Ni-MH Battery Knowledge

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Catalogue

No.1 ***Battery Principle And Mark***

1.1．What is battery?

A battery is a source of electrical energy. It is consisted by two substances, and represented by two electrochemically active electrodes of different composition, both of which are immersed in an electrolyte that provides a conductive medium between them. When a battery is connected on an outside load, it provides energy by conveying its internal electrochemical actions.

1.2．What is the difference between primary and secondary battery?

A primary battery can discharge once only, while a second battery is rechargeable. When discharge a rechargeable battery, its electrode volume and structure cause a reversible change. Therefore the design of a rechargeable battery must be adequate to adjust these changes. Since the internal structure of a primary battery is much simple, it doesn't have to accommodate reversible volume changes. The primary battery has bigger quality ratio and volume ratio than rechargeable battery, however it has much bigger impedance, consequently the load capability is lower. Furthermore self-discharge of a primary battery is far lower than secondary one.

1.3．What is IEC?

IEC is the abbreviation of International Electrical Commission, which is a worldwide organization of national electrical commission. To promote the standardization in electrician and electron area is its goal. Currently there have been IEC285 for Ni-Cd cell and IEC61436 for Ni-MH. For Li-ion cell there is not yet any IEC standards, generally it is based on Sanyo or Panasonic.

1.4．What is the electrochemistry principle of Ni-MH battery?

Ni-MH has the similar Ni oxide with Ni-Cd as its positive, hydrogen metal as negative, KOH as basis electrolyte. When Ni-MH cell is charged, positive reaction is:

Ni(OH)2 –e + OH- → NiOOH + H2O

Negative reaction is: M +H2O+e → MH +OH^-

Discharged, positive reaction is: NiOOH + H2O + e → Ni(OH)2 + OH-

Negative reaction is: MH + OH^- → M + H2O+e

1.5. The classification and comparation of the chemical battery

Type	Advantage	Disadvantage	Usage
Lead-acid battery	Low price ; good performance in high rate discharge、floating charge and discharge in low temperature	Pollution of the environment ; low capacity and specific energy ; inconvenience in carry-over	Rechargeable battery of automobile and motorcycle ; the in support battery of the UPS system
Cd-Ni rechargeable battery	Stabilization in high rate discharge ; comparative low price	Pollution of the environment ; harmful to human being ; possession of memory effect ; lower specific capacity than MH-Ni battery	Power-driven tool and some electrical toy ; personal stereo
MH-Ni rechargeable battery	High specific capacity good performance in high and low temperature ; No memory effect ; good in high rate discharge ; No pollution ; high security	The specific energy lower than Lithium-ion battery ; higher price than Cd-Ni battery	Power-driven tool and toy ; Electromotion cycle and sliding plate ; wireless telephone ; personal stereo ; in support battery ; inside battery of some equipment
Lithium-ion battery	High specific energy ; cabinet ; low weight ; No pollution ; No memory effect	Low security ; low performance in high rate discharge ; high price	Mobile telephone ; Note-book computer
Li-polymer battery	High security ; high specific energy ; can be made to any shape at will ; No pollution ; No memory effect	Low performance in high rate discharge ; technology is not enough mature ; high price	Mobile telephone ; the inside battery of magcard

1.6．How many battery package materials are frequently used?

1.6.1 Insulation rings (or paper) e.g. fiber paper, double sides pastern
1.6.2 PVC、trademarked tubes
1.6.3 Connections plates: stainless steel plates, nickel plates, nickel plating steel plates
1.6.4 Lead plates: stainless steel plates (easily tin soldered), nickel plates (strong spot welding)
1.6.5 Plugs
1.6.6 Protectors: thermal switches, poly-switch, current-limited resistances
1.6.7 Boxes and cases
1.6.8 Plastic shells

1.7．What are the marking approaches of rechargeable batteries?

In accordance with IEC, the marks of nickel hydrogen batteries must cover 5 elements:

1） Cell types: KR is designed for Ni-Cd, HF for Ni-MH, and HR for Ni-MH

2） Cell sizes: the diameter and height of cylinder battery, or the height, width and length of prismatic battery as well as numerical value should be separated by a solidus "/". The unit is mm.

3） Discharge characteristic signs: L suggests that the rate of discharge is within 0.5C, M within 0.5C-3.5C, H within 3.5C-7.0C, X within 7C-15C high.

4） T is designed to mark high temperature cells.

5） Cell terminations: CF means connection-free; HH (head to head) suggests that cells with connection tabs on the cover and along the length in series; HB (head to base) means that cells with connection tabs on the cover and on the base in series. For example: HF 18/07/49 means that prismatic Ni-MH cell, the width is 18mm,thickness is 7mm, height is 49mm.

1.8.What are the marks and its meanings of SPK Ni-MH battery packages?

In general marks are covered five compositions:

① Cell system: D for Ni-Cd and H for Ni-MH

② Cell type: AAA、AA、A、SC、C、D and others

③ Cell nominal capacity

④ A means high cap cell, B for low cap cell, H for high temperature cell, and P for strong current discharge required.

⑤ Numbers of cells are packed.

例：D —— AA 800 H ＊5

① ② ③ ④ ⑤

H —— SC 2200 P ＊3

① ② ③ ④ ⑤

D —— AA 800 B ＊3

① ② ③ ④ ⑤

1.9．What are the main compositions?

The main compositions are: positive plates, negative plates, separators, caps, cases, and insulation layers.

1.10 . What is the objective to pack and assemble cells?

1.10.1 Be beautiful to look at, trademark (design mark and brand tube);
1.10.2 Voltage limitation: combine batteries in series to get high voltage;
1.10.3 Protect battery: prevent battery from short-circuit and extend the cycle life;
1.10.4 Size limitation;
1.10.5 Ease to transportation(design of paper cabinet and paper box);
1.10.6 Especial function design, such as waterproof, especial surface design.

No.2 Battery Performance And Testing

2.1．What are the main characteristics of second battery？

Its main characteristics include voltage, impedance, capacity, gas pressure, self-discharge rate, cycle life, sealing, safety, storage, and appearance. There still are others such as over-charge, over-discharge, soldering, causticity proof and so on.

2.2．What is secondary battery self-discharge?

Self-discharge is also named holding electricity capability. It is the capability that a battery holds electricity under open circuit condition. In general, techniques, materials, and storage conditions determine it. Self-discharge is one of the major parameters for estimating a battery performance.

