Panasonic

ALKALINE

TECHNICAL HANDBOOK INDUSTRIAL BATTERIES FOR PROFESSIONALS

ONE OF THE WORLD'S LARGEST BATTERY MANUFACTURERS

274,143
EMPLOYEES*1

61
BILLION
SALES*2
€

Panasonic INDUSTRY EUROPE GMBH (PIEU)

Panasonic Industry Europe GmbH is part of the global Panasonic Group and provides industrial products and services in Europe. As a partner for the industry sector, Panasonic researches, develops, manufactures and supplies technologies that contribute to a better life and a better world. Looking back on 100 years of engineering knowhow in electronics, Panasonic is the right supplier when it comes to engineering expertise combined with solution competence. The portfolio covers key electronic components such as batteries, devices and modules up to complete solutions and production equipment for manufacturing lines across a broad range of industries.

Panasonic BATTERIES

Panasonic offers a wide range of power solutions for portable and stationary applications. Our product range includes high reliability batteries such as Lithium-Ion, Lithium-Ion Pin-type, Lithium, Nickel-Metal Hydride, Nickel-Cadmium, Valve-Regulated-Lead-Acid (VRLA), Alkaline, and Zinc-Carbon. With this breadth and depth to the portfolio, we can power your business in virtually all applications.

Panasonic began manufacturing batteries in 1931 and is today the most diversified global battery producer worldwide, with an extensive network of manufacturing companies. The company employees are dedicated to research, development and production of batteries for an energised world.

*1 Employees of Panasonic Corporation

*2 Refers to the fiscal year ended March 2018 of Panasonic Corporation, based on exchange rate EUR/JPY 131.

PIEU OFFICE
IN HAMBURG

PIEU HEADQUARTER
IN OTTOBRUNN
(NEAR MUNICH)

BATTERIES

INDUSTRY

Panasonic INDUSTRY EUROPE GMBH

PIEU

AUTOMOTIVE

FACTORY SOLUTIONS

CERTIFICATIONS

'Quality is our Business' – this is what Panasonic stands for. It is the principle for all our batteries and supporting services. This commitment is confirmed by numerous certifications.

Our battery production facilities use leading-edge manufacturing processes that meet the toughest quality standards. All our factories are certified to ISO standards – with ISO 9000 and ISO 14000 being the minimum benchmarks. This means each factory has its own quality and environmental management, delivers products that measure up to toughest standards of reliability.

YOUR TOOLS TO FIND

At Panasonic Batteries we offer diverse services intended to make the customer´s life easier. Find the right pictures and media files in our Mediapool, gain insight into battery technology in our handbooks and white papers and be entertained by watching amazing videos at our YouTube channel. Finally, our HTML Battery Finder will help you to find the right battery for your application. Test our services!

MEDIAPOOL

DOWNLOAD THE RIGHT BATTERY MEDIA FILES

The Panasonic Mediapool is a complete online library of Panasonic battery images, videos, handbooks, press releases, and white papers, providing you with just the right material for all sorts of projects. The Mediapool is open to all visitors to the Panasonic website, and offers material for both print and web. The image files differ with respect to their resolution (image size) and colour space (CMYK or RGB). The library contains files in five formats: TIF, PNG, JPG, AI, PDF, and MP4. New files appear in the folder 'New files' for three months.

You can assemble as many files as you need and download them directly to your computer. Here's an overview of what you can do:

- Locate the material you need by product name or by clicking through the categories
- Preview file details – the preview function tells you the full name of the file, its size, format, and resolution
- Select the files you wish to download. You can take files from multiple folders, or select all the material in a particular folder or category in one-click operation – there's no need to select each one individually
- Preview your personal 'Download bag' of the files you have selected
- The Mediapool zips your data into a file, which you then download to your computer. You unzip the file to the location of your choice simply by double-clicking the file name. The material is then ready for use.

YOUTUBE CHANNEL

FIND THE RIGHT BATTERY VIDEO

Please find a comprehensive selection of Panasonic battery videos at our YouTube channel. You can discover videos about the inner structure of our different battery chemistries, a couple of application videos and films which explain why batteries sometimes help to save human lives and sharks' lives as well. Are you getting curious? Please follow the QR code to our batteries video world!

SHORT FORM CATALOG AND HANDBOOKS

GET THE RIGHT PRODUCT OVERVIEW

Our range of digital tools to help you in your daily work are complemented by our 'classics' on paper: the Short Form Catalog and the technical handbooks on the various battery product groups. These remain popular with customers as valuable reference aids.

HTML APP BATTERY FINDER

FIND THE RIGHT BATTERY FOR YOUR APPLICATION

Designed for engineers, electronics specialists and developers who need batteries for their projects, the Battery Finder Application provides an overview of what's available in the Panasonic range of industrial batteries, and gives a recommendation on the type of battery that's best suited to the user's application. It also offers a wealth of information, graphics and videos on battery technology. All in all – it's now easier than ever to find the right battery!

WHITE PAPER

FIND THE RIGHT TECHNICAL INFORMATION

Our white papers give developers and technical professionals the opportunity to leverage the expertise of our specialists for their own projects. We have been manufacturing batteries for a number of decades, and over this time have accumulated considerable knowledge and experience that we wish to share.

The white paper 'Lead acid battery containers made of ABS' takes a detailed look at the experience of our engineers with the material ABS for VRLA containers.
Our white paper 'Lithium primary battery characteristics' is meant to give an overview about requirements and characteristics of current Lithium technologies in the field of Wireless and IoT (Internet of Things) applications.
We are looking forward to expand our range of white papers step by step.

IDEAL FOR HIGH-PERFORMANCE STANDARD APPLICATIONS

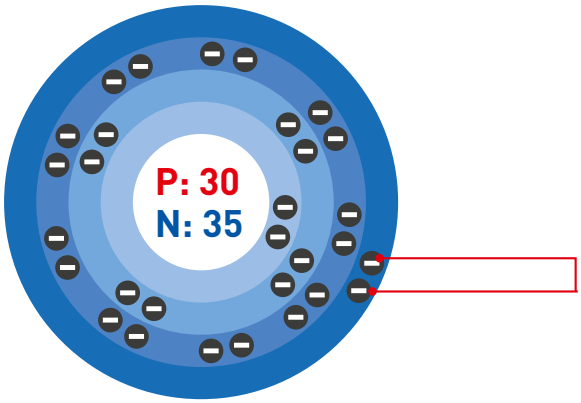
HIGH AND MEDIUM DRAIN APPLICATIONS
CONTINUOUSLY RELIABLE ENERGY PROVISION
LONG SHELF LIFE
SUPERIOR LOW TEMPERATURE BEHAVIOR

Scan QR code to view product series video.

INTRODUCTION

In this handbook we describe Alkaline Manganese batteries. These are basically made from the same materials as normal Zinc-Carbon batteries, but offer higher capacity and high drain performance, longer shelf life, better leakage resistance and superior low temperature behaviour.

The cylindrical Alkaline battery is composed of Manganese dioxide (+), Zinc powder (-) and caustic Alkali (Potassium hydroxide) as the electrolyte. These Alkaline batteries have a higher energy output than Zinc-Carbon batteries, a longer shelf life and better leakage resistance due to the use of purest materials to minimize self discharge. Their low-temperature performance is also much better than that of Zinc-Carbon batteries.



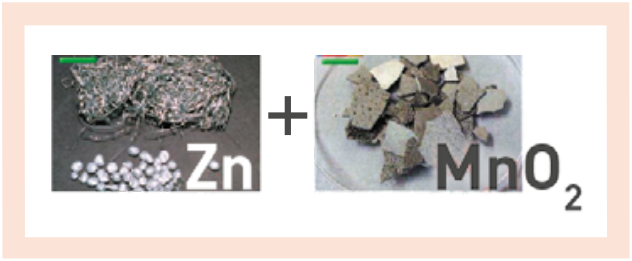
2 electrons on outer layer are given up by the Zinc atoms

The actual electrical current is generated through an outside flow of electrons coming from the anode (Zinc), passing through the attached load and flowing back into the battery at the cathode (from the can into the Manganese dioxide).

ELECTRO-CHEMICAL DESCRIPTION

The **negative electrode** or **anode** is composed of Zinc powder in the shape of a mixed gel. The quality of the Zinc powder and the size of the particles are carefully controlled to ensure there is a good wide surface area during the chemical reaction. This lowers the internal resistance, which is important in case of high drain discharges. Because it is the Zinc which is giving up electrons, thus creating a flow of electrical current, the anode is also the 'capacity determining element'.

The **positive electrode** or **cathode** is made of Manganese dioxide and is produced in shape of tablets. Graphite and electrolyte (and small quantities of other additives) are added for better conductivity. This material is generated through an electrolytic process, ensuring the purity and richness of oxygen.



The **electrolyte** is a Potassium hydroxide solution, which is Alkaline (base) and is present in the anode, cathode and separator (as all three are porous in nature) to assure high conductivity during discharge.

The **separator paper** divides the positive and negative parts of the battery to prevent internal short circuiting and immediate loss of energy. The separator paper is made of a special material that prevents anode particles from migrating inside the battery and causing self discharge.

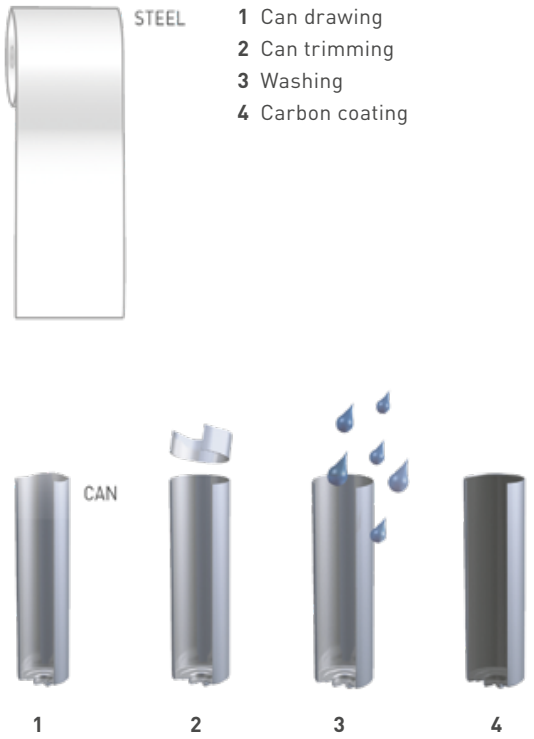
The **battery can** is made of Nickel-plated steel and serves as the holder for the battery, and also as the cathode collector. Panasonic performs strict checks on the quality of its own in-house manufactured steel cans to provide thin but strong containers which can hold maximum volumes of active material both safely and reliably.

A **nail** connected to the bottomplate serves as the anode collector. It is important for this nail to be of an exact length and thickness to ensure the battery works properly.

A **moulded nylon seal** connected to the nail serves as a seal with an integrated safety venting mechanism. This vent ensures safe, controlled release of any excessive gas which could be generated by improper use of the battery (e.g. short circuiting, overheating, or if the battery is thrown on a fire or overcharged, or incorrectly inserted polarity-wise). Once the vent has opened, it will not close again; besides the escaping gas there is always the risk that a certain volume of the electrolyte will leak as well.

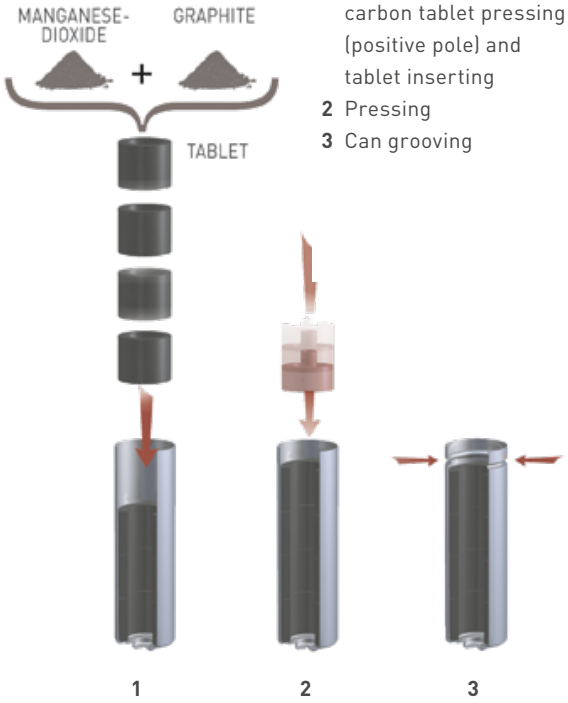
A **non-conductive** label provides the opportunity for cosmetic design on the batteries. The label also functions as an isolator between the large positive area of the steel can and the negative area of the bottomplate to avoid external short circuit.

