR2450-HE6	Air & Boat	250	363	150	185	2.4
		CR2450-HO5	Air & Boat	250	363	150	185	2.4
		CR2450-VE6	Air & Boat	200	363	150	185	2.1
	Extended Temp.	CR2032X-HE1	Air & Boat	250	363	150	185	1.6
		CR2032X-HO	Air & Boat	250	363	150	185	1.6
		CR2450X-HE6	Air & Boat	250	363	150	185	2.4
		CR2450X-HO5	Air & Boat	250	363	150	185	2.4
		CR2477X-HE2	Air & Boat	125	363	150	185	1.9
		CR2477X-HO4	Air & Boat	125	363	150	185	1.9
	Heat-resitant	CR2032W-HE1	Air & Boat	250	363	152	187	1.6
		CR2032W-HO	Air & Boat	250	363	152	187	1.6
		CR2050W-MP	Air & Boat	400	381	155	196	2.7
		CR2450W-HE6	Air & Boat	250	363	152	187	2.5
		CR2450W-HO	Air & Boat	250	363	152	187	2.5
		CR2450W-MP	Air & Boat	250	381	155	196	2.5
		CR2477W-HE2	Air & Boat	125	363	152	187	2.1
		CR2477W-HO	Air & Boat	125	363	150	185	2
	High Drain	CR2032R-HE1	Air & Boat	250	363	150	185	1.6
		CR2032R-HO	Air & Boat	250	363	150	185	1.6
		CR2450R-HE6	Air & Boat	250	363	150	185	2.4
		CR2450R-HO5	Air & Boat	250	363	150	185	2.4

8.8　Transportation (Sea & Air)

All coin manganese dioxide lithium batteries manufactured by Tohoku Murata Manufacturing Co., Ltd. have passed all the test items from T1 to T8 in the UN recommended transport test UN38.3, and are in compliance with the International Air Transport Association (IATA) and International Maritime Organization (IMO) regulations.

【Sea transportation】

All lithium metal cells shipping from Tohoku Murata Manufacturing Co., Ltd. and their packing condition conform to the IMO-IMDG Code SP188 and meet the requirements, therefore they can be shipped as exemption from Class 9 Dangerous goods.

【Air transportation】

As all of murata Coin manganese dioxide lithium batteries contain lithium metals less than 1.0g, Packing Instruction 969/970 can be applicable to the products that murata Coin manganese dioxide lithium batteries are assembled into. The equipment is excluded from dangerous goods regulation. When our cell or battery is contained in equipment or packed with equipment, it is classified into UN3091.

If shipped as a single battery, not contained in equipment or packed with equipment, it will be classified as UN3090. Also, since the lithium metal contained in the battery is less than 1.0g, it can be transported only by cargo aircraft as SECTION IB or SECTION II.

Table.6 CR Battery air transportation

Dangerous Goods List on IATA DGR

UN No.	Proper Shipping Name/Description	Class or division	Packing Instruction	Passenger Aircraft	Cargo Aircraft	S.P.
3090	LITHIUM METAL BATTERIES	9	PI968 (Section IA)	Forbidden	Max Net Qty /Package 35kg	A88 A99 A154 A164 A183 A201 A206
			PI968 (Section IB)	Forbidden	Max Net Qty /Package 2.5 kg	
			PI968 (Section II)	Forbidden	Max Net Qty /Package 2.5 kg & Single package for single consignment	

※As all of murata Coin manganese dioxide lithium batteries contain lithium metals less than 1.0g, Packing Instruction 969/970 can be applicable to the products that murata Coin manganese dioxide lithium batteries are assembled into.
The equipment is excluded from dangerous goods regulation.

When our cell or battery is contained in equipment or packed with equipment, it is classified into UN3091.

※For the details of indication on package and document required for transportation, please refer to IATA DGR 61st Edition (Dangerous Goods Regulations, 61st Edition).