2.3．What is impedance? How to measure?

Because a cell is equivalent to a resourceful resistance, thus characteristic can be used as the measurement approach. If a cell is connected with a 1000Hz and 50mA constant current while series actions are taken such as sampling its voltage, commutating and filtering wave, its impedance value can be gained accurately. Battery impedance is the resistance when the current flow through an operating cell, in general the internal resistance is included both d.c. and a.c. resistance. For the rechargeable cell resistance is small and electrode is easy to be polarized along with producing a polarization resistance while measure d.c. resistance, the accurate value can't be measured. But measuring a.c. resistance can avoid the inflection of polarization, so accurate value will be gained more easily.

2.4．What is charge efficiency?

It is the ratio between the output and input capacity when the cell is discharged at a certain condition. It can be calculated by the following formula:
Charge efficiency=
Some of the input energy can transform the active material into charge status; some is consumed to produce oxygen in subsidiary reaction. The charge efficiency is affected by charge speed and ambient temperature. During charging the current must be defined in a certain range, too heavy or too small

current can bring low charge efficiency. Because of self-discharge the battery can't be fully discharged.

2.5．What is cell capacity?

It means that the output energy when the cell is discharged to an end voltage at a certain discharge condition. IEC standard specifies that Ni-MH cell rating capacity indicates the output energy which the cell is charged at 0.1C for 16hrs, then discharged at 0.2C to 1.0V at temperature of 20℃±5℃. It can be described as C5C.

2.6．What are the most usual charge methods?

2.6.1 Constant current (ab. CC) charge: it is the most usual method that charge currents are fixed at a certain value during the charge progress.
2.6.2 Constant voltage (ab. CV) charge: during the charge progress the voltages between the two terminals of the power supply is maintained at a certain value, while the current in the circuit become smaller and smaller with the battery voltage rises.
2.6.3 CC&CV charge: firstly a cell is charged at CC, when the cell voltage rises to a value, its voltage keeps steady, while the current in the circuit drops to the smallest till to zero at last.

2.7．What is pulse charge? What is the impact on battery performance?

Charge then discharge is the common method used in pulse charge, i.e. charge for 5 seconds, then discharge for 1second, thus the most oxygen generated during charge is reverted to electrolyte at pulse discharge. Not only the gasification quantity of inner electrolyte is limited, but also the old batteries which have been seriously polarize can recover to or approach to their primary capacities after using this method for 5-10 times
.

2.8．What are the standards for charging and discharging batteries?

Prior to charging at 0.1C for 16hrs the cell shall have been discharged at 0.2C to 1.0V/cell, after that it shall be rested for 1hour, then discharged at 0.2C to 1.0V/cell. That is the charge and discharge standard for batteries.

2.9．How many items for battery reliability test?

2.9.1 Capacity test

2.9.2 Impedance test
2.9.3 Charge retention test
2.9.4 Overcharging endurance test
2.9.5 Cycle life test
2.9.6 Inner gas pressure test
2.9.7 Voltage measurement
2.9.8 Drop test

2.10．What is drop test?

The having been charged batteries are been dropped from 1m high at three different directions twice onto a hard rubber board. There is no damage of the assembly performance and outside packages.

2.11．What is standard for charge retention test?

Prior to the test, the battery shall be discharged at 0.2C to 1.0C/cell. After the battery is charged at 0.1C for 16h at an ambient temperature of 20℃±5℃ and a relative humidity of 65%±20%, it shall then be stored for 28 days on open circuit. After that the battery is discharged at 0.2C to 1.0V/cell, and the discharge duration of Ni\MH should be not less than 3h15min.

2.12．What is the high temperature acceleration test?

As the charge retention takes a longer time, generally high temperature acceleration test is suggested for Ni-MH cell. Store the fully charged cell at an ambient temperature of 45℃ for 3 day, after that rest it for 1h, then discharge at 0.2C to 1.0V and the duration shall be more than 3h.

2.13．What is high temperature and humidity test?

The cell shall have been discharged at 0.2C to 1.0V and charged at 1C for 75 minutes before it is placed at circumstances of 66℃ temperature and 85% relative humidity to store for 192h(8 days). Then rest it at normal temperature for 2h. There should be no deformation or leakage, and 80% or more nominal capacity shall be recovered.

2.14．What is the criterion of overcharge endurance test?

The cell is discharged at 0.2C to 1.0V, and then it is charged 0.1C for 28 days. There shall be no deformation or leakage and the duration shall be more than 5h as discharged at 0.2C to 1.0V.

2.15．What is IEC standard for lifecycle test?

After the cell is discharged at 0.2C to 1.0V:

1） Charged at 0.1C for 16h, and then discharged at 0.2C for 2h30mins (1st cycle).

2） Charged at 0.25C for 3h10mins, and then discharged at 0.25C for 2h20mins(2-48th cycle)

3） Charged at 0.25C for 3h10mins, and then discharged at 0.25C at 1.0V(49th cycle).

4） Charged at 0.1C for 16h, rested for 1h, then discharged at 0.2C to 1.0C(50th cycle). For Ni-MH cell, repeat the 1-4 step for 400 cycles, among which the 0.2C discharge duration should be more than 3h. Despite this method lifecycle at 1C is adopted by BYD, i.e. after rating discharge, charge at 1C for 80mins, controlling the charge end by -△V=20mV, then discharge at 1C to 1.0V. Repeating as this for 500 cycles, there should be more than 60% of initial capacity.

2.16．What is 24h self-discharge?

As the standard test on charge retention lasts too longer, the 24h self-discharge becomes the most common way to take fast test. The cell should have been discharged at 0.2C to 1.0V Prior the test. It shall be charged at 1C for 80mins, rested for 15mins, and then discharged at 1C to 1.0V and the cell capacity C1 are gained. Charge the cell at 1C for 80min, and rest for 24h, then test the 1C capacity C2, the C1C2/C1*100% should not less than 15%.

2.17．What is vibration test?

After the cell is discharged at 0.2C to 1.0V, it is going to be charged at 0.1C for 16h and rested for 24h,then vibrated according to the following conditions:
Swing: 4mm
Frequency: 1000times vibrating for 30mins in XYZ three directions
And the cell voltage change should be between ±0.02V and the impedance change should be within ±5mΩ.

2.18．What is bump test?

After discharged at 0.2C to 1.0V and then charged at 0.1C for 16h at temperature of 20±5 ℃, it will be fixed on the bump platform, then the test is carried out according to the following conditions:
The peak acceleration is 98m/S2 (10g), the relevant pulse time (D) is 16m/S and the relevant speed change is 1.00m/S. At the end of 1000 times bump its discharge time that, after rested for 1-4hrs at the temperature of 20±5 ℃, discharged at 0.2C to 1.0V should not be less than 5hrs

2.19 . What is trickle charge?

This method is used to makeup the losing capacity of self-discharge when fully being charged. Commonly pulse charge is adopted. Experience tells that when fully charged, the losing capacity is 5% compared to the rate one. While in theory, continually charging at C/500 can makeup the loss: C*(5/100)*24H*C/500. But for the current is small, in fact the charge rate is extremely low, so that the battery is rarely charge. Pulse charge can be adopted to resolve this matter. Charge at C/10 for 1.2 second, rest for 58.8second. According to the above station, everyday the charge capacity is 5% of rate capacity. In general, pulse charge is applicable to the following situation which will be adopted in field: CC: C/20, CT: 0.1 second to 60 second.
Examples for trickle charge:

Charge (high) Charge (low) Pulse period (S) Daily charge capacity
Current Time Current Time
C/10 1.2s 0C 58.8s 60s 5% of rate capacity
C/20 2.4s 0C 57.6s 60s
C/10 0.6s 0C 29.4s 30s

2.20 . What is the residual discharge capacity of battery?

When discharge a rechargeable battery at high rate current (such as 1C or more), the batteries' capacity can't be discharged completely when its voltage reaches the cut-off value due to the slow diffuse rate of internal active materials. If discharge the battery at 0.2C to 1.0V/cell after that, the battery can still discharge some capacity, the second discharge capacity is named residual capacity.

2.21 . What is the penetration test?

This is a safety experiment. After a battery is fully charged, penetrate its center with a nail (diameter is 2.5mm-5mm) and make the nail stay in the batter, the battery shall not explode or catch fire.

2.22．What is the bump test?

Safety test. After a battery is fully charged, put a hard stick (diameter is 15.8mm) on the battery, drop a 20 pounds object from 610mm high to the stick, the battery shall not explode or catch fire.

2.23．What is the temperature rise test?

Safety test. Put fully charged battery in an oven and raise its temperature at a rate of 5℃/min, do that until the temperature reaches 150℃, and keep this temperature for 10 minutes, during and after the test the battery shall not explode or catch fire.

2.24．What is the burn test?

Safety test. Burn the fully charged batteries with blue blaze in an explosion proof cabinet, the battery shall not explode or catch fire and the safety vent shall open after some time

2.25．What is short-circuit test?

Safety test. Connect the positive electrode and negative electrode of a battery directly with a lead wire for some times in a explosion proof cabinet, the battery shall not explode or catch fire.

2.26．What is the temperature cycle test?

A temperature cycle test include 27 cycles, every cycle is composed of next procedures:

① Put battery in an ambient condition (Temp.: 66±3℃，relative humidity: (15±5)%) for 1h from room temperature;
② Change the ambient condition to 33±3℃, (90±5)%) for 1h;
③ Change the ambient condition to -40±3℃ for 1h;
④ Rest battery in 25℃ for 0.5h.

The 4 steps consist of a cycle. After 27 cycles, battery shall no leakage, swelling, rust or other abnormal phenomena.

2.27．What is the temperature shock test?

This test needs two constant temperature cabinets. One is set as 66℃, and the other is set as -40℃. Every cycles is composed of next procedures:

① Put battery in -40℃ for 1h;

② In 5 seconds transfer battery to 66℃ oven for 1h.

This cycle test shall start from low temperature and end in high temperature and the cycle number is 24. After the test the battery shall be capable of charge and discharge, its electrical performance shall not be affected.

2.28．What is the overcharge test?

After discharge at 0.2C to 1.0V/cell, charge battery at 1C for 3h, measure the deformation and calculate with a formula to get the internal pressure value。The battery shall not leak ， explode or catch fire.

2.29 .What are the differences of impedance between fully charged and fully discharged battery?

In general, impedance of fully discharged battery is not stable, and larger than the value when it is fully charged. The impedance of fully charged battery is stable and small. During battery use process, only the charged state impedance has actual meaning. At the end of cycle life, impedance will increase due to the electrolyte dry up and the activity of chemical materials decrease.

2.30．What is the power output of battery?

A battery's power output refers to its ability to deliver a specific amount of energy within a fixed period of time. The power output P of a battery is calculated from the product of the discharging current I(measured in amperes) and the discharging voltage U (in volts), thus: P=I x U. The power output is expressed in watts.

The smaller a battery's inner resistance, the higher its possible power output. Its inner resistance must always be smaller than that of the electric device to be operated. Otherwise the battery voltage will break down, i.e. the battery will be unable to operate the device. At a given discharging voltage, a battery's power output increases with increasing electrode surface and operating temperature,

and vice versa.
90.What are the ideas of nominal voltage, OCV, mid-point voltage, cut-off voltage?
Nominal voltage means general operating voltage, to secondary Ni-MH battery, 1.2V/cell;
OCV means open circuit voltage, that is the voltage of a battery without any load;
Mid-point voltage is the voltage when a battery has been discharged 50% of capacity, it is used to scale the high rate discharge performance of power tool battery; Cut-off Voltage is the voltage that discharge shall be finished.

2.31．What shall we pay attention to during use?

2.31.1 Read the battery use manual carefully and use the recommended battery;
2.31.2 Check the touch parts of electrical appliance and battery and affirm that they are clean; use a wet cloth to wipe up if need, and enclose battery after it is dry;
2.31.3 Don’t let baby replace battery without a guardian, mini-type battery (such as AAA) shall be kept in a place that baby can’t touch them.
2.31.4 Don’t mix to use new and old battery, and don’t mix to use different types battery;
2.31.5 Don’t try to regenerate a primary battery by heating, charging or other methods;
2.31.6 Don’t short a battery;
2.31.7 Don’t heat battery or throw it in water;
2.31.8 Don’t disassemble battery;
2.31.9 Please cut the switch off when stop to use the electrical appliance;
2.31.10 Battery shall be taken out if the electrical appliance will not use for a long time;
2.31.11 Battery shall be stored in shade, dry and no sunshine beat.

2.32．What is the explosion of battery?

It is named explosion that the solid-state matter of any parts in battery spurt out momentarily and is pushed to a distance more than 25cm. To judge a battery explode or not, following methods are used:
Put a net mantle battery in the center, the distance between battery and every sides of net shall be 25mm;
The density of net is 6-7pieces/cm, and reticle is soft aluminum line (diameter is 0.25mm);
If no solid-state matter get across the net during experiment, it proves that no explosion occurs.

No.3 Battery FAQs

3.1 . What is over-charge? What are impact results on cells performance?

The continual charge action after fully charged with certain charge approach is overcharge.
For Ni-MH battery, the positive capacity is lower than the negative on design, the generated oxygen in positive can be composite, through separator, with MH generated in negative. In general condition the internal pressure will not rise obviously, but if the charge current is so heavy or the charge time is so long, and the generated oxygen can not be used up in time, there will be some

quality defect risen such as internal pressure rising, battery distortion, leakage and so on. Meanwhile its performance will decline.

3.2．What is over-discharge? What are impacts on cell performance?

If a cell's voltage reaches a designed value, that means the battery has discharge the stored capacity, but still the discharge action is continual, over-discharge will cause. Commonly the end voltage can be identified through discharge current, for example the end voltage is set at 1.0V/cell as discharged at 0.2C-2C, and 0.8V/cell at 3C or more, e.g. 5C or 10C. Over-discharge may cause disaster, especially at heavy current or repeated over-discharge. Commonly over-discharge can make cell inner pressure raise, and the reversibility of activity materials both in positive and negative will be damaged. Even by charge only part can recover and the capacity is reduced obviously.

3.3．How many charging control methods are there?

In order to protect being over-discharged, it is necessary to control the end point of charge. When the cell is fully charged, some special appearances can suggest the charge is final。 Usually there are 6 methods:

1） Peak voltage: measuring a cell's peak voltage can tell charge is end;

2） dT/dt control: measuring a cell's peak temperature change ration can tell the charge is end.

3） △T control: the temperature difference between the cell and the ambient as the cell is fully charged will be the biggest.

4） -△V control: as the cell is fully charged, its voltage will drop to a certain value.

5） Time control: generally the time which takes necessarily to charge 130% nominal capacity is set to control the end of charge.

6） TCO control: Considering the cell safety and characteristic, it will avoid being charged under high temperature (exception HT cell). So when the cell temperature reaches to 60℃ high, charge will be stopped.

3.4．What is the best condition for cells store?

In accordance with IEC, the cell should be stored under temperature 20℃±5℃ and humidity （65±20）%. Commonly temperature is higher, while capacity retention is lower, and vice versa. The best place to store a cell is in a refrigerator with a temperature range of 0℃-10℃, especially for primary batteries. While for secondary batteries, their loss of capacity during storage, may be better compensated by recharging.

3.5 . How long can a cell be stored?

On theory energy loss can’t be avoided during store. Its proper electrochemistry construction makes the losing unavoidable. Self-discharge is the best-known causation. Generally this has to do with the electrolytic solubility of the positive electrode material or its thermodynamic instability (easy spontaneous decomposition). Self-discharge in rechargeable batteries is particularly high in comparison to primary battery. Furthermore every month a battery self-discharge rate is various depending on the system. It changes in the range of 10-35%. Primary battery self-discharge is lower considerably. At room temperature it may even be below 2%. However, various processes take place in parallel with this which lead to an increase of the battery’s internal resistance during storage. These processes lead to a reduction in load capability. However energy loss is more noticeable at relatively high discharge current. The below table lists self-discharge approximation under normal storage conditions:

type Self-discharge
Alkali manganese（MnO_2/Zn），cycloidal ＜2%
Zinc carbon（MnO_2/Zn），cycloidal ＜4%
Li-ion($LiMnO_2$)，cycloidal and button cell Approx 1%
Ni-MH/Ni-Cd cell ＜35%

3.6 . What are the voltage of difference cell types and the usage area?

type voltage application area
SLI（engine） 12V automobile, commercial vehicle, motorcycle
Li 6V cameras
LiMn button 3V pocket calculators, watches, remote control devices
Silver oxide button 1.55V wrist watches, small clocks
Alkali manganese 1.5V portable audio equipment, cameras, games
Alkali manganese button 1.5V pocket calculators, electronic devices
Zinc carbon cycloidal cell 1.5V larms, flashlights, toys
Zinc air button cell 1.4V hearing aids
MnO_2 button cell 1.35V hearing aids, cameras

Ni-MH 1.2V mobile telephone, cordless phone, portable cameras, notebooks, emergency lights, house applications

3.7 . What impact may an ambient temperature have on battery performance?

Low temperatures (e.g. -15℃) will obviously reduce Ni-MH battery discharge rate. At -20℃ electrolyte is at its freezing point, charge speed will greatly slow down. At low temperature (under -15℃) charge will raise the internal gas pressure and probably unseal the safety vent. Ambient temperature of 5℃to 30 ℃ is the best range to get effective charge. Generally with temperature rising charge efficiency will become higher. But when the temperature rises to 45℃ or higher, the materials performance in the battery will be degenerated and battery service life will be shorten greatly.

3.8 . What a battery short circuit and its consequences?

Any kinds of conductive material being bridged with the external terminals of a battery will result in short circuit. Based on the battery system, a short circuit may have serious consequences, e.g. rising electrolyte temperature or building up internal gas pressure. If the internal gas pressure value exceeds the limitation of cell cap endurances, the electrolyte will leak, which will damage battery greatly. If safe vent fails to respond, even explosion will occur. Therefore don’t short circuit.

3.9 . What is memory effect?

Memory effect only happens on Ni-Cd batteries. As in traditional technology a Ni-Cd battery’s negative is agglomeration with thick Ni crystal, if Ni-Cd batteries are recharged before they have been fully discharged, Ni crystal easily gathers to form agglomeration, which makes the primary discharge platform come into being. The battery stores the platform, which will be considered as the end of discharge for the next cycle even though the capacity decides that the battery can be discharged to a lower platform. The battery will store this process in its memory so during the next discharge, the battery only remembers this reduced capacity. Similarly any further incomplete discharge in each use will aggravate the effect makes lower capacity. The effect there are two methods to remove the effect: firstly deep discharge at trickle current (i.e. 0.1C to 0V), secondly several cycles at high currents (e.g. 1C).

3.10．What impact is the battery on environment?

Nowadays almost all available batteries are free from Hg. But heavy metals are still essential components in Hg battery, rechargeable Ni-Cd battery, and lead-acid battery. If disposed improperly and in large quantities these metals may damage the environment. Internationally at present special institutions have been existed to collect the used batteries such as oxidation mercury, Ni-Cd, lead-acid. Currently the percentages both of Ni-MH and Li-ion have risen greatly.

3.11．What are the possible reasons to cause 0V or low voltage?

3.11.1 Batteries are external short-circuited or overcharged, reverse charged (forced over-discharge)
3.11.2 Continually being overcharged at high rate current will cause electrode pole expand and positive poles touch directly.
3.11.3 Internal or slight short circuit, e.g. burrs in positive and negative plates touch together if penetrated through separator, or positive and negative plates are wrongly placed causing the two plates to contact together, or the positive plate gets in touch with the outside steel case, or negative material fall into separator, or separator is defective, or positive current collector contacts with negative plate.

3.12．Why do batteries packs with 0V or low voltage happen?

3.12.1 One of the cells voltages is 0V.
3.12.2 Plugs are short or open circuit, or ill touched.
3.12.3 Lead wires are broken from the soldering or weakly soldered.
3.12.4 Wrong battery connection or the connection tabs are miss or weak weld or broken off.
3.12.5 Inner connections of the assembly compositions are wrong or damaged.

3.13．What are the possible reasons causing cells or battery packages un-chargeable?

3.13.1 0V cell or 0V cell in packages.

3.13.2 Wrong battery connection, or abnormity inner parts or circuit protector
3.13.3 Charger is failure to output current.
3.13.4 External factors can be possible triggers of extremely low charge rate (e.g. extremely low or high temperatures).

3.14 . What are the possible reasons causing cells or battery packages un-dischargeable?

3.14.1 Storage will shorten its service life.
3.14.2 Not be fully charged or not be charged;
3.14.3 Excessively low ambient temperature;
3.14.4 Low discharge efficiency, for instance at high current discharge, inside materials of ordinary battery will diffuse, and the reaction speed can't follow, which will cause the voltage toboggan and the battery un-dischargeable.

3.15 . Cells or batteries with short discharge time, what is the reason?

3.15.1 Battery is not fully charged, such as inadequate charge time, lower charge efficiency and so on.
3.15.2 Excessively heavy discharge current will result shorter discharge time as well as low discharge efficiency.
3.15.3 Discharge excessively at low ambient temperature will descend discharge efficiency.

3.16 . Battery bottom plumping up, belly protruding, even leakage, what are the possible causes?

3.16.1 Batteries are overcharged especially at continuous high rate current.
3.16.2 Batteries are forced to over discharge.

3.17 . Why the battery service life is short?

3.17.3 Charger or charge circuit does not matched to battery system.
3.17.2 Over charged or over discharged.
3.17.3 Battery systems are not consistent with appliances.

3.18 . What will happen if cells with different capacity are packed together?

If different capacity cells or mixing fresh and old cells were used, leakage or zero voltage would occur. That is because when charge, some cells with high capacity cannot be fully charged, while the others with low capacity will be overcharged due to the different capacity. While discharge high capacity cell can't be fully discharged, however the low one is over discharged. If repeated like so, the cells would be damaged to leakage or low (zero) voltage.

3.19 . Can the cell be remained in the application without using for a long period or after being used?

If the application is not in use for an extended period of time it is better to remove the battery from the application and to store in a dry and cool place. If this is not done, a minimum amount of current will continue to be taken out of the battery by the application, even if the application is switched off-which may shorten the battery's service life.

3.20 .A cordless telephone should be put back onto the base after each use?

According to usual practice and the cordless phone design, the phone should be put back onto the base after each use so that the battery was activated to makeup the discharged capacity and the losing capacity of self-discharge. But occasional complete discharge is recommended to recover the battery to its initial capacity and discharge character. Properly it is better to take the battery out, and keep it open circuit, charge it when reuse.

3.21 .Why the temperature hoik and the voltage decrease at the end of charge?

Continue to charge is an overcharge procedure when a battery has been fully charged. At this time the Ni(OH)2 of positive electrode had become NiOOH, the battery voltage reaches a balance value(maximum value). Continued charge will oxide OH- into oxygen:

4OH- - e → O2 + 2H2O + heat--(1)

The formed oxygen permeate separator and react with MH of negative electrode:

MH + O2 → M + H2O + heat--(2)

This chemical combination reaction generates large amount of heat, so the temperature of total battery system increases sharply. The more high temperature, the more low balance voltage, that is why temperature increases will lead to balance voltage decreases, so the battery voltage will decrease after it had been fully charged.

3.22 . What are the advantages and shortcomings of protection elements of battery?

Follow table compare their performance several familiar protection elements of battery:

Name Main Materials Function Advantage Shortcoming

Temperature- controlled switch PTC Large current protection Induce the current and temperature change quickly, too high temperature or too large current will make the temperature of double metal parcels in switch reaches its rated value, the double parcels break quickly, so the circuit is protected. The metal parcels may not set and the battery can’t work any more.

Poly-switch PTC Large current protection The impedance of the element increases linearly when its temperature increase, and its impedance will increases sharply if the current or temperature reaches a specified value, so the current will decrease to several mA level. When the temperature decreases to normal level, the element can recover to initial state. It can be used to assemble battery as a connect parcel. High cost fuse induce the current and temperature of circuit. Fuse will melt to protect the electro-circuit if the current or temperature reaches a specified value. Fuse can’t recover after melting, and need to replace it in time, this is a trouble.

3.23 . What is the influence of temperature on battery performance in general?

Of all environmental factors, the temperature has the greatest effect on battery charge and discharge behavior. This has to do with the temperature-dependent

electrochemical reactions occurring at the electrode/electrolyte interface, which may be considered the heart of the battery. If the temperature decreases, the rate of electrode reaction decreases too. Assuming the battery voltage remains constant, the discharging current drops and thus the power output of the battery. The opposite effect occurs if the temperature rises, i.e. the power output of the battery increases.
The temperature also affects the speed of transport processes within the electrolyte and its porous electrode. A rise in temperature accelerates transport processes and a decrease in temperature slows them down. The charge / discharge performance of the battery may also be affected. But if the temperature is too high (more than 45℃), battery cycle life will short sharply due to the active materials decline and electrolyte exhaust.

No.4 Battery Types And Application Fields

4.1 . What is the characteristic of a portable battery?

Every battery constitutes an energy converter. It is capable of converting stored chemical energy into electricity energy directly. In the case of rechargeable batteries, this process is described as the following: when charging electricity energy is converted into chemical energy →during discharge the conversion is reversed→during charge electricity energy is converted into chemical energy, on secondary batteries this process can repeat more than 1000 times.
Rechargeable portable batteries are available in different electrochemistry battery systems, i.e. lead acid systems (2V), Ni-Cd systems (1.2V), Ni-MH systems (1.2V), and Li-ion systems (3.6V). The typical characteristics for the above battery systems are their relatively constant discharge voltages (when discharge a voltage flat roof is available), as well as the quickly breaking down voltages both at the beginning and the end.

4.2 . What are the advantages and disadvantages of rechargeable

battery?

Long service life is the advantage of the rechargeable battery, for it can be recharged for more than 1000 times. It is economical for frequent use even though it is more expensive than primary batteries, and its load capacity is more powerful than most of primary batteries. Generally a Ni-MH battery is not recommended to use in cameras because its discharge voltage is almost constant and it is difficult to predict when the discharge ends, while rechargeable Li-ion batteries can provide camera longer service time, higher load, higher energy density, voltage decrease in discharge with discharge deeply going.

4.3 . What kind of applications are rechargeable batteries preferred?

Rechargeable batteries are particularly applicable to devices which require comparatively higher power supply or strong current discharging such as portable cassette players, CD displayer, mini radios, electronic game players, radio control toys, various household applications, professional cameras, mobile telephones, cordless phones, notebook computers, and other higher power requirement devices. Rarely used equipments are not recommended to use

rechargeable batteries for its comparatively higher self-discharge. But if a device requires discharging at stronger currents, rechargeable batteries are necessary. In general it is wise to follow the appliance manufacture's guidelines for battery selection as given in the operating instructions.

4.4 . Which types 0f rechargeble batteries are available? For which applications are they especially suit?

Battery types Characteristics Applications
NI-MH round cell is environmentally benign(contain no mercury, lead, cadmium)Overcharge-proof audio devices, camcorders, mobile phone, cordless phone, emergency light, notebooks computers
Ni-MH prismatic cell High capacity, environmentally benign, overcharge-proof Audio devices, camcorders, mobile phone, cordless phone, emergency light, notebooks computers
Ni-MH button cell High capacity, environmentally benign, overcharge-proof Mobile phone, cordless phone

4.5．What is the service life of rechargeable battery on cordless phone?

Under normal conditions, its service life is 2-3 year or longer. If any one of the following items occurs, the batteries should be replaced:

1） After each charge, the talk time becomes shorter;

2） Ring sign is not enough clear or talk effect is indistinct and chirp voice is louder.

3） The distance between cordless phone and the base should be closer and closer, i.e. the ranges that the phone can work become narrower.

4.6．What types of batteries are used for watches?

There is a wide range of button cells available for watches. The preferred electrochemical system is silver oxide. The type of battery to be used is listed in the watch's operating instructions. In general, analog watches (hands watches) and simple digital watches all can be powered by low drain batteries.

4.7．What other battery systems can be used for watches?

In addition to the silver-oxide system, alkaline-manganese and lithium-manganese systems are also used in watches. The alkaline-manganese button cell is most commonly used for low price watches. An identical sized silver-oxide button cell can later replace this battery. The advantage of the silver-oxide button cell is its constant operating (highly accurate time-keeping) and higher capacity (longer operation). Another category of watches uses lithium coin cells (further information), which may also be equipped with multiple functions. A typical coin cell for this purpose is the CR2025, with a diameter of 22mm and a height of 2.5mm. In total there are more than 12 different sizes (different diameter and height).

4.8．What is the self-discharge rate of the solar battery?

Compared with the other rechargeable battery systems, solar batteries with liquid electrolyte have obviously lower self-discharge of 10%/month at 25℃.

4.9．What is an intelligent secondary cell?

Intelligent batteries are equipped with an electronic chip, which not only supplies energy to the devices, but also controls its main function. This kind of batteries can show the rest of its capacity, having been cycled times, temperatures and so on. Yet currently it has not been available on market, in future they will play a major role-especially being used in portable videos, cordless telephones, mobile phones and notebooks.

4.10．Can primary cell be recharged?

An alkaline-manganese round cell can be recharged about 20times. In reality, however, this is not a true recharge process as offered by secondary batteries, because they do not permit a normal deep discharge like a true rechargeable battery, but only a partial discharge. Consequently, the recharge process is also only a partial one, and which therefore should be better called "regeneration" to differentiate it from a true recharge as offered by secondary batteries. The serious limitation of its charge/discharge behavior and its very short "cycle life" renders the regeneration of an alkaline-manganese battery rather uneconomical.
Various conditions must be met in order to ensure the successful regeneration of alkaline-manganese batteries:

1). A regeneration is possible only if a maximum 30% of the battery's initial capacity is withdrawn at moderate discharge rates, whereby the discharging voltage should not drop below0.8V. When removing more than 30% of the capacity, an irreversible manganese dioxide structure will develop that prevents any further "regeneration". The "30% "capacity point" and the 0.8V discharge voltage can only be monitored by use of proper measuring instruments, which the average consumer does not possess.

2). Alternatively, the user would need to buy a charger for performing regeneration. Other charging devices like charges for rechargeable nickel-metal-hydride or nickel-cadmium accumulators should never be used. Because their charging current may be too high and may lead to gas generation inside the battery, which in turn may lead to the safety vent opening and electrolyte being ejected. In extreme cases an explosion may even occur if the safety vent fails to respond (due to e.g. a molding defect during production). Cases like this happen very rarely, nevertheless they can happen, especially if the battery is not used properly.

3). The length of time needed for "regeneration" (approx. 12 hours) is out of all proportion to the discharge time (approx. 1hour).

4). After about 20 partial cycles at the very latest, the battery capacities will have dropped to about 50% of its initial value.

5). If a given device needs more than three batteries connected in serious, an additional problem will arise if the batteries have different capacities as a result of "regeneration". This can lead to a voltage reversal of the weakest battery. This danger is particularly possible if regenerated batteries are used together with fresh ones. A battery reversal leads to hydrogen evolution inside the battery, with the danger that unacceptably high pressures will build up. This can result in electrolyte being ejected and even an explosion!
Regeneration of primary batteries is not only uneconomical in the long run, but bears in itself a safety risk. To avoid these risks it is better to use fresh primary batteries or secondary batteries (accumulators) rather than to regenerate primary ones.

4.11.Can 1.2V rechargeable batteries replace 1.5V alkaline manganese batteries?

The alkaline manganese battery discharges over the voltage range 1.5V and 0.9V,whereas rechargeable portable batteries discharge at a virtually constant voltage of 0.2V/cell. This voltage level is roughly equivalent to that of the average discharging voltage of an alkaline manganese battery. Therefore, exchanging a rechargeable, portable battery for an alkaline-manganese battery or vice versa should never be a problem.

4.12 . When is it preferable to use a high-capacity accumulator for a mobilephone?

High-capacity accumulators deliver a longer operating time than slim-line accumulator; however, they are heavier and larger. Slim-line accumulators are lighter and are especially designed to fit mobile telephones, but offer a shorter operating time. This aspect should be kept in mind when selecting an accumulator for a mobile telephone.

4.13 . What are the advantages of a solar battery?

Solar energy systems are easy to install, easy to expand, and easy to disassemble. They are economical as well, since there are no energy costs during operation. In addition, solar energy systems are subject to virtually no mechanical wear. A solar energy system requires a reliable solar battery for charge acceptance and storage. General solar batteries are characterized by:

1) High charge acceptance

2) Durability in cycle operation
3) Good re-chargeability
4) Maintenance free

4.14 . Which batteries will dominate the market in years to come?

In years to come, rechargeable portable batteries will probably have a large market share than primary batteries. The popularization of portable camcorders, mobile and cordless telephones, notebooks and multimedia devices ,more and more rechargeable batteries are needed

4.15 . Will there be a system in future that will combine all the characteristics?

Presently all kinds of batteries will still exist for a long time. Because each one of today’s battery systems is a specialist in its own right, able to fulfill a specific task better than any other battery system. They are all special either in terms of value for money, high capacity, high energy density, long cycle life, high or low operating temperatures, environmental compatibility or economical, environmentally benign re-chargeability. A battery system capable of combining all such characteristics is unlikely ever to be available.

4.16 . What are the advantages of Ni-MH battery?

4.16.1 Low cost;
4.16.2 Good quick charge performance;
4.16.3 Long cycle life;
4.16.4 No memory accumulation;
4.16.5 Green energy sources, no pollution;
4.16.6 Extensive temperature range;
4.16.7 Good safety performance;

4.17 . What is nanometer battery?

Nanometer means 10^{-9}m. Nanometer battery is made with nanometer materials (such as nano-MnO2, nano-LiMn2O4, nano-Ni(OH)2). Nanometer materials have especial microcosmic structure and physical & chemical performance (such as quanta size domino effect, surface domino effect and tunnel quanta domino effect). Up to now, the nanometer battery with mature technology is nanometer activated carbon fiber battery. It is used in electric automobile, electric motor and electro-motion-aid vehicle. This kind battery can be charged and discharged about 1000 cycles and its use duration is about 10 years. Fully charge a battery only spends about 20 minutes, the journey in flat road is about 400km, and its weight is 128kg. It has exceeded the technology level of American and Japan: their Ni-MH battery needs 6-8h to be fully charged, and the journey in flat road is about 300km.

4.18 . Which types battery is used in emergency lighting?

① Seal Nickel-Cadmium battery
② Lead-acid battery with adjustable vent
③ Other battery which is in accordance with corresponding safety and performance requirements of IEC standard (emergency lighting part) can be used too.

4.19 . Which type battery can be used in remote control devices?

The battery stipulated in its battery compartment should only operate a remote control device. Different zinc-carbon batteries are available for different remote control devices. They can be identified by their IEC designation. Commonly used batteries include the R03 (AAA, "Micro"), R6 (AA, "Mignon") and the 9V Block 6F22. A better choice is the alkaline versions of these batteries, which offer twice the operating time of the zinc-carbon battery. They can be identified by their IEC designations LR03, LR6 and 6LR61. Nevertheless, because of the relatively low current required by this application, zinc-carbon batteries still remain a good and economical alternative.
Interchangeable accumulators may - in principle - be used as well. They are, however, less recommendable for this application because of their relatively high self-discharge, which requires repeated charging, thus rendering this type of battery rather is impractical

4.20 . What are "dry" and what are "liquid" batteries?

The terms "dry battery" and "liquid battery" are restricted to primary systems and date from the early development of galvanic elements. At that time, a liquid cell consisted of an electrolyte-filled glass container into which electrochemically active electrodes were immersed. It was only later that un-spillable cells that could be used in any position and had a completely different construction were introduced, these being similar to today's primary batteries. These earlier cells were based on paste electrolytes. At that time they were known as dry batteries. In this sense today's primary batteries are also dry batteries.

The term "liquid battery" is in principle still applicable to certain modern secondary batteries. For large stationary lead-acid or solar batteries, liquid sulfuric acid is preferred for the electrolyte. For mobile applications un-spillable, maintenance-free lead-acid batteries are recommended and have been available for many years. The sulfuric acid is immobilized as a gel (or a special micro-glass mat).

4.21 . What are "portable batteries"?

A portable battery is primarily a battery, which provides electrical energy to operate portable, cordless equipment. In a more generalized definition it also includes batteries that only operate certain sub-devices within a larger system (which may be operated by the mains), e.g. a desktop computer. Sub-devices of the above kind may be a computer's internal clock or a memory backup. Larger batteries (e.g. four kilograms and above) are no longer considered portable. Today's typical portable batteries will weigh several 100 grams.

The portable battery family includes both primary and rechargeable (secondary) batteries. Button cells belong to a special group of their own.

4.22 . Do alkaline-manganese batteries really last longer than zinc-carbon?

Yes, they do. The alkaline-manganese battery has nearly twice the energy content of a zinc-carbon battery of the same size, even at higher loads. This battery is particularly suited for continuous discharge. For low power applications (such as transistor radios) or applications using discontinuous discharge regimes (e.g. flashlights), the zinc-carbon battery still represents an interesting and inexpensive alternative. The on-load period should preferably not exceed five minutes at higher loads. This limitation does not apply for the more expensive alkaline-manganese batteries.

4.23 . May any charger be used to recharge portable batteries?

No, because each charger employs a specific charging technology which is matched to a given electrochemical system, e.g. lithium-ion, lead-acid or nickel-metal-hydride. They differ not only in their voltage characteristics, but also in their charging mode, e.g. only quick chargers which have been specially developed for nickel-metal-hydride batteries will ensure optimal charging results for this system. Former Varta chargers for nickel-metal-hydride batteries can continue to be used, but may need more time to fully charge the battery. Care must be taken when using a charger that does not meet the required charging conditions for a given electrochemical system, even if it carries a label that seems to signal "officially approved". A label of this kind may only state that the device was wired according to the European Electrochemical Standard (CENELEC) or other national standards such as VDE (in Germany: Association of German Electro-technical Engineers)!This type of label does not make any reference to the charger's suitability for a specific battery system. With cheap devices of this kind, charging nickel-metal-hydride batteries can be both dangerous and lead to unsatisfactory results. This warning also applies to chargers developed for other systems (e.g. lead-acid accumulators)

4.24 . What is a micro battery/button cell?

A "button cell" should actually be better called a "button battery", because it has the external attributes of a battery (further information). Its popular name, however, is "button cell". A button cell may be defined as a battery whose diameter is equal to or larger than its height. Present dimensional limits for button cells using an aqueous electrolyte range from a) diameter: 4.8 mm to 11.4 mm, b) height: 1.05 mm to 5.4 mm. Depending on the electrochemical system their nominal voltage is either 1.2V, 1.35V, 1.4V, 1.5V or 1.55V. Batteries of this family were given this name because of their visual similarity to buttons. Coin Cells also belong to the group of button cells (further information).

No.5 The advantages and characteristics of SPK Ni-MH Battery

5.1 The types and models of SPK Ni-MH battery

Types	Voltage(V)	Capacity	Cycle Life	Diameter	Height
SPK50AAAA450	1.2	450	500	8.5-0.7	50.5-1.0
SPK67AAAA600	1.2	600	500	8.5-0.7	67.5-1.0
SPK15AAA120P	1.2	120	500	10.5-0.7	15.5-1.0
SPK15AAA140P	1.2	140	500	10.5-0.7	15.5-1.0
SPK18AAA160P	1.2	160	500	10.5-0.7	18.5-1.0
SPK18AAA180P	1.2	180	500	10.5-0.7	18.5-1.0
SPK28AAA300P	1.2	300	500	10.5-0.7	28.5-1.0
SPK44AAA600	1.2	600	500	10.5-0.7	44.5-1.0
SPK44AAA700	1.2	700	500	10.5-0.7	44.5-1.0
SPK44AAA800	1.2	800	500	10.5-0.7	44.5-1.0
SPK44AAA900	1.2	900	500	10.5-0.7	44.5-1.0
SPK67AAA1000	1.2	1000	500	10.5-0.7	67.5-1.0
SPK28AA700P	1.2	700	500	14.3-0.7	28.5-1.0
SPK43AA1200	1.2	1200	500	14.3-0.7	43.5-1.0
SPK50AA1800P	1.2	1800	500	14.5-0.7	50.5-1.0

SPK50AA2000P	1.2	2000	500	14.5-0.7	50.5-1.0
SPK50AA2100	1.2	2100	500	14.5-0.7	50.5-1.0
SPK50AA2200	1.2	2200	500	14.5-0.7	50.5-1.0
SPK50AA2300	1.2	2300	500	14.5-0.7	50.5-1.0
SPK50AA2400	1.2	2400	500	14.5-0.7	50.5-1.0
SPK50AA2500	1.2	2500	500	14.5-0.7	50.5-1.0
SPK28A1100P	1.2	1100	500	17.0-0.7	28.5-1.0
SPK43A2000	1.2	2000	500	17.0-0.7	43.5-1.0
SPK50A2300	1.2	2300	500	17.0-0.7	50.5-1.0
SPK43SC2800P	1.2	2800	500	17.0-0.7	43.5-1.0
SPK43SC3300	1.2	3300	500	17.0-0.7	43.5-1.0
SPK63D8000	1.2	8000	500	33.0-0.7	63.5-2.5
SPK63D9000	1.2	9000	500	33.0-0.7	63.5-2.5

Notice 1:The type P is dynamic or fast rechargeable.
Notice 2: Every type could be manufactured into high temperature rechargeable battery according to requirements of clients.
Notice 3: Other types are displayed in detail contents.

5.2 The performance characteristics of SPK Ni-MH batteries

1. High reliability. SPK can offer high quality products owning to its high character raw materials and advanced manufacturing technique.
2. High consistency. SPK can make nice consistency products by strictly controlling its production process according to ISO9001 Standard.
3. Low self-discharge. The capacity loss due to self-discharge for every month is lower than 20% of the rating capacity.
4. Working temperature. SPK Ni-MH batteries have a good service performance under high and low temperature. Their usage temperature ranges from 20℃ below zero to 50℃.
5. Service life. SPK batteries could be charged/discharged for 500-1000 times when correctly used.

5.3. What is the reason to choose SPK batteries?

1. As for as full automatic product lines of positive and negative electrodes are applied, fast and continuous production is realized. The reactivity of the positive and negative electrodes could be guaranteed at utmost as well as the energy consumption and utilization efficiency of the raw materials.
2. The SPK battery assures a high uniformity after testing the net mass increase of active substance and rolling them in a way of collocation.
3. SPK adopts the domestic advanced formation system with a low electric current to charge/discharge its batteries.
4. PCDA Cycle is employed to promote its efficiency and quality management. In order to reduce product cost, continuous improvement is also applied.

5. SPC statistical technique is adopted to analyze and control SPK production and product quality.

5.4 The achievements we have obtained on the research and development of Ni-MH battery.

In August, 2004 we successfully developed 50AA2350mAh Ni-MