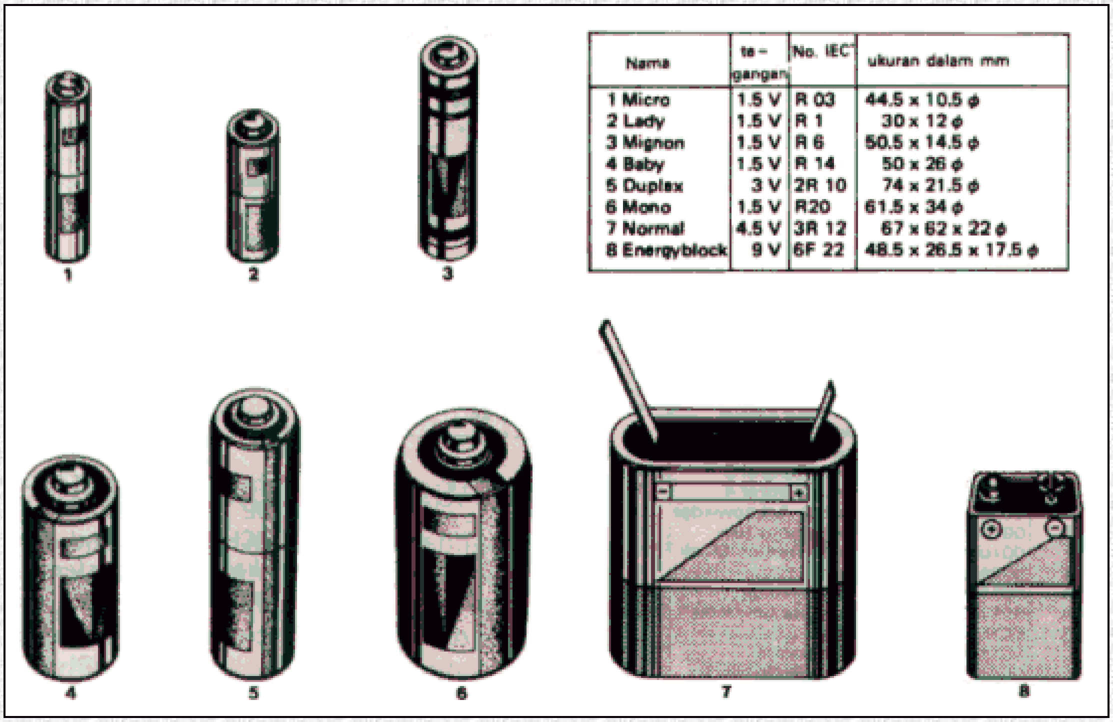
BATTERIES

UNDER CONSTRUCTION

I. KIND OF BATTERIES

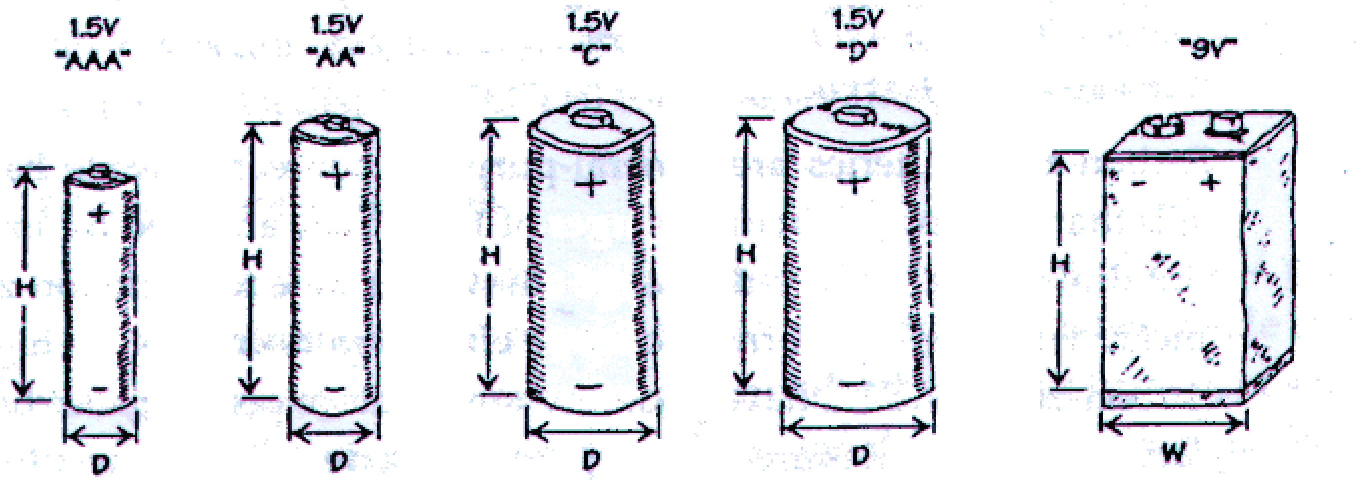
- **PRIMARY BATTERIES**

Primary batteries are one shot deals, once they are drained, it is all over. Common primary batteries include carbon zinc batteries, alkaline batteries, mercury batteries, silver oxide batteries, zinc air batteries, and silver zinc batteries. Here are some common battery packages and their characteristics :



Nama	te-gangan	No. IEC	ukuran dalam mm
1 Micro	1.5 V	R 03	44.5 x 10.5 ϕ
2 Lady	1.5 V	R 1	30 x 12 ϕ
3 Mignon	1.5 V	R 6	50.5 x 14.5 ϕ
4 Baby	1.5 V	R 14	50 x 26 ϕ
5 Duplex	3 V	2R 10	74 x 21.5 ϕ
6 Mono	1.5 V	R20	61.5 x 34 ϕ
7 Normal	4.5 V	3R 12	67 x 62 x 22 ϕ
8 Energyblock	9 V	6F 22	48.5 x 26.5 x 17.5 ϕ

Common Alkaline and Carbon Zinc Cells



"AAA"	D	0.41"	(13/32")
"AAA"	H	1.75"	(1 31/32")
"AA"	D	0.56"	(9/16")
"AA"	H	1.97"	(1 31/32")
"C"	D	1.02"	(1 1/64")
"C"	H	1.97"	(1 31/32")
"D"	D	1.32"	(11/32")
"D"	H	2.39"	(2 27/64")
"9V"	W	1.03"	(13/32")
"9V"	L	0.65"	(11/16")
"9V"	H	1.91"	(1 15/16")

Lithium

Voltage:
1.55 to 6V
Diameter:
0.460 to 0.965"
Thicknesses:
0.079" to 0.990"
mAh:
60 to 250 mAh
Label:
Given in I.E.C. number (e.g., CRXXXX or BRXXXX)

Zinc air

Voltage:
1.15 to 1.4V
mAh:
70 to 600 mAh
Labels:
ZAXXX

Mercury

Voltage:
1.35 to 5.6V
Diameter:
0.5 to 0.695"
Thicknesses:
0.135" to 0.845"
mAh:
80 to 1000 mAh

Silver oxide

Voltage:
1.55V
Diameter:
0.267 to 0.610"
Thicknesses:
0.81" to 0.210"
mAh:
15 to 250 mAh
Label:
Given in I.E.C. number (e.g., SRXX)

CELL TYPE	ANODE (-)	CATHODE (+)	MAXIMUM VOLTAGE (THEORETICAL) (V)	MAXIMUM CAPACITY (THEORETICAL) (Ah/KG)	WORKING VOLTAGE (PRACTICAL) (V)	ENERGY DENSITY (Wh/KG)	SHELF LIFE AT 25°C (80% CAPACITY) (MONTHS)
Carbon-zinc	Zn	MnO_2	1.6	230	1.2	65	18
Alkaline-MnO_2	Zn	MnO_2	1.5	230	1.15	65	30
Mercury	Zn	HgO	1.34	185	1.2	80	36
Silver oxide	Zn	AgO	1.85	285	1.5	130	30
Zinc-air	Zn	O_2	1.6	815	1.1	200	18
Lithium	Li	$(CF)_n$	3.6	2200	3.0	650	120
Lithium	Li	CrO_2	3.8	750	3.0	350	108
Magnesium	Mg	MnO_2	2.0	270	1.5	100	40

1. CARBON ZINC BATTERIES

George Leclanche invented the carbon zinc battery in 1866. By 1868 it was adopted by the Belgium telegraph sevice and ultimately went on to be the standard for portable batteries around the world. The original leclanche cell was a wet cell, with the electrodes immersed in liquid electrolyte. Laterdevelopments moved the electrolyte to a wet paste, giving us the carbon zinc dry cell. A heavy duty version uses a zinc carbon zinc chloride chemistry, for a higher capacity.

Carbon zinc batteries are general purpose, nonrechargeable batteries made from cells that have open circuit voltages of 1.6 V. They are used for low to moderate current drains. The voltage discharge curve over time for a carbon zinc battery is nonlinear, whereas the current output efficiency decreases at high current drains. Carbon zinc batteries have poor low temperature performance but good shelf lives. This battery is susceptible to leaking its corrosive electrolyte. Carbon zinc batteries are used to power such devices as power toys, consumer electronic products, flashlights, cameras, watches, and remote control transmitters.

2. ZINC CHLORIDE BATTERIES

A zinc chloride battery is a heavy duty variation of a zinc carbon battery. It is used in applications that require moderate to heavy current drains. Zinc chloride batteries have better voltage discharge per time characteristics and better low temperature performance than carbon zinc batteries. Zinc chloride batteries are used in radios, flashlights, lanterns, fluorescent lanterns, motor driven devices, portable audio equipments, communications equipments, electronic games, calculators, and remote control transmitters.

3. ALKALINE BATTERIES

Alkaline batteries, as a class, were developed between 1895 and 1905 and were finally commercialized in the mid 1950s. This coincided with the rising popularity of electronic flash units in small portable cameras, which required the high power output the alkaline chemistry provided.

Alkaline batteries are general purpose batteries that are highly efficient under moderate continuous drain and are used in heavy current or continuous drain applications. Their open circuit voltage is about 0.1 V less that that of carbon zinc cells, but compared with carbon zinc cells, they have longer shelf lives, higher power capacities, better cold temperature performance, more leak resistant and weigh about 50 percent less. One drawback of the rechargeable alkaline is its capacity fade. After each discharge, the battery will lose some of its capacity. After about 25 cycles, it is at 50% capacity, 50 cycles sees it at 20% capacity, where it appears to stay until the 100 cycle point at the end of its rated life. Alkaline batteries are interchangeable with carbon zinc and zinc chloride batteries. Alkaline batteries are used to power such things like video cameras, motorized toys, photoflashes, electric shavers, motor driven devices, portable audio equipments, communications equipments, smoke detectors, and calculators. As it turns out, alkaline batteries come in both nonrechageable and rechargeable forms.

4. MERCURY BATTERIES

Mercury batteries are very small, nonrechargeable batteries that have open circuit voltages of around 1.4 V per cell. Unlike carbon zinc and alkaline batteries, mercury batteries maintain their voltage up to a point just before the die. They have greater capacities, better shelf lives, and better low temperature performance than carbon zinc, zinc chloride, and alkaline batteries. Mercury batteries are designed to be used in small devices such as hearing aids, calculators, pagers, and watches.

5. LITHIUM BATTERIES

Lithium batteries are nonrechargeable batteries that use a lithium anode, one of a number of chatodes, and an organic electrolyte. Lithium batteriescome with open circuit voltages of 1.5 or 3.0 V per cell. They have high energy densities, outstanding shelf lives (8 to 10 years), and can operate in a wide range of temperatures, but they have limited high current drain capabilities. Lithium batteries are used in such device like cameras, meters, cardiac pacemakers, CMOS memory storage devices, and liquid crystal displays (LCDs) for watches and calculators.

6. SILVER OXIDE BATTERIES

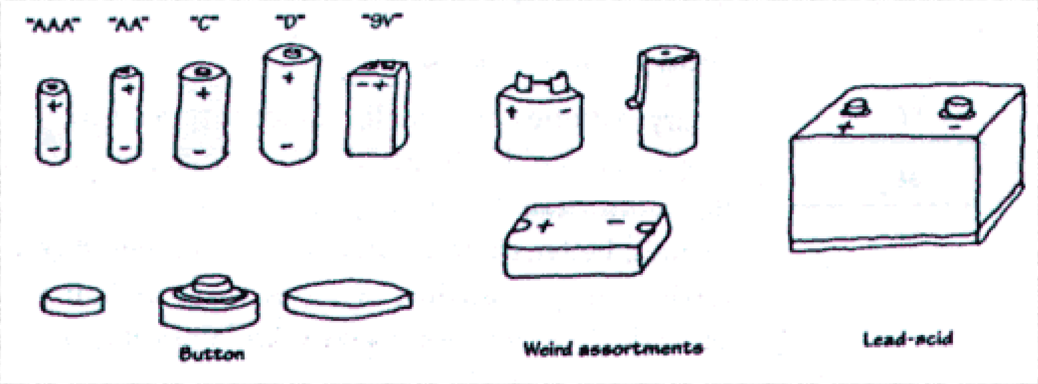
Silver oxide batteries come with open circuit voltages of 1.85 V per cell. They are used in applications that require high current pulsing. Silver oxide batteries have flat voltage discharge characteristics up until death but also have poor shelf lives and are expensive. These batteries are used in such devices like alarms, backup lighting, and analog devices. As it turns out, like alkaline batteries, they too come in nonrechargeable and rechargeable forms.

7. ZINC AIR BATTERIES

Zinc air batteries are small, nonrechargeable batteries with open circuit voltages of 1.15 to 1.4 V per cell. They use surrounding air (O_2) as the chatode ingredient and contain air vents that are taped over during storage. Zinc air batteries are long lasting, high performance batteries with excellent shelf lives and have reasonable temperature performance (about 0 to 50 ^oC, or 32 to 122 ^oF). These batteries typically are used in small devices such as hearing aids and pagers.

- ## SECONDARY BATTERIES

Secondary batteries, unlike primary batteries, are rechargeable by nature. The actual discharge characteristics for secondary batteries are similar to those of primary batteries, but in terms of design, secondary batteries are made for long term, high power level discharges, whereas primary batteries are designed for short discharges at low power levels. Most secondary batteries come in packages similar to those of primary batteries, with the exception of, say, lead acid batteries and special purpose batteries. Secondary batteries are used to power such devices like laptop computers, portable power tools, electric vehicles, emergency lighting systems, and engine starting systems. Here are some common packages for secondary batteries and their characteristics :



BATTERY TYPE	ANODE (-)	CATHODE (+)	MAXIMUM VOLTAGE (V)	MAXIMUM CAPACITY (THEORETICAL) (Ah/kG)	WORKING VOLTAGE (PRACTICAL) (V)	ENERGY DENSITY (Wh/kG)
Lead-acid	Pb	PbO_2	2.1	55	2.0	37
Edison (Ni-Fe)	Fe	NiO_x	1.5	195	1.2	29
NiCad	Cd	NiO_x	1.35	165	1.2	33
Silver-cadmium	Cd	AgO	1.4	230	1.05	55
Cadmium-air	Cd	Air (O_2)	1.2	475	0.8	90
Silver-zinc	Zn	AgO	1.85	285	1.5	100
Zinc-air	Zn	Air (O_2)	1.6	815	1.1	150

1. LEAD ACID BATTERIES

Secondary batteries became practical in 1860 with the invention of the lead acid battery by Raymon Gaston Plante. In 1881, Faure (and others) improved the yield of the lead acid cell by substituting a lead oxide paste for the pure lead of the plante cell.

The largest problem associated with this batery is the damage caused by leaking acid. German researchers addressed this problem in the early 1960s by developing a gelled electrolyte. Working from another direction, other researchers developed a way to completely sealed the battery, preventing leaks. Either way, the sealed lead acid battery needs a little or no maintenance, which, while costing more, can be an advantage in some situations.

A completely sealed battery, wheather it is a gel cell or not, also pevents hydrogen gas from escaping when you recharge the battery, which is an improvement in safety when the battery is to be used indoors, such as on a robot or wheelchair. A gelled battery won't leak even if it is punctured, but it can also have a slightly lower energy density than its liquid counterpart, at about 80% or so.

Deep cycle batteries are a special variety of lead acid battery that can be discharged to low voltage levels without coming on to harm. Deep cycle batteries are typically used in marine or wheelchair applications. Regular car batteries are designed for short bursts of high ampere use to start the vehicle, with no deep discharges allowed. The electrode plates in a deep cycle battery are made thicker and less porous than the car battery, and will last two to four times longer than the car battery in deep cycle applications. Dual marine batteries are a compromise of the two types.

Lead acid batteries are rechargeable batteries with open circuit voltages of 2.15 V per cell while maintaining a voltage range under a load from 1.75 to 1.9 V per cell. The cycling life (number of times the battery can recharged) for lead acid batteries is around 1000 cycles. They come in rapid, quick, standard, and trickle charging rate types. Lead acid batteries have a charge retention time (time until the battery reaches 80 percent of maximum) of about 18 months. They contain a liquid electrolyte that requires servicing (replacement). Six lead acid cells make up a car battery.

2. NICKEL CADMIUM (NiCd) BATTERIES

The technology behind the nickel cadmium battery was invented in 1899 by Wldmar Jungner, but the battery didn't reach commercial use until the 1930s when new electrodes were developed. The original version of the NiCd battery used a vented, unsealed cell that required regular maintenance. In the 1940s they perfected the sealed NiCd cell, though the cell do retain a need to breathe a bit, which is maintenance free, and the battery came to the fore in the 1950s. In 2000, it accounted for more than 50% of the world's rechargeable batteries for portable applications. Today's NiCd batteries can take a lot of abuse, both mechanical and electrical, and are cheaper than other batteries in cost per hour of use.

The capacity of a Nicd isn't seriously affected by the discharge rate. If you extract current from the cell at a lower than specified rate, you get a little more life. Extracting current from the cell at a rate ten times the specified rate only lowers the capacity to about 70% of its rated level, so a 1000Ah battery would only give 700Ah.

This battery has a surprisingly high capacity for current delivery. The AA battery shown has a recommended maximum continuous current draw of 9 amps, with 18 amp pulses allowed. There are two issues you face when you use a NiCd battery. One is the dreaded memory effect (which doesn't seem to plague other batteries), and the other is cell reversal. Though hotly disputed in hobbyist circles, the memory effect is very real in some, but not all, NiCd batteries. This effect appears because the battery retains the characteristics of previous discharges that is, after repeated shallow discharges, the battery may be unable to discharge beyond the earlier points. It would seem that, under certain conditions, electrodes in the cell can develop a crystalline growth. This growth reduces the area of the electrode exposed to the electrolyte. This leads to a voltage reduction and a loss of performance. Avoiding the memory effect is fairy simple. Fist, quick charge rather than trickle charge your NiCd batteries. Quick charginghelps negate the effect of NiCd memory. Second, be sure to fully discharge your batteries to their 1 volt level, under a light load, on a regular basis.

Cell reversal is a condition that can occur with multiple NiCd cells connected in series, such as in a multiple cell battery or a battery pack. Since not all cells are exactly the same, one cell in a chain may use up all of its charge before the others. As the pack continues to be used, a reverse charge is sent through the empty cell due to its charged neighbors. This reacts the water with the cathode, bonding the oxygen to the electrode and releasing hydrogen, which is then vented. This loss of water reduces the life of the cell. To prevent cell reversal, don't perform a deep discharge on a battery pack. It is save to cycle an individual cell to zero volts. In fact, timing the discharge cycle of a cell is one way of determining its exact capacity. With this information, a cell can be matched with other equivalent cell into a battery pack that is less prone to reversal.

Nickel cadmium batteries contain rechargeable cells that have open circuit voltages of about 1.2 V. They are often interchangeable with carbon zinc and alkaline batteries. For the first 2/3 of its life, a nickel cadmium battery's discharge curve is relatively flat, but after that, its curve begins to drop. Nickel cadmium batteries weigh about a third as much as carbon zinc batteries. Placing these batteries in parallel is not recommended (series is ok). These batteries are used in such devices like toys, consumers electronic producs, flashlights, cameras, photographic equipments, power tools, and appliances.

3. NICKEL METAL HYDRIDE (NiMH) BATTERIES

The NiMH battery chemistry began its life in the 1970s, but it took more than ten years before its performance was good enough for commercial use. Modern batteries seem to be either incremental improvements on old technologies or inventions of large corporate research departments, so it's harder to name the inventors of this chemistry. Since the 1980s, the performance of the NiMH battery has been improved continuously by many companies, and it is now an excellent battery for portable applications.

The NiMH battery comes in the same sizes, with the same nominal voltage and same discharge curves as the NiCd battery. NiMH battery has a higher energy density and a lower internal resistance, the AA size has a maximum continuous current draw rating of 10 amps, with 15 amp pulses. While the NiMH battery won't hold its charge as long as the NiCd, it can carry more power. The average AA size has 1200Ah of capacity, compared to 800Ah for NiCd. NiMH batteries are less prone than NiCd batteries to the memory effect, but can still suffer from cell reversal problems when deeply discharged in packs.

4. LITHIUM ION (Li-ION) BATTERIES

Continuing in the tradition of modern battery chemistries, the lithium ion battery has an increased energy density and can provide a respectable amount of current. High discharge rates don't significantly reduce its capacity, nor does it lose very much capacity after each cycle, still retaining 80% of its energy capacity after 500 recharge cycles. This is a volatile technology, early versions were prone to exploding in the labs. It is the volatile nature of lithium that gives this battery its punch, though. These benefit come with a price, of course (perhaps to pay for equipment damaged in the research?). As the technoly matures, youshould expect the price to drop.

5. FUEL CELLS BATTERIES

Fuel cells aren't available for small, portable applications yet, but they are coming soon. The fuel cell isn't so much a battery as it is a catalytic chemical engine that creates electricity from fuel. The fuel is typically a variation of hydrogen, such as the hydrocarbon fuels methanol, natural gas, or even gasoline. When these reach market you won't be recharging your batteries anymore, you will be refilling them.

Reference :

- 'Data Sheet Book 2' - by: J.P.M. Steeman, 1988, Elektuur B.V., Beek L., Netherlands, translate by: PT. Elex Media Komputindo, Jakarta, Indonesia.
- 'Practical Electronics for Inventors' - by : Paul Scherz, 2000, Mc. Graw Hill.
- 'Applied Robotics II' - by : Edwin Wise, 2003, Delmar Learning, Thomson publishing.

Create on : May 21, 2006
Last updated : - by : David Setya Atmaja

Return to Prev. Page