CAN PRODUCTION PROCEDURE - STEEL CAN PRODUCTION



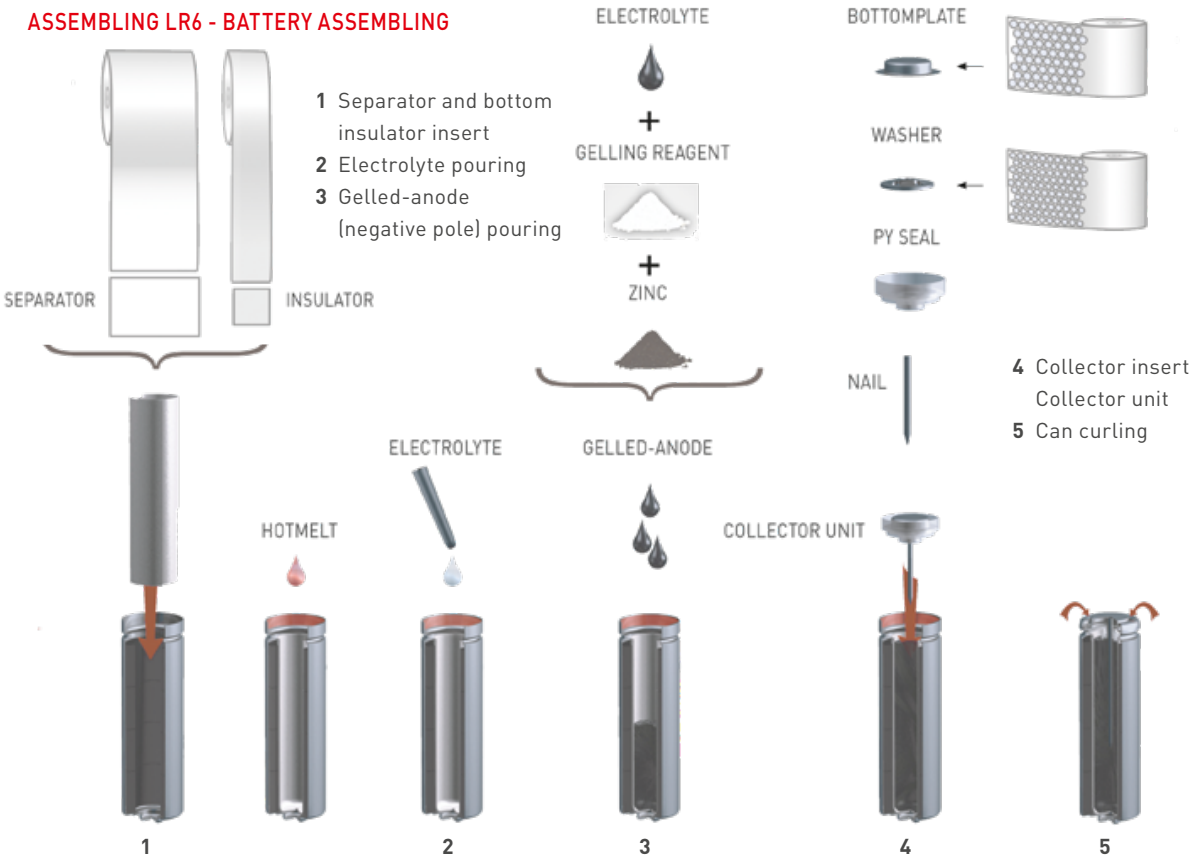
1 Can drawing
2 Can trimming
3 Washing
4 Carbon coating

CATHODE UNIT LR6 - MIXTABLETS (+) PRESSING



1 Manganese dioxide carbon tablet pressing (positive pole) and tablet inserting
2 Pressing
3 Can grooving

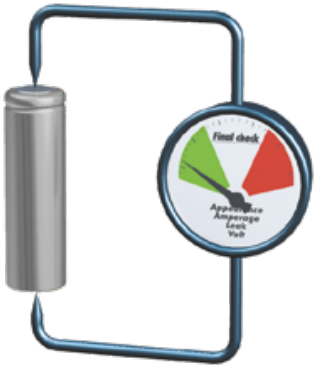
ASSEMBLING LR6 - BATTERY ASSEMBLING



1 Separator and bottom insulator insert
2 Electrolyte pouring
3 Gelled-anode (negative pole) pouring
4 Collector insert Collector unit
5 Can curling

BATTERY FINISHING LR6

1 Final check on volt, amperage, leakage and appearance
2 Labeling



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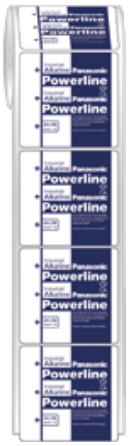
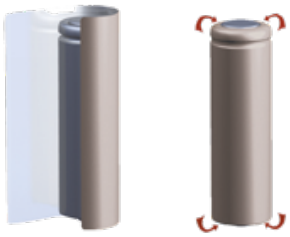




2

PACKAGING LR6 INTO 10 PIECES BOX

QUALITY CONTROL

What is quality and how to secure the best quality level during the production process of tons of Alkaline batteries in our Belgian factory?

High tech in quality control
For us, the best possible product quality is indispensable. We therefore invest an extraordinary amount of effort in quality control of our batteries. It starts with the sophisticated construction of our batteries, followed by a high level material purchasing process and ends in state-of-theart battery production.

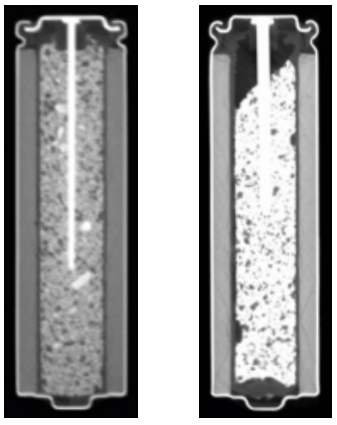
SPECIAL TESTINGS

In some cases samples are checked by means of a CT (computer tomography) scan, which renders the interior completely visible.

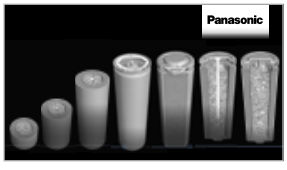
CT-scan Panasonic LR6 vs. competitor
It is then possible to see any defects immediately, or to identify batteries that are not evenly filled. The CT-scan produces a series of many X-ray images that are computed into a 3D model. The batteries are randomtested using this complex technology.

Differences in terms of battery construction (e.g. length of nail), open material spaces or bubbles and the filling level of material are easily recognized. All these parameters are proof of the different level of battery quality.

Panasonic battery LR6 Competitors battery



Scan QR code to view CT-scan video.



VOLTAGE AND CAPACITY

The voltage of Alkaline batteries usually ranges between 1.55V and 1.65V OCV (Open Circuit Voltage). 1.5V is considered to be the nominal voltage. The speed of voltage decrease during use is determined by the type of appliance and the load (drain) which is put on the battery.

Measuring the OCV of a battery gives only a very rough idea of battery capacity and/or freshness. CCV (Closed Circuit Voltage), measured when the battery is on discharge, gives a much better view of the discharge status. If the voltage is still close to 1.5V, the battery is still in relatively fresh condition; if the voltage is closer to 1.0V, the battery is nearing the end of its useful life.

Every kind of appliance needs a minimum voltage to operate, and the level at which the appliance will stop is usually referred to as the 'cut-off voltage'. Even if several batteries are needed to operate an appliance, for battery test purposes the cut-off voltage is stated in terms of the cut-off voltage per cell. (Example: if we have a portable CD player which uses two cells and needs a least 2V to operate, the cut-off voltage is 1.0V per cell.)

The **capacity** of a battery is usually expressed in mAh. The actual drain in combination with the cut-off voltage will determine the capacity in mAh for each individual use or appliance. It is impossible to put a single figure on how a battery will behave with regard to its capacity, since this depends on a range of parameters. To specify battery capacity precisely, one should give the exact parameters under which the batteries are to be tested, or have a wider range of different discharge conditions to view the battery performance.

The maximum battery capacity is determined by the weight and volume of the two main raw materials, Zinc and Manganese dioxide. A LR20 battery will last much longer than a LR6 battery, simply because there is much more active material inside. Some batteries, like the 9V Alkaline battery, are designed with six cylindrical batteries in series and are spot-welded together to ensure reliable performance during discharge.

Temperature also plays a role in battery capacity and performance. Alkaline batteries are best suited for operating temperatures between -10°C and +45°C. In some cases the batteries can reliably deliver small currents at lower or higher temperatures as well, but this should be subject to careful testing under the specific conditions. At higher temperatures the internal resistance of the battery will increase at a lesser speed, which will provide better high drain performance.

DISCHARGE TYPES

We differentiate between the following types:

Constant resistance (B)
The appliance keeps its resistance constant in Ω.

Constant current (A)
The appliance keeps running on constant drain in A or mA.

Constant power (W)
As the power should remain constant, the drain in A will increase gradually during discharge as the voltage decreases.

Power (Watt) = Current (A) x Voltage (V)

In this case, the increasing internal resistance towards the end of the useful battery life will also determine the actual useful capacity of the batteries. The total capacity is of course also strongly influenced by the cut-off voltage.

The discharge (continuous or intermittent) and load (light or heavy) largely determine what performance can actually be obtained from a battery.

SHELF LIFE

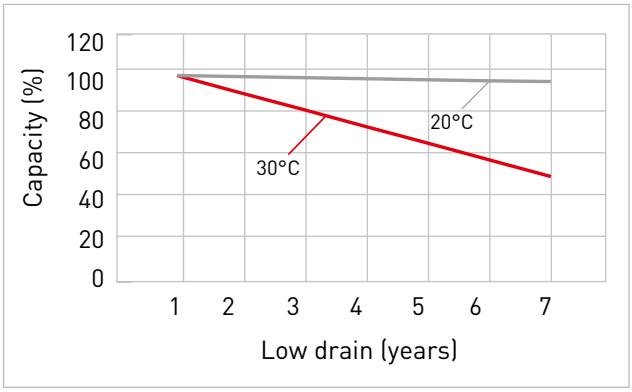
The shelf life is the ability of a battery to maintain more or less the same performance over time. Alkaline batteries nowadays carry a freshness date of about 5 years from the date of production. This means that the service life on a specific discharge compared to a fresh battery of the same generation is expected to be over 70% compared to initial capacity testing. (If batteries have been stored appropriately in a controlled environment with constant temperature and humidity.)

The shelf life is influenced by temperature, humidity and internal construction.

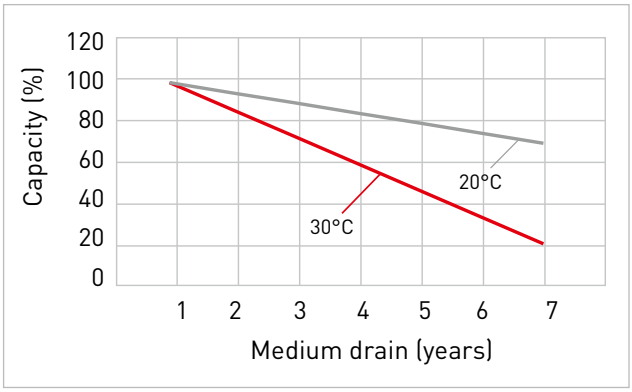
Too high temperatures should be avoided as it can influence the level of self-discharge. Alkaline cells will lose approximately 3% of their capacity per year when stored at 20°C due to slow electrochemical reactions that continually occur. At low temperature storage, the chemical activity is delayed and this will in turn decrease loss of capacity over time. Recommended storage conditions are 10°C to 25°C with not more than 65% of relative humidity as a comparison Zinc carbon cells loose on average yearly nearly 15% of capacity at room temperature.

High temperature (above 30°C to 35°C) and high humidity will speed up the degradation of chemicals, which leads to greater capacity loss in a shorter time. Poor quality internal construction might also influence the degradation of chemicals, but mainly as a potential risk for internal short circuit and leakage over time. Yet another factor – and even more unpredictable – is that the electrolyte could cause non-metallic battery parts to deteriorate over time, resulting in leakage. Though there is little chance of this happening, it is still advisable to use Alkaline batteries within the first half of their expected shelf life.

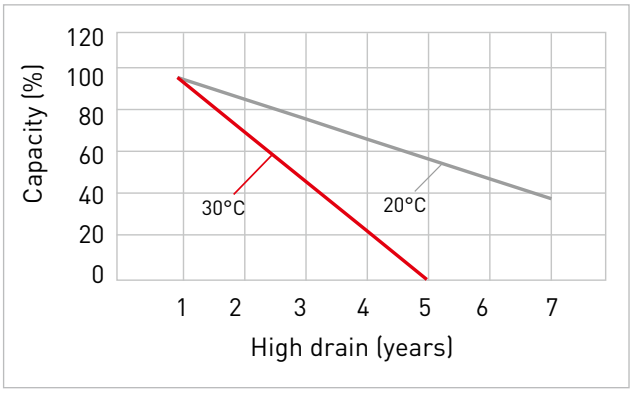
Shelf life with low drain discharge*[1]



Shelf life with medium drain discharge*[2]



Shelf life with high drain discharge*[3]



*[1] Up to 97% of capacity remains when battery is optimal stored 20°C or lower, and used after 5 years in a low drain appliance. *[2] Depending low medium to high medium drain appliances, between 90 to 50 % at 20°C or 20 to 50% at 30°C ,of the capacity remains in the battery when used in such an appliances after 5 years. *[3] After 5 years of storage a minimum at 20°C ,40 % of the batteries capacity remains when battery is stored in optimal conditions and is used in very High drain appliance.

ALKALINE

Panasonic Alkaline batteries are made from the same basic materials as Zinc-Carbon batteries, but deliver generally higher performance on all criteria. These batteries can therefore power high-performance standard applications. Our Alkaline batteries are made in Europe and fulfill the highest quality standards.

FEATURES

- Developed for high and medium drain appliances
- Continuously reliable energy provision
- Long shelf life
- Excellent leakage resistance
- Superior low temperature behavior

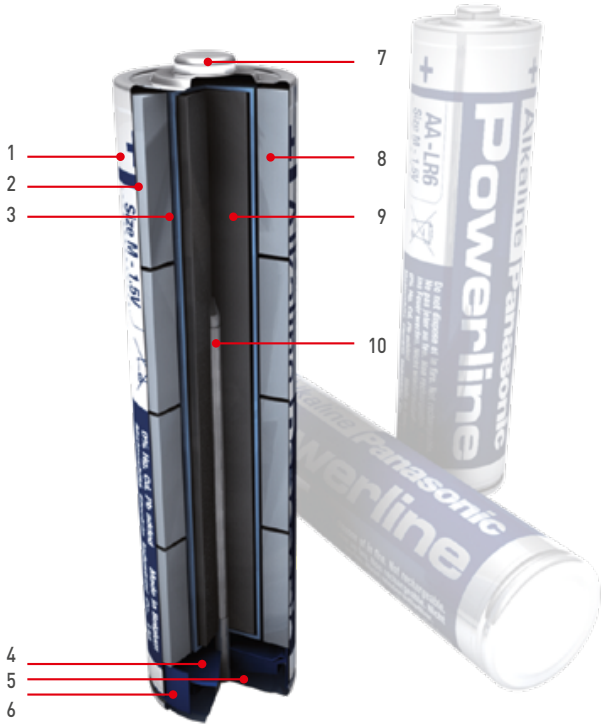
APPLICATIONS

- Smoke detectors
- Marine devices
- Medical equipment
- Scales
- Cleaning and hygiene services
- Seismic sensors
- Gas barbecue igniter
- Suitcase electronic pass, etc.

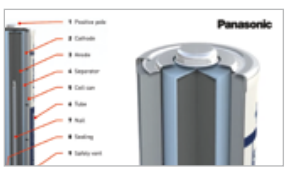
Model number	Size	Nominal voltage (V)	Diameter (mm)	Total height (mm)	Weight (g)	IEC
LR03AD	AAA	1.5	10.5	44.5	11.0	LR03
LR6AD	AA	1.5	14.5	50.5	22.0	LR6
LR14AD	C	1.5	26.2	50.0	66.0	LR14
LR20AD	D	1.5	34.2	61.5	138.0	LR20
6LR61AD	9V	9.0	26.5 x 17.5	48.5	43.0	6LR61

STRUCTURE OF ALKALINE INDUSTRIAL BATTERIES*[1]

1 Label
2 Cell can
3 Separator
4 Safety vent
5 Negative pole
6 Sealing
7 Positive pole
8 Cathode (Manganese-dioxide-Carbon)
9 Anode (Zinc-gel)
10 Nail



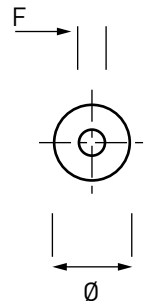
Scan QR code to view 3D animated video.

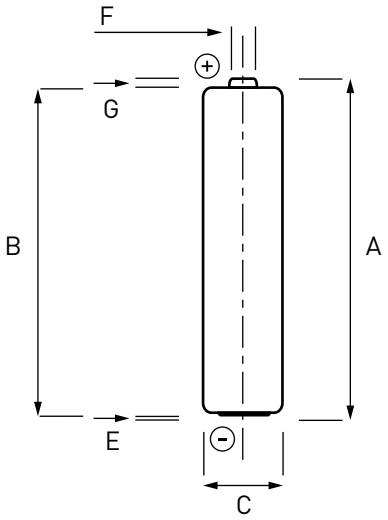


*[1] The illustration shows only one example of Alkaline battery structure.

LR03AD POWERLINE

DIMENSIONS (MM)



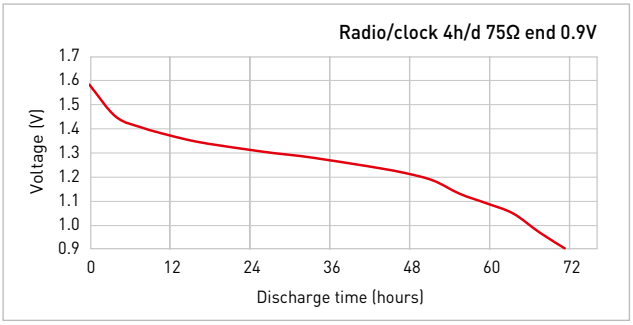


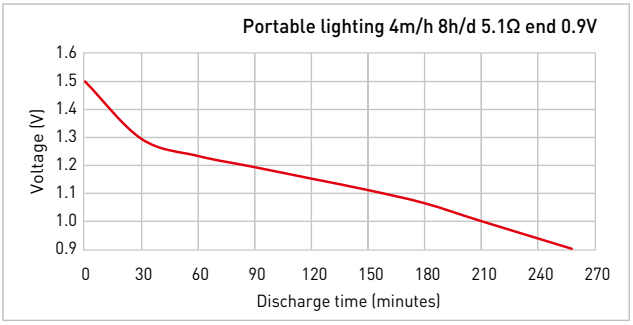
IEC dimensions	Maximum	Minimum
A	44.5	
B		43.5
C		4.3
E	0.5	
F	3.8	
G		0.8
Ø	10.5	9.5

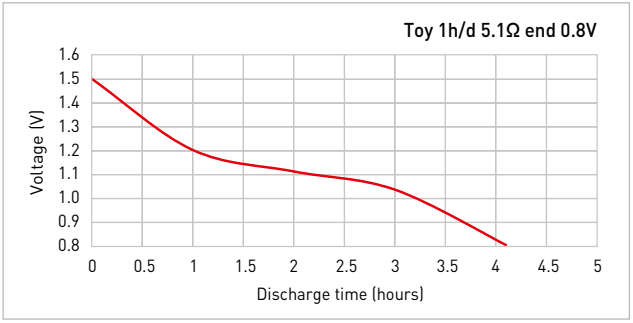
Specifications	LR03 / S / AAA / AM4 / MICRO / MN2400 / 24A / 24AC
Made in	Belgium
Type	Alkaline Foil
Nominal voltage (V)	1.5
Electrolyte	Potassium Hydroxide
Average weight (g)	11.0
Storage temp. range	+10°C (50°F) ~ + 25°C (77°F)
Operating temp. range	-20°C (-4°F) ~ + 55°C (131°F)
Average Impedance	+/- 180 m-Ω @ 1kHz fresh
Heavy metals	No added Mercury (Hg), Cadmium (Cd) or Lead (Pb)
Compliant to	IEC 60086-1, IEC 60086-2, IEC 60086-5 non dangerous goods regulation EU directive 2006/66/EC Nordic Ecolabel
Recommended cut off voltage	0.8V per cell (0.9V per cell for multi series usage)

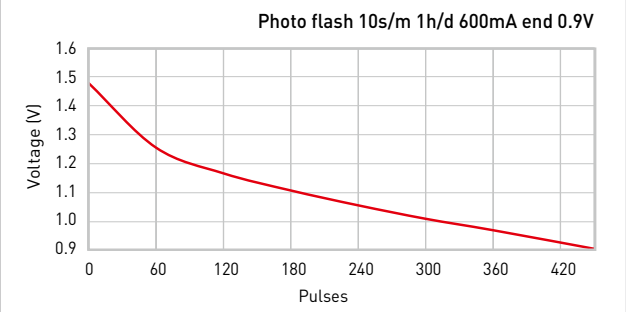
LR03AD POWERLINE

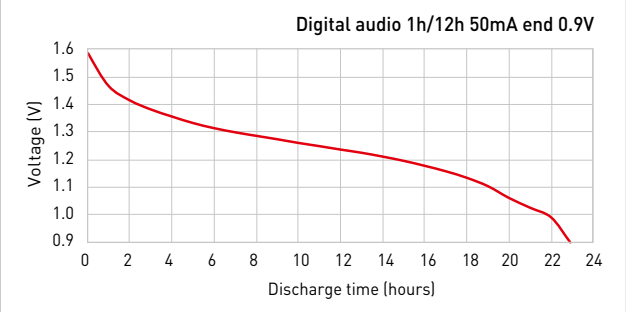
TYPICAL DISCHARGE VALUES

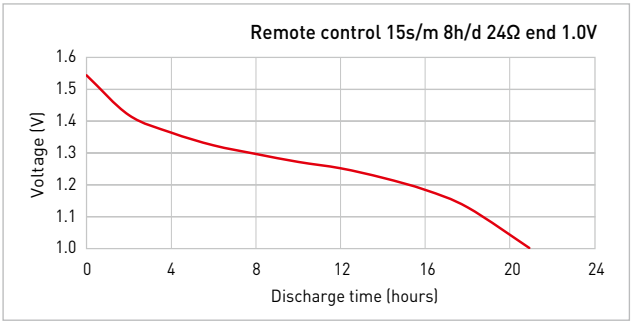




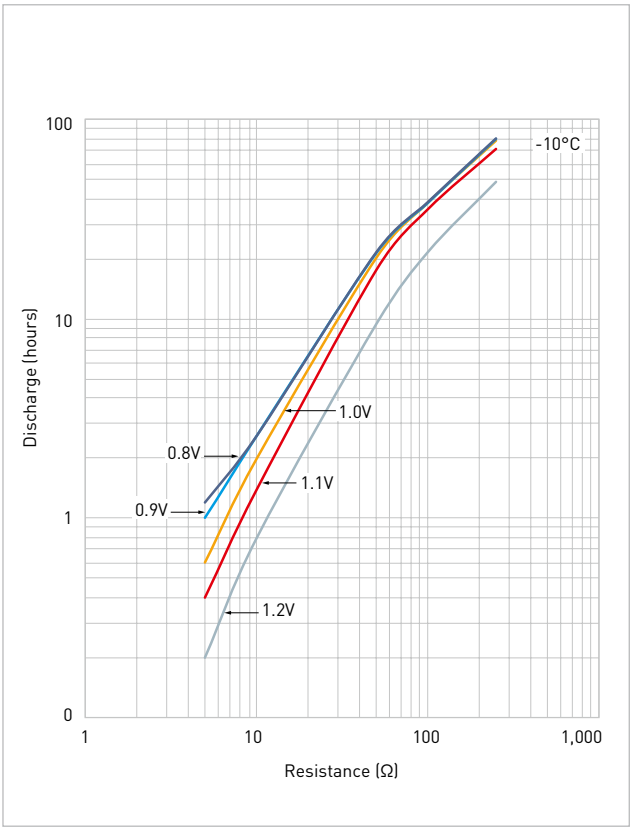






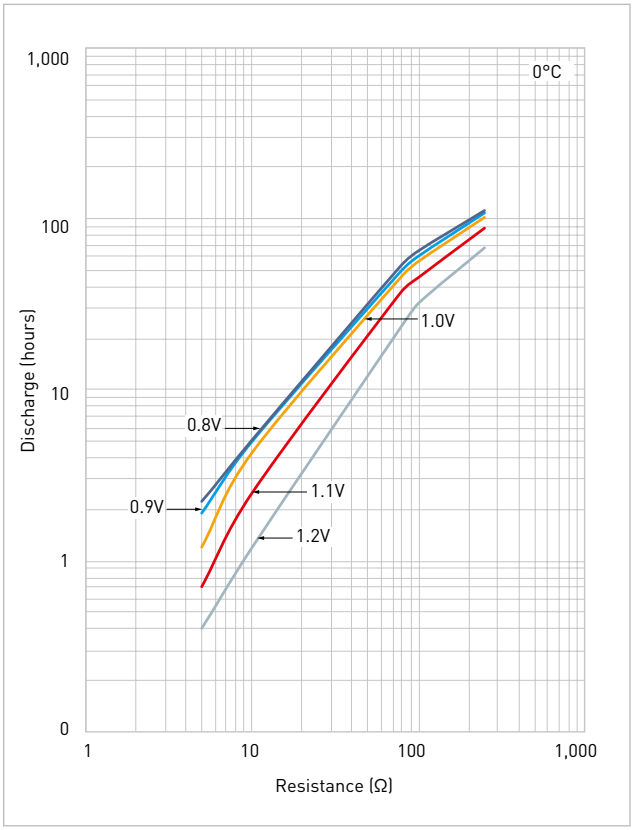


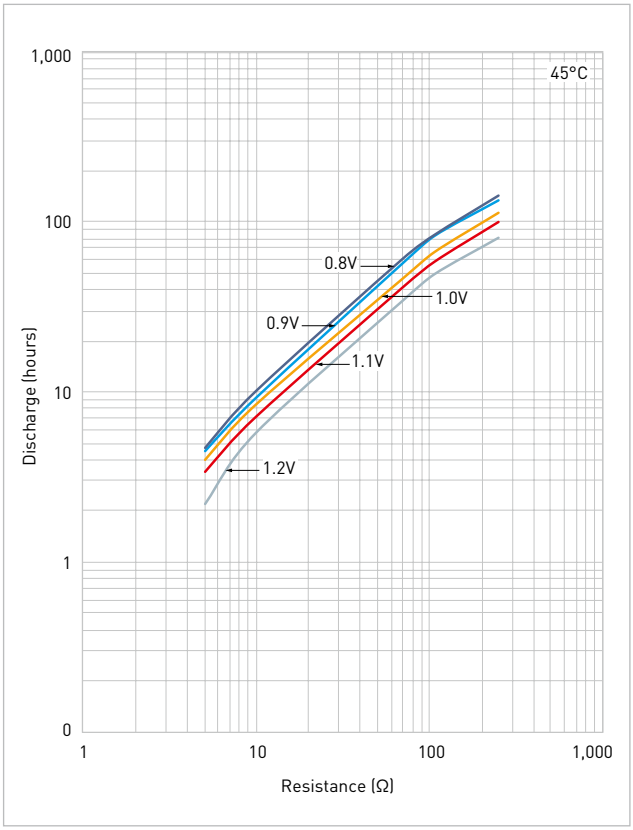
DISCHARGE TEMPERATURE CHARACTERISTICS

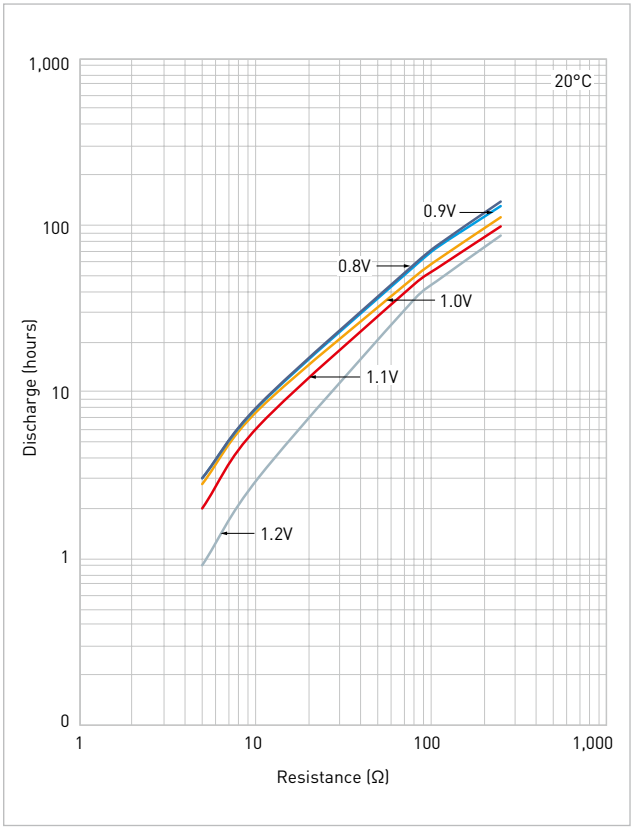


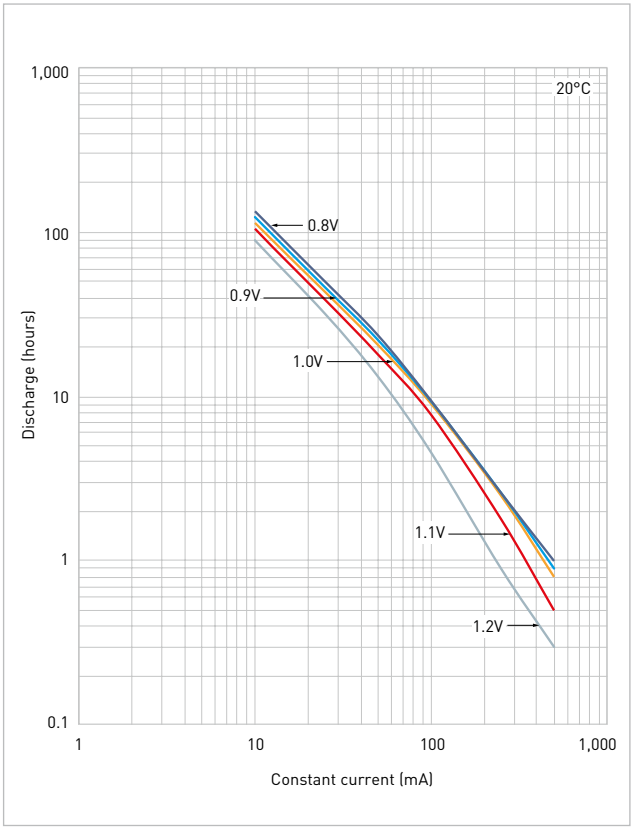
LR03AD POWERLINE

DISCHARGE TEMPERATURE CHARACTERISTICS



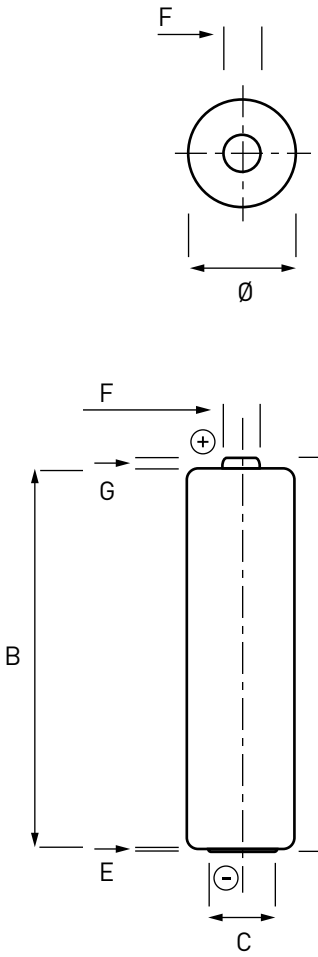






LR6AD POWERLINE

DIMENSIONS (MM)

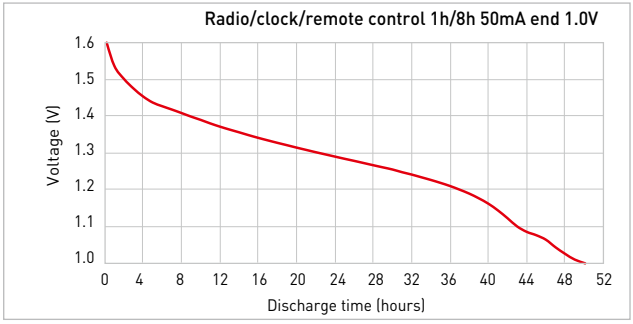


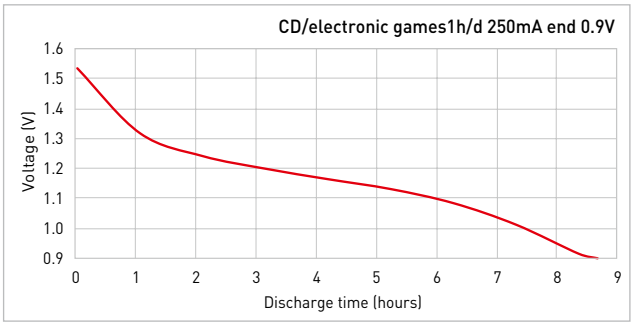
IEC dimensions	Maximum	Minimum
A	50.5	
B		49.5
C		7.0
E	0.5	
F	5.5	
G		1.0
Ø	14.5	13.7

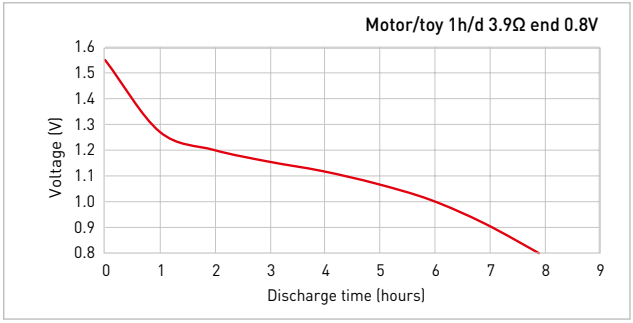
Specifications	LR6 / M / AA / AM3 / MIGnon / MN1500 / 15A / 15AC
Made in	Belgium
Type	Alkaline Foil
Nominal voltage (V)	1.5
Electrolyte	Potassium Hydroxide
Average weight (g)	22.0
Storage temp. range	+10°C (50°F) ~ +25°C (77°F)
Operating temp. range	-20°C (-4°F) ~ +55°C (131°F)
Average Impedance	+/- 105 m-Ω @ 1kHz fresh
Heavy metals	No added Mercury (Hg), Cadmium (Cd) or Lead (Pb)
Compliant to	IEC 60086-1, IEC 60086-2, IEC 60086-5 non dangerous goods regulation EU directive 2006/66/EC Nordic Ecolabel
Recommended cut off voltage	0.8V per cell (0.9V per cell for multi series usage)

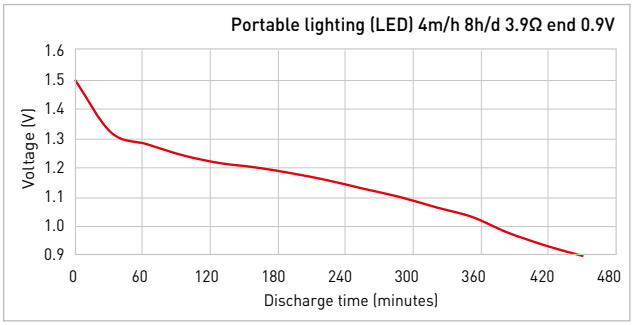
LR6AD POWERLINE

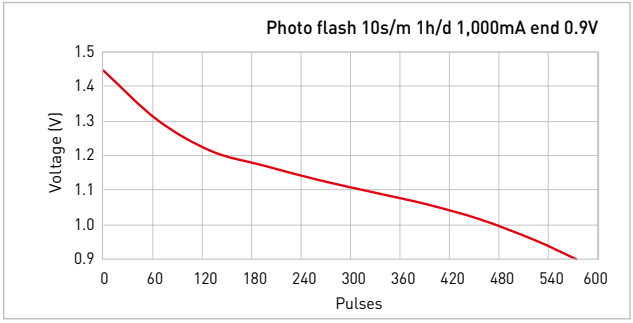
TYPICAL DISCHARGE VALUES

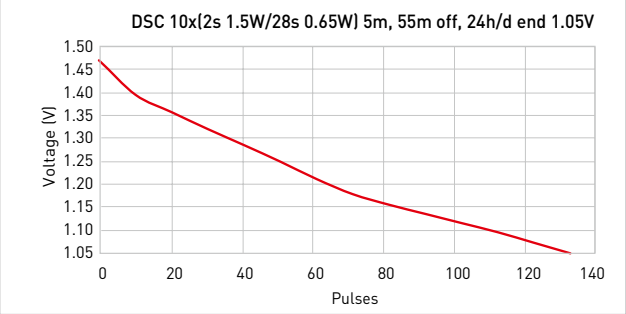


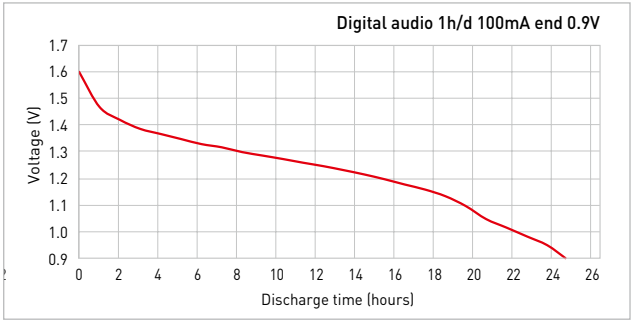




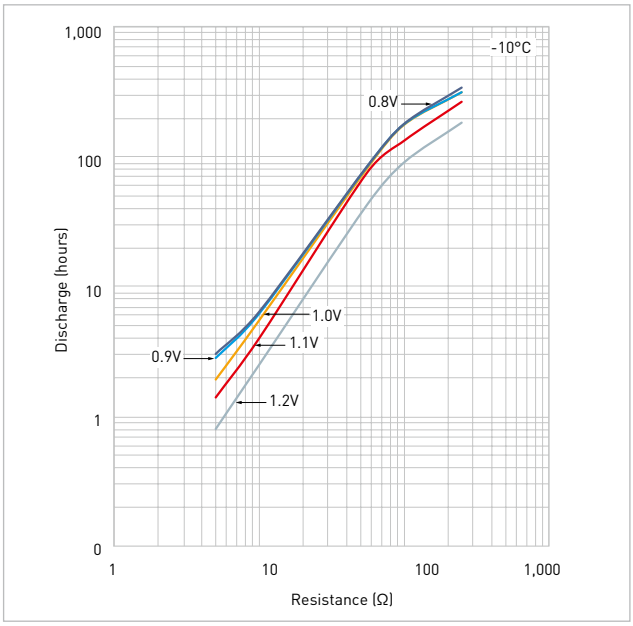






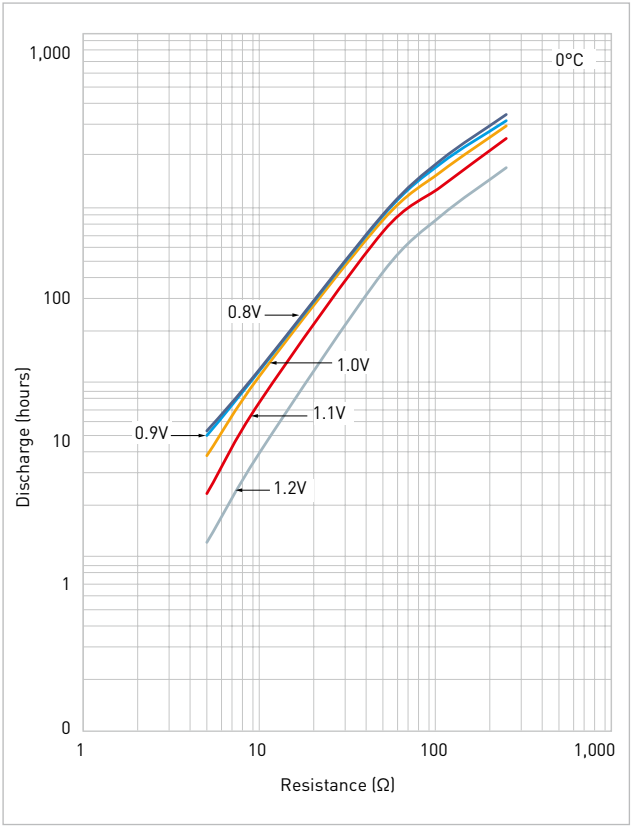


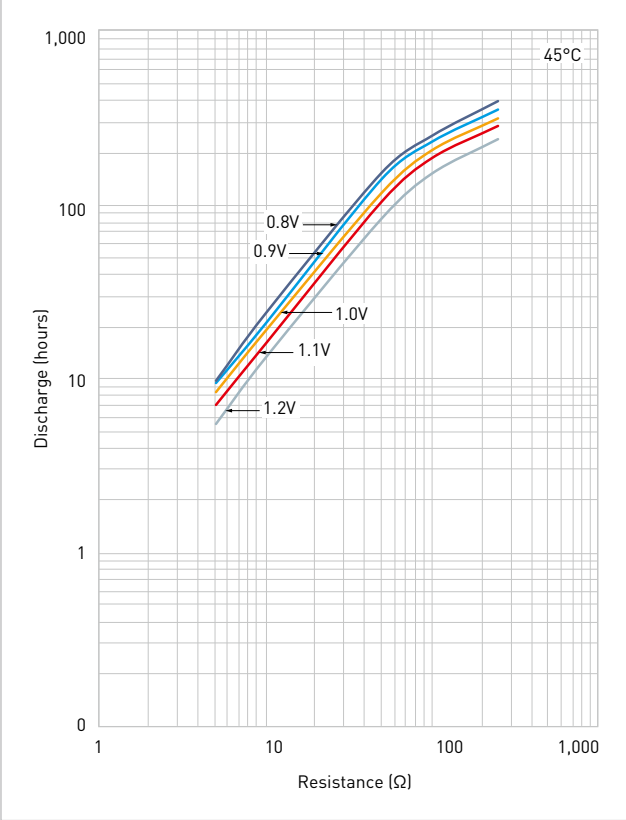
DISCHARGE TEMPERATURE CHARACTERISTICS

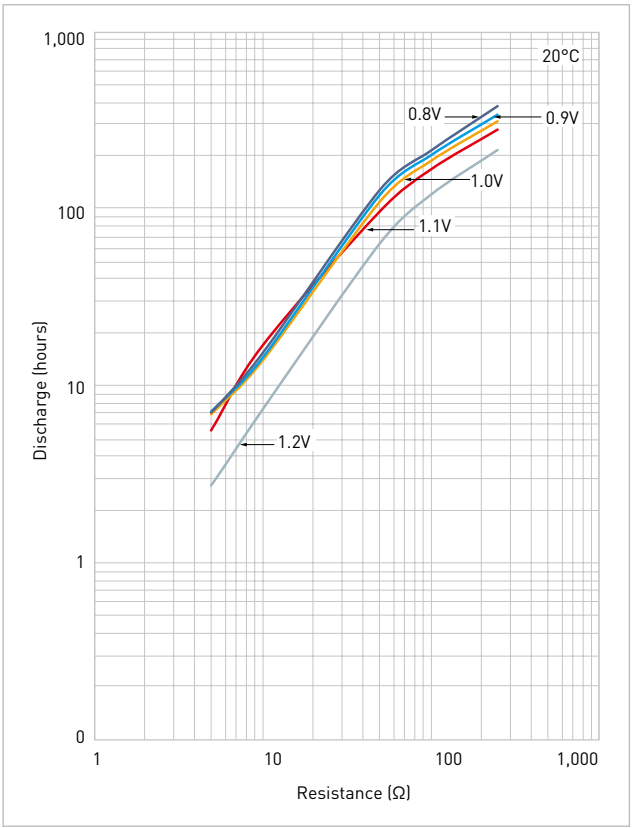


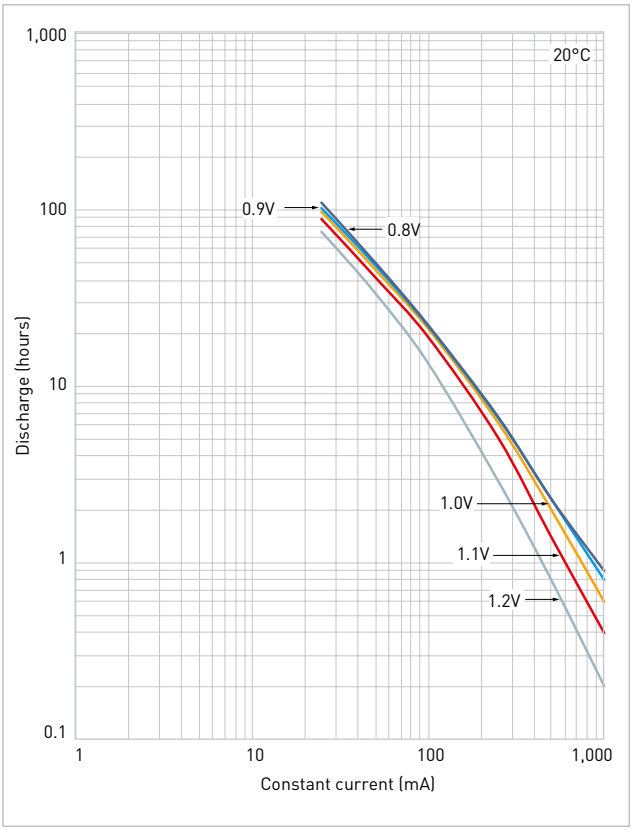
LR6AD POWERLINE

DISCHARGE TEMPERATURE CHARACTERISTICS



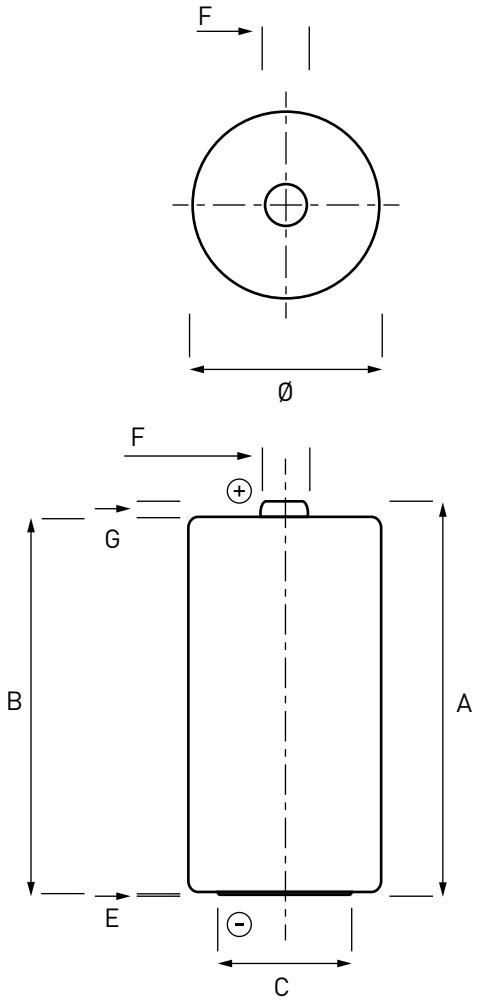






LR14AD POWERLINE

DIMENSIONS (MM)

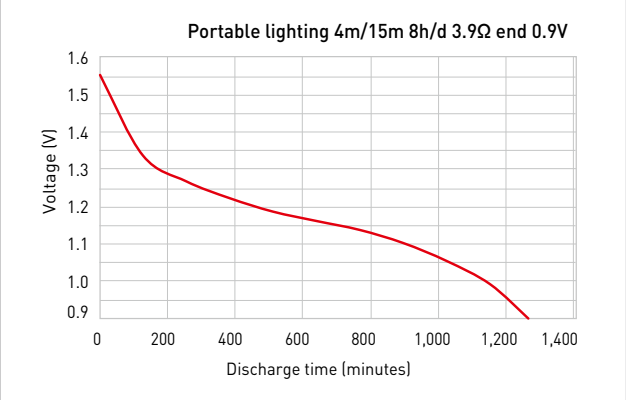


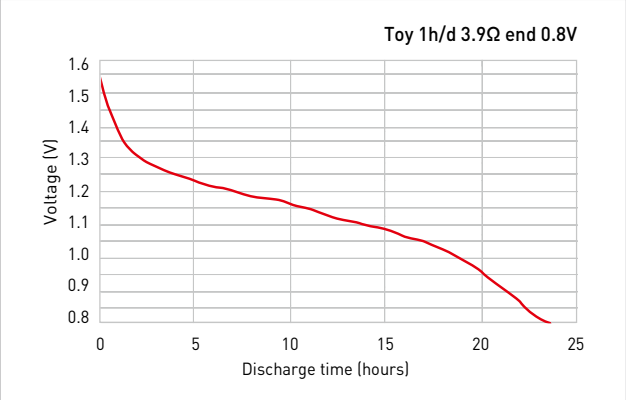
IEC dimensions	Maximum	Minimum
A	50.0	
B		48.6
C		13.0
E	0.9	
F	7.5	
G		1.5
Ø	26.2	24.9

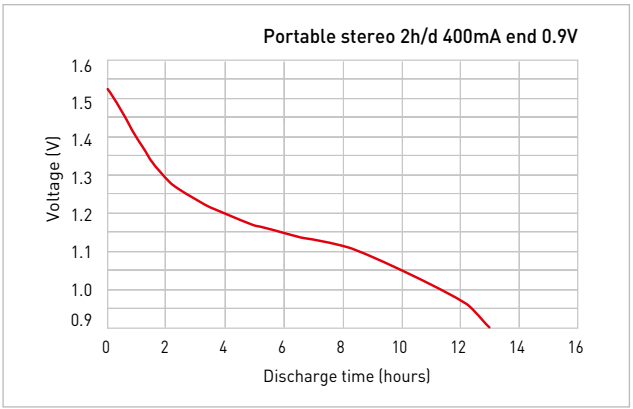
Specifications	LR14 / L / C / AM2 / BABY / MN1400 / 14A / 14AC
Made in	Belgium
Type	Alkaline Foil
Nominal voltage (V)	1.5
Electrolyte	Potassium Hydroxide
Average weight (g)	66.0
Storage temp. range	+10°C (50°F) ~ + 25°C (77°F)
Operating temp. range	-20°C (-4°F) ~ + 55°C (131°F)
Average Impedance	+/- 100 m-Ω @ 1kHz fresh
Heavy metals	No added Mercury (Hg), Cadmium (Cd) or Lead (Pb)
Compliant to	IEC 60086-1, IEC 60086-2, IEC 60086-5 non dangerous goods regulation EC directive 91/157EC & 98/101EC Nordic Ecolabel
Recommended cut off voltage	0.8V per cell (0.9V per cell for multi series usage)

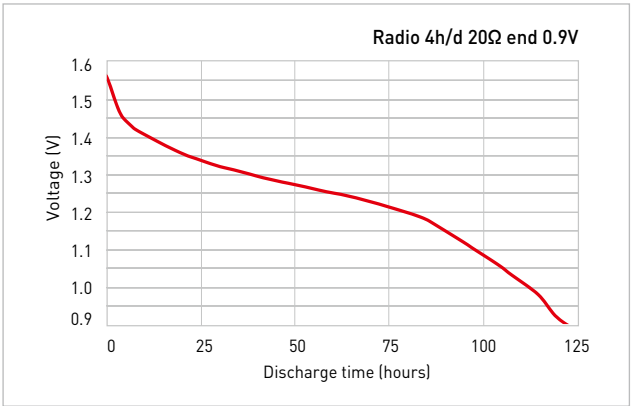
LR14AD POWERLINE

TYPICAL DISCHARGE VALUES

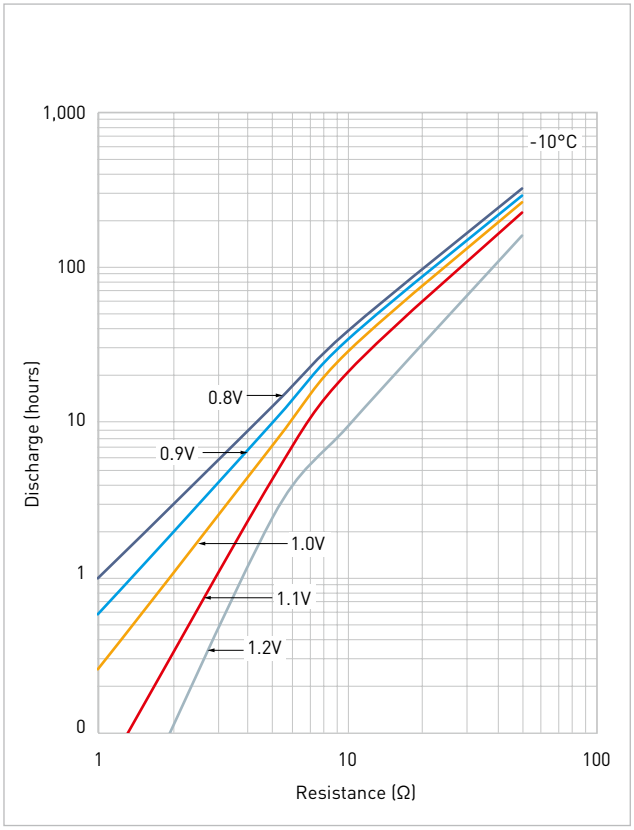


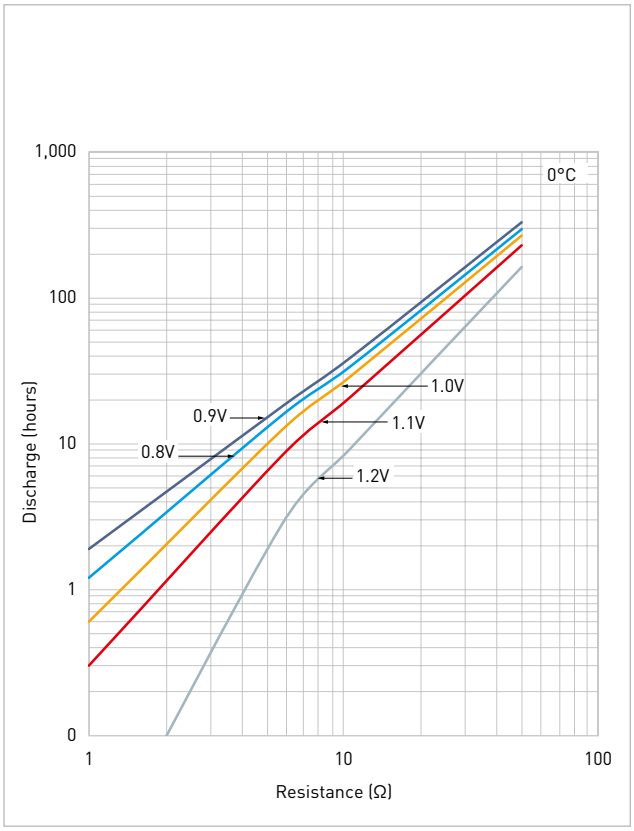






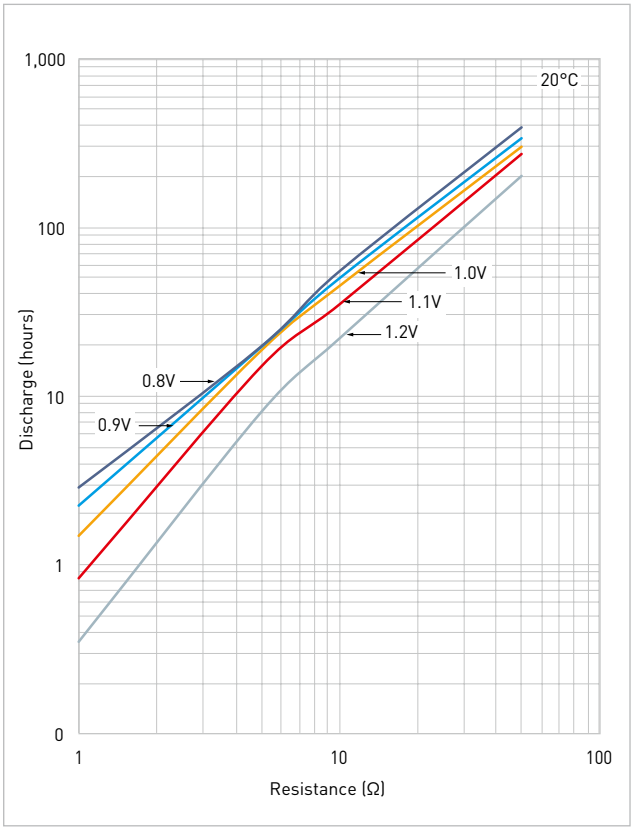
DISCHARGE TEMPERATURE CHARACTERISTICS

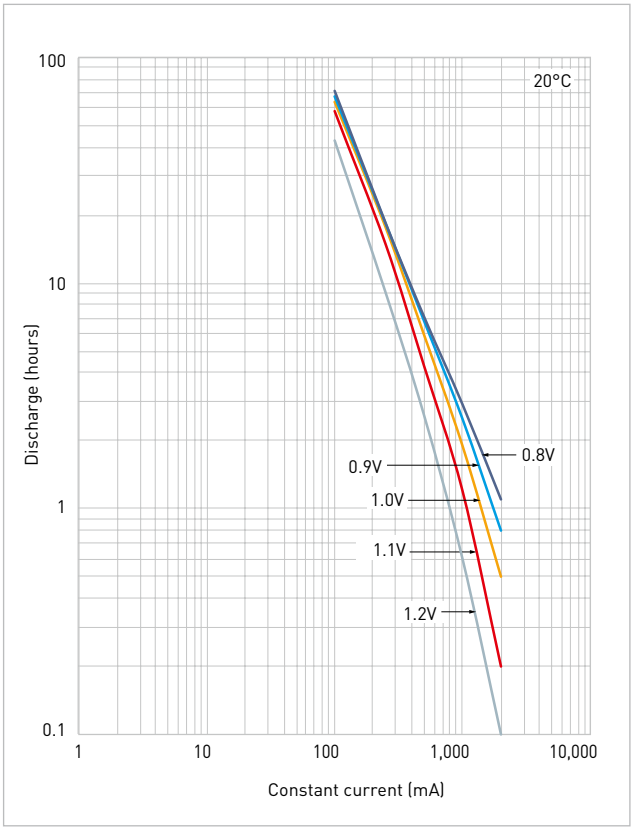


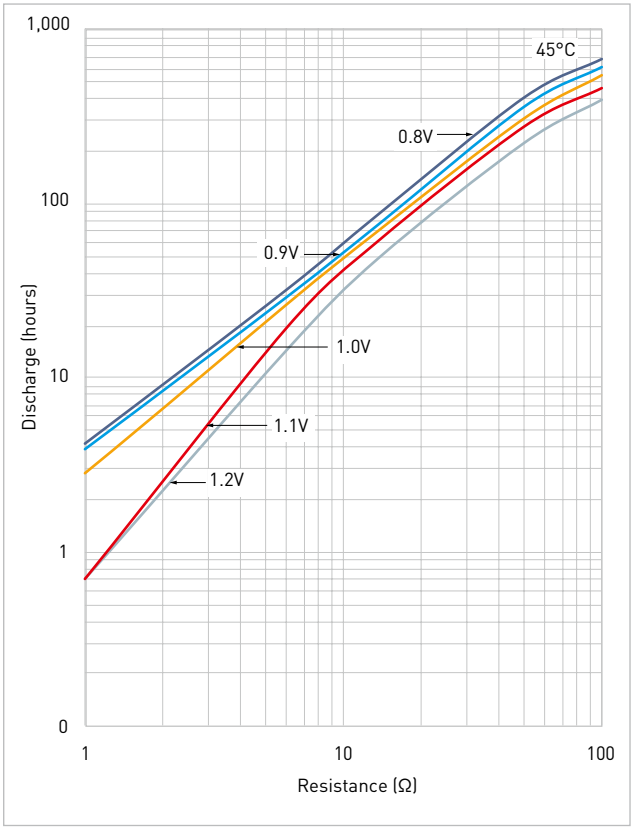


LR14AD POWERLINE

DISCHARGE TEMPERATURE CHARACTERISTICS

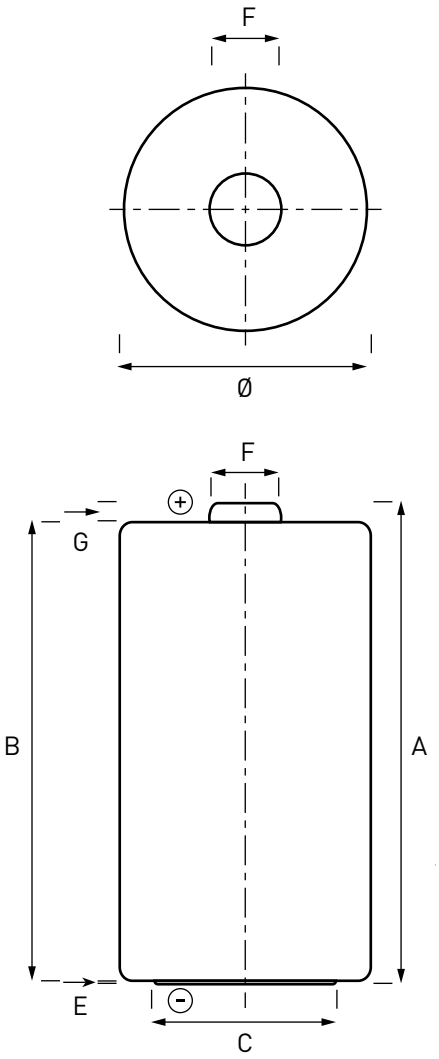






LR20AD POWERLINE

DIMENSIONS (MM)

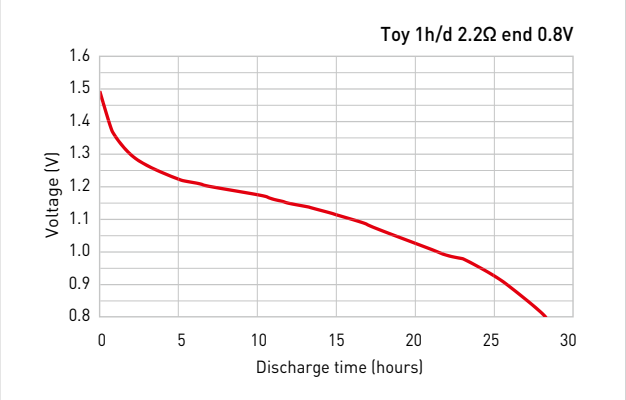


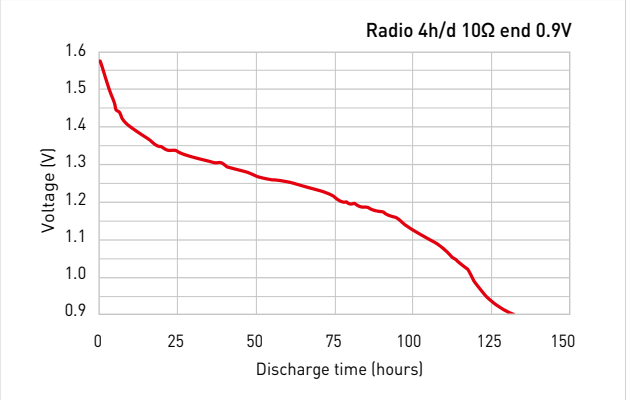
IEC dimensions	Maximum	Minimum
A	61.5	
B		59.5
C		18.0
E	1.0	
F	9.5	
G		1.5
Ø	34.2	32.3

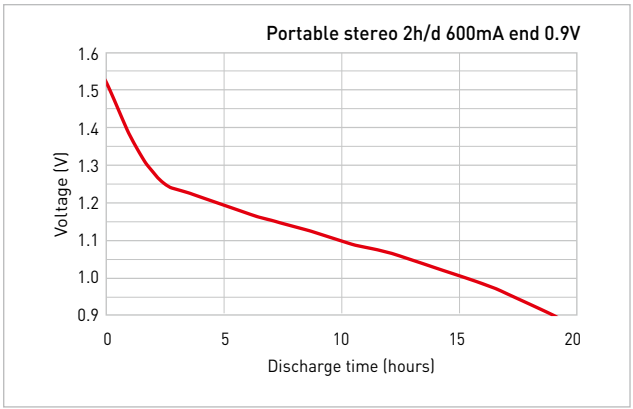
Specifications	LR20 / XL / D / AM1 / MONO / MN1300 / 13A / 13AC
Made in	Belgium
Type	Alkaline Foil
Nominal voltage (V)	1.5
Electrolyte	Potassium Hydroxide
Average weight (g)	138.0
Storage temp. range	+10°C (50°F) ~ + 25°C (77°F)
Operating temp. range	-20°C (-4°F) ~ + 55°C (131°F)
Average Impedance	+/- 90 m-Ω @ 1kHz fresh
Heavy metals	No added Mercury (Hg), Cadmium (Cd) or Lead (Pb)
Compliant to	IEC 60086-1, IEC 60086-2, IEC 60086-5 non dangerous goods regulation EU directive 2006/66/EC Nordic Ecolabel
Recommended cut off voltage	0.8V per cell (0.9V per cell for multi series usage)

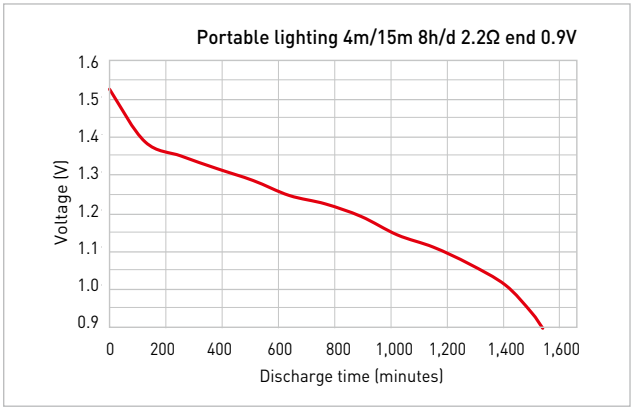
LR20AD POWERLINE

TYPICAL DISCHARGE VALUES

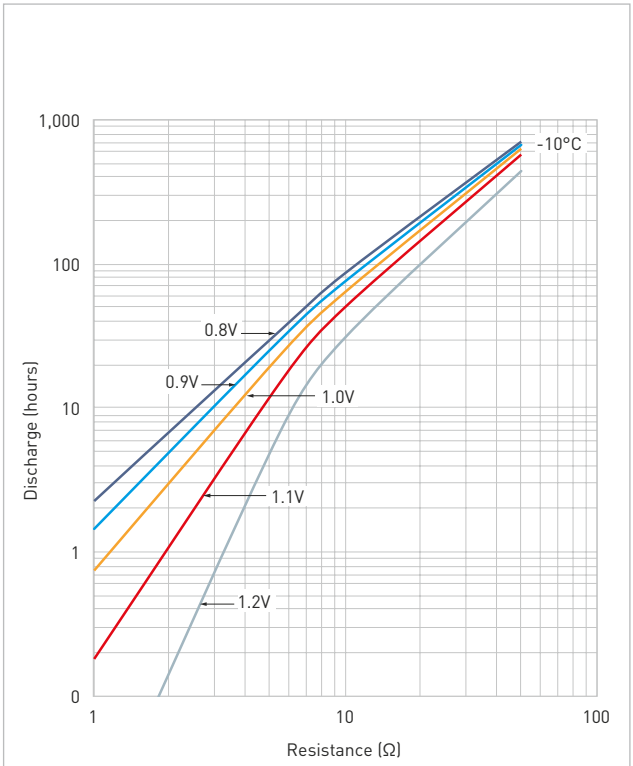


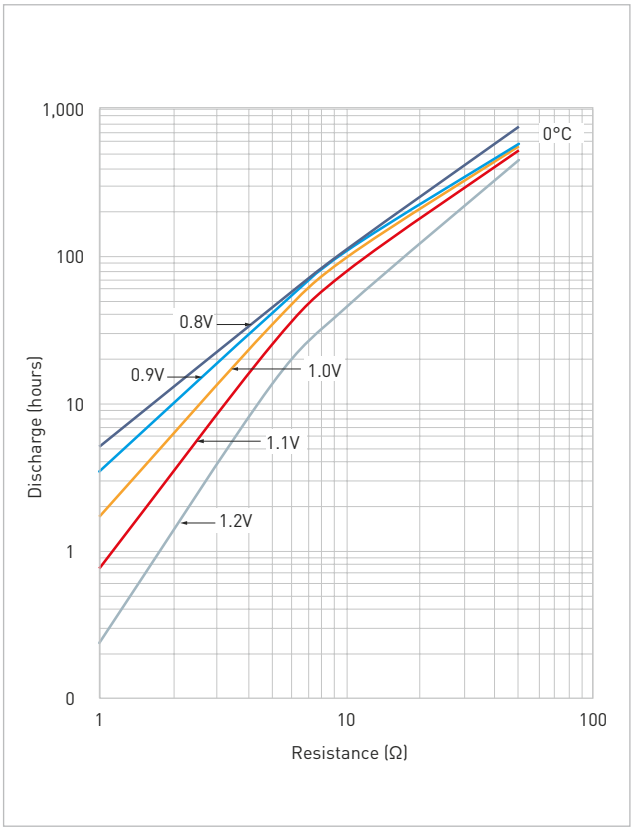






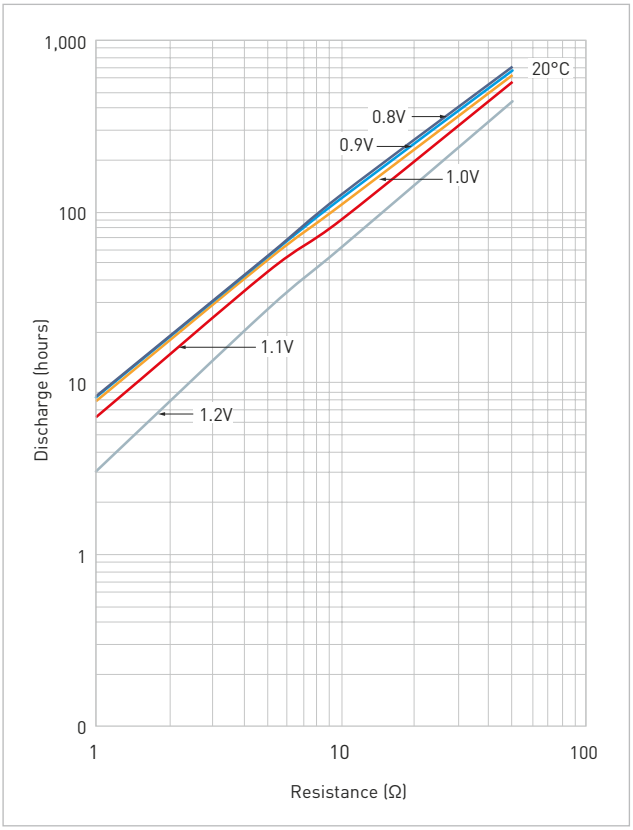
DISCHARGE TEMPERATURE CHARACTERISTICS

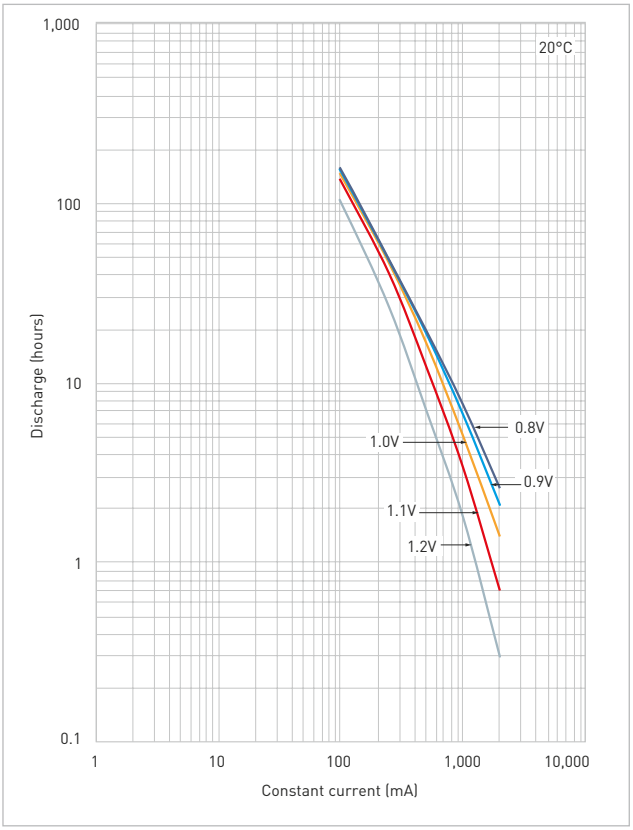


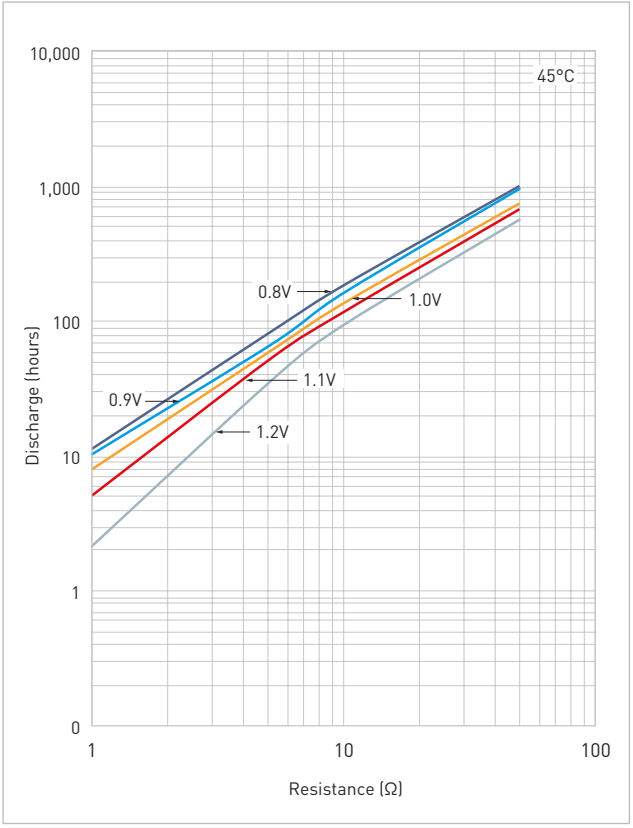


LR20AD POWERLINE

DISCHARGE TEMPERATURE CHARACTERISTICS

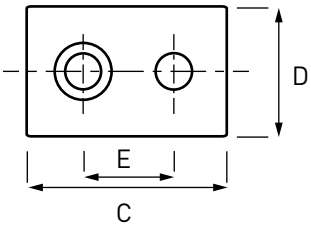


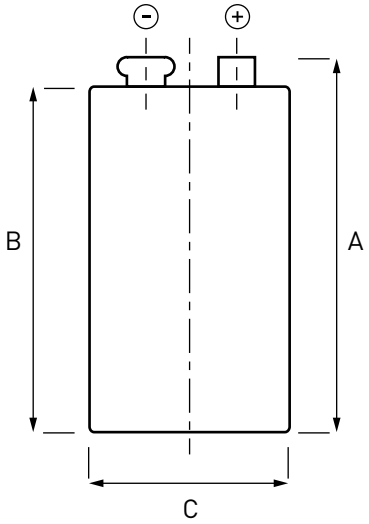




6LR61AD POWERLINE

DIMENSIONS (MM)



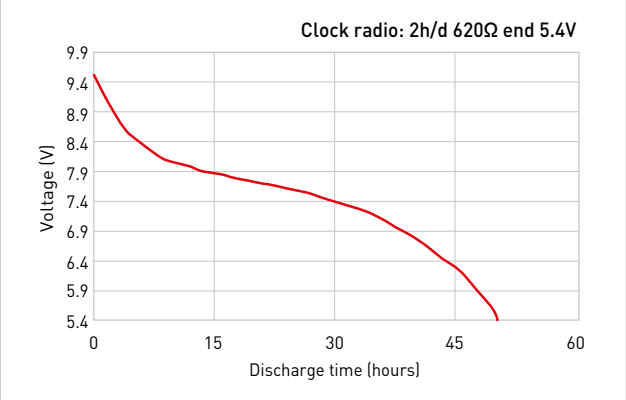


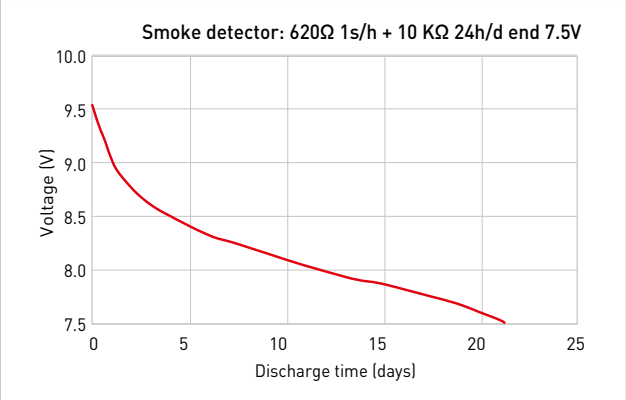
IEC dimensions	Maximum	Minimum
A	48.5	46.5
B	46.4	
C	26.5	24.5
D	17.5	15.5
E	12.95	12.45

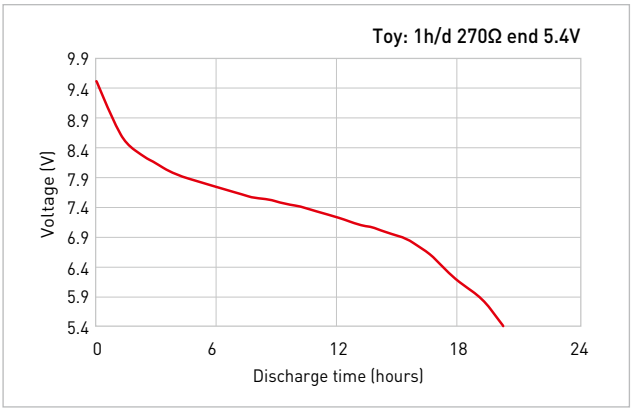
Specifications	9V / 6LR61 / 6AM6 / MN1604 / 1604A / 1604AC
Made in	Belgium
Type	Alkaline Foil
Nominal voltage (V)	9.0
Electrolyte	Potassium Hydroxide
Average weight (g)	43.0
Storage temp. range	+10°C (50°F) ~ + 25°C (77°F)
Operating temp. range	-20°C (-4°F) ~ + 55°C (131°F)
Average Impedance	+/- 2,3Ω @ 1kHz fresh
Heavy metals	No added Mercury (Hg), Cadmium (Cd) or Lead (Pb)
Compliant to	IEC 60086-1, IEC 60086-2, IEC 60086-5 non dangerous goods regulation EU directive 2006/66/EC Nordic Ecolabel
Recommended cut off voltage	5.4V per battery

6LR61AD POWERLINE

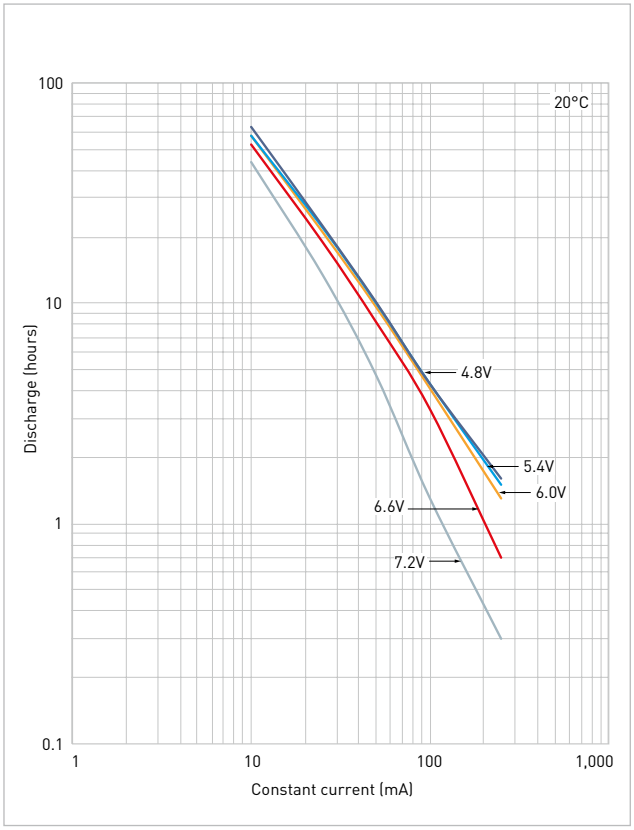
TYPICAL DISCHARGE VALUES







DISCHARGE TEMPERATURE CHARACTERISTICS



IEC

The IEC (International Electrotechnical Commission) is a worldwide standards organisation that prepares and publishes international standards for electrical and electronic technology, including batteries. These standards are technical guidelines that allow appliances and systems which store, use or produce electricity to work together safely, wherever in the world they are manufactured. With IEC standards being so widespread, battery space and contacts in appliances should be designed to enable the use of any IEC-compliant battery.

As a non-profit, non-governmental organisation, the IEC is made up of members (or national committees) from a wide range of countries, and IEC standards are adopted as national standards by its members.

The IEC cooperates closely with other standards organisations such as ISO and IEEE. It provides standards for battery denominations, size and voltage, testing methods, packaging, storage and appliance connections.

The sections below look at some of these areas.

BATTERY DENOMINATION STANDARDS

The denomination of the battery and the corresponding maximum sizes used to be decided by a number of different organisations such as ANSI (American National Standards Institute) or JIS (Japan Industrial Standard). This work has now been concentrated in the IEC.

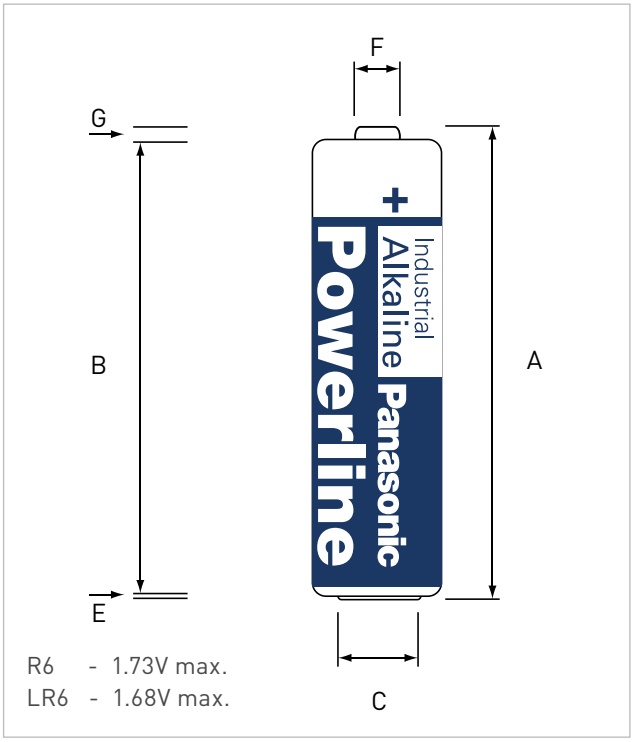
IEC	LR20	LR14	LR6	LR03	6LR61
ANSI	D	C	AA	AAA	9V
JIS	AM-1	AM-2	AM-3	AM-4	6AM-6

Manufacturers should ensure battery dimensions stay within the limits of the specified IEC standards for size. In some cases, however, these limits are rather wide, which can lead to non-conformity between certain devices and certain battery brands.

SIZE AND VOLTAGE STANDARDS

The voltage of a single Alkaline battery is regulated by IEC to be between 1.5V and 1.68V (OCV). IEC defines standard settings and deviations for all batteries. This ensures all manufacturers following these guidelines have products which comply with specific standards. A maximum voltage per battery category is also specified.

IEC dimensions (Example R6/LR6)



R6 - 1.73V max.
LR6 - 1.68V max.

TESTING STANDARDS

There are standard IEC tests and procedures for all types of batteries, considered to be average examples of market usage. Parameters such as average use and cut-off voltage are also decided by this commission. It usually takes months, even years, for IEC to adopt new tests, or change existing tests if this is shown to be necessary to reflect reality. Tests and test methods are periodically discussed with the manufacturers represented on the IEC committee in order to review the criteria based on new appliances or new technologies. Tests should be conducted on batteries which are not older than 60 days after production. Temperature should be controlled during storage as well as during discharge to +/- 2°C.

Testing standards by battery

6LR61AD	Toy - Clock radio - Smoke detector
LR20AD	Portable lighting - Toy - Radio (old IEC) - Portable stereo
LR14AD	Radio (old IEC) - Portable lighting - Toy - Portable stereo
LR6AD	DSC (Digital still camera) - Photoflash (old IEC) - Portable lighting - Motor/toy - CD/wireless gaming and accessories - Radio/clock/remote control - Digital audio
LR03AD	Portable lighting - Toy - Digital audio - Remote control - Radio (old IEC) - Photoflash

PACKAGING STANDARDS

Packaging prevents mechanical damage to the products during transport, handling and stacking. Materials and pack designs are chosen to prevent electrical conduction, corrosion and ingress of moisture. During transport, shock and vibration should be kept to a minimum (gel overspill should be avoided).

Bulk - pizza-box (example)

Small box (example)

STORAGE STANDARDS

The ambient conditions – particularly the temperature – have a major impact on storage quality. Batteries should normally be stored at temperatures between +10°C and +25°C, and the temperature should never exceed +30°C. Storage will improve if the temperature can be held at a consistently lower level (-10°C to +10°C), but at freezing conditions the batteries should have protective packaging to protect them from condensation when they are brought back to normal temperature. Batteries which have been cold-stored should be put into use as soon as possible after being brought back to ambient temperature (preferably during 24-hour conditioning).

Extreme humidity (over 95% and less than 40%) should be avoided, since this is detrimental to both the batteries and the packaging. Care should also be taken with point-of-sale conditions in shops. Batteries should not be exposed to direct sunlight or spotlight, and should be kept away from heat sources.

USAGE STANDARDS

When an appliance device needs new batteries, all the batteries in the appliance should be replaced at the same time, with fresh batteries of the same size. Care should be taken not to combine batteries of different brands, grades and technology.

Appliances should always be switched off after use (users should check that the power switch is in the 'off' position). Batteries should be removed if the appliance is going to be out of use for longer periods (e.g. 14 days for the Nikon flashlight).

SAFETY

IEC 60086-part 5 is dedicated to safety, notably with regard to explosion risk. A range of tests are performed to verify safety:

- Storage after partial use
- Transportation shock
- Transportation vibration
- Climatic temperature cycling
- Incorrect installation
- External short circuit
- Overdischarge
- Free fall test

The outcome of all the tests should be: NO EXPLOSION. In other words, if there is a technical problem, the 'safety unit' should work correctly, preventing the excessive gassing or swelling which would lead to explosion. Inevitably this can result in some degree of leakage.

TRANSPORT

The ICAO TI and U.S. hazardous materials regulations do not classify dry cell batteries as dangerous goods. However, these regulations contain generally consistent Special Provisions that identify how these batteries (and products powered by them) must be packaged for transportation.

Special Provision 304 in the UN Model Regulation Chapter 3.3 states:
Batteries, dry, containing corrosive electrolyte which will not flow out of the battery if the battery case is cracked are not subject to these regulations provided the batteries are securely packed and protected against short-circuits. Examples of such batteries are: Alkali-Manganese, Zinc-Carbon, Nickel-Metal Hydride and Nickel-Cadmium batteries.

Special Provision A123 in the ICAO TI states:
'This entry applies to batteries, electric storage, not otherwise listed in Table 3-1. Examples of such batteries are: Alkali-Manganese, Zinc-Carbon, Nickel-Metal Hydride and Nickel-Cadmium batteries. Any electrical battery or battery-powered device, equipment or vehicle having the potential of a dangerous evolution of heat must be prepared for transport so as to prevent:

(a) A short circuit (e.g. in the case of batteries, by the effective insulation of exposed terminals; or, in the case of equipment, by disconnection of the battery and protection of exposed terminals); and
(b) Unintentional activation.

The words 'not restricted' and the special provision number A123 must be provided on the air waybill when an air waybill is issued.'

CAPACITY OF ALKALINE BATTERIES

Battery capacity is typically expressed in terms of milli Ampere hours (mAh). This is an indication of how long a battery will provide service at a specific drain rate to a specific cut-off voltage. To specify battery capacity precisely, one should give the exact parameters under which the batteries are to be tested: discharge mode, cut-off voltage, temperature, aging time, etc.

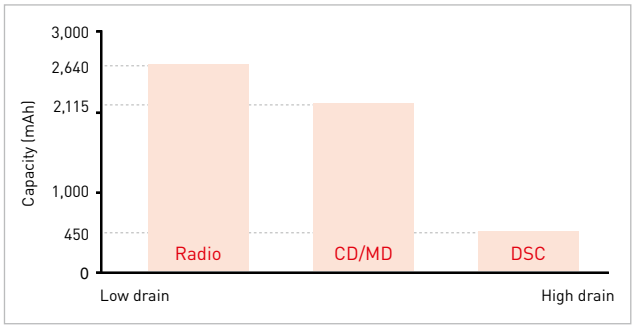
In general, batteries will discharge more efficiently at lower drain rates (i.e. radio test) and thus will exhibit a higher capacity with respect to high drain rates (i.e. DSC test). The type of application, more specific a continuous or a pulse discharge mode, will also impact battery capacity. A very light duty cycle will typically allow the battery time to recover and extend service versus a continuous drain. The major contributing factor to this recovery is the migration of active materials within the battery into the reaction area thereby replacing depleted materials and reaction byproducts. The amount of additional service will depend on the drain rate, and the duty cycle (ON time and OFF time of the pulse). Actual testing is needed to determine the amount of additional service expected in pulse applications since there is no simple equation to accurately calculate the impact of duty cycle on service.

The application cut-off voltage will also impact the battery capacity. The higher the device cut-off voltage, the more of the battery's capacity will be left in the battery unused. However, a minimum voltage cut-off of 0.8V per cell is recommended because of the increased chance of excessive internal gassing when Alkaline batteries are deeply discharged. Overdischarge will also incite the MnO_2 to get over-saturated, start expanding and increase the risk of high pressure inside the cells.

LR6 Powerline capacity high vs. low drain

IEC mode	Drain	Capacity (mAh)
Radio	low	2,640
CD/MD	middle	2,115 (-20%)
DSC	high	450 (-83%)

Why is it so difficult to give an Alkaline battery capacity? Example LR6AD



BATTERY LABELING MARKINGS

Production date code and shelf life date code
There are two important markings on each Alkaline battery label which offer helpful information to the battery user. On the one side each battery label shows the production date code at the bottom of the cell. On the other side the label shows the shelf-life date. This marking indicates the recommended date until which the Alkaline battery will give ideal performance to the application.

LR6AD Powerline

Date code number (example)

61125 01 2024

Shelf life valid until January 2024 (**MM YYYY**) - for Powerline this is until now at least 5 years
Day of production DD - Produced on **25**
Month of production **MM** - Produced in November **(11)**
Year of production (201)**Y** - Produced in 201**6**

PRODUCT SAFETY DATA SHEET*[1]

1. PRODUCTS AND COMPANY IDENTIFICATION

Name of product:	Alkaline Battery LR20, LR14, LR6, LR03, 6LR61
Model name:	Alkaline Battery (EVOLTA/EVOIA) LR20, LR14, LR6, LR03, 6LR61
Name of company:	Panasonic Energy Belgium nv
Address:	Havenlaan 6, B-3980 Tessenderlo Belgium
Telephone:	+32 13 610 523
Fax:	+32 13 678 376
Emergency telephone Belgium:	+32 13 610 523
Emergency telephone Japan:	+81-6-6994-4560 (Working hours) +81-6-6991-1141 (Holiday)
Document number:	ALMN-MSDS-1E-04 PECBE
Issued:	March 14, 2017

2. HAZARDS IDENTIFICATION

Most important hazardous

Adverse human health effects:	When the leaked liquid adheres to the skin, it may cause damage of the skin. When it is got in contact with the eye, it may cause the damage of eye such as losing sight.
Physical and chemical hazard:	There is the risk of explosion if batteries are disposed in fire, heated above 100 degree C. Stacking or jumbling batteries may cause external short circuits, heat generation and explosion.
Specific hazards:	Not applicable.
Class name of hazardous chemicals:	Not applicable.

3. COMPOSITION /IMFORMATION ON INGREDIENTS

Substance name:	Alkaline battery
CAS number:	Not specified

Composition

COMPONENT	CONCENTRATION (WT %)	FORMULA	CAS NO.
<Positive electrode> Manganese dioxide Graphite	 20–45 1.0–4.5	 MnO_2 C	 1313–13-9 7782–42-5
<Negative electrode> Zinc	 10–20	 Zn	 7440–66-6
<Electrolyte> Potassium hydroxide Water	 3–10 1–15	 KOH H_2O	 1310–58-3 –

1*[1]

*[1] The aforementioned PSDS is only an extract. Please contact Panasonic to get the complete version.

ENVIRONMENT

Fully aware that humankind has a special responsibility to respect and preserve the delicate balance of nature, we at Panasonic acknowledge our obligation to maintain and nurture the ecology of this planet. Accordingly, we pledge ourselves to the prudent, sustainable use of the Earth's resources and the protection of the natural environment while we strive to fulfil our corporate mission of contributing to enhanced prosperity for all. At Panasonic Energy Company (PEC) by regarding 'working in harmony with the global environment' as a key management issue, each employee will be encouraged to voluntarily promote environmental preservation activities in all business areas.

Environmental Policy of Panasonic Energy Europe
The policy of our company is to contribute to society by serving our customers worldwide with our products and with our high-quality and highly reliable technology.

- Establish environmental management systems and pursue environmental preservation activities.
- Correctly understand the impact that company activities have on the environment and pursue unremitting environmental preservation activities which our technology and finances allow.
- Pursue external auditing of our operation based on an ISO 14000 environmental management system.
- Where applicable take action for resource and energy conservation, recycling and waste reduction.
- By offering environmental education and training to all employees, raise their awareness about environmental preservation.
- Our Factory PECBE is the first Panasonic factory in the world achiving a full CO_2 neutral production. With an onsite windmill and many other efforts they achived this neutral status.

PANASONIC STANDARDS

ISO standards
PECBE produces LR20, LR14, LR6, LR03 and 6LR61 in Belgium and has following ISO certificates:
ISO 9001-2000 series
ISO 14001 series

IEC standards
Our batteries comply with following international standards:
IEC 60086-1
IEC 60086-2
IEC 60086-5
ANSI C18.1M

PACKAGING

Panasonic offers you a wide range of standard packaging solutions for Alkaline batteries. We can also provide special packaging customized to your requirements. If you need tailor-made packaging, please get in touch with us.

10 PIECES BOX

Model number	Size	Packaging	Packaging description	Units/ box	Units/ bundle	Units/ pallet
LR03AD	AAA	LR03AD/10BB	10 pieces box	120	–	79.200
LR6AD	AA	LR6AD/10BB	10 pieces box	120	–	37.440
LR14AD	C	LR14AD/10BB	10 pieces box	60	–	13.680
LR20AD	D	LR20AD/10BB	10 pieces box	60	–	6.600
6LR61AD	9V	6LR61AD/10BB	10 pieces box	120	–	16.800

BULK (PIZZA-BOX)

Model number	Size	Packaging	Packaging description	Units/ box	Units/ bundle	Units/ pallet
LR03AD	AAA	LR03AD/B	bulk (pizza-box)	500	500	72,000
LR6AD	AA	LR6AD/B	bulk (pizza-box)	500	500	36,000
LR14AD	C	LR14AD/B	bulk (pizza-box)	80	80	11,520
LR20AD	D	LR20AD/B	bulk (pizza-box)	85	85	6,120
6LR61AD	9V	6LR61AD/B	bulk (pizza-box)	198	198	14,256

SMALL BOX

Model number	Size	Packaging	Packaging description	Units/ box	Units/ bundle	Units/ pallet
LR03AD	AAA	LR03AD/4P	4-shrink	48	240	49,920
LR6AD	AA	LR6AD/4P	4-shrink	48	240	36,000
LR14AD	C	LR14AD/4P	4-shrink	24	120	10,560
LR20AD	D	LR20AD/4P	4-shrink	24	120	5,760
6LR61AD	9V	6LR61AD/1P	1-shrink	12	60	11,520

BIG BOX

Model number	Size	Packaging	Packaging description	Units/ box	Units/ bundle	Units/ pallet
LR03AD	AAA	LR03AD/2P	2-shrink (unsorted packed in carton box)	500	500	50,000
LR03AD	AAA	LR03AD/3P	3-shrink (unsorted packed in carton box)	450	450	45,000
LR6AD	AA	LR6AD/2P	2-shrink (unsorted packed in carton box)	200	200	20,000
LR6AD	AA	LR6AD/3P	3-shrink (unsorted packed in carton box)	600	600	28,800

Customized packaging: if you need special types of packaging, please bear in mind that reasonable supply quantities are required, and it will also take a certain time to evaluate the production procedure.

FIND THE RIGHT CONTACT

Website for Panasonic HTML App Battery Finder
Get more information on Panasonic Battery Finder website.
https://eu.industrial.panasonic.com/battery-finder-html-app

YouTube Channel
Please find a comprehensive selection of Panasonic battery videos at our YouTube Channel.
https://www.youtube.com/user/panasoniceubatteries

E-mail and website for all European countries
battery-solutions@eu.panasonic.com
http://industry.panasonic.eu

Notice to Readers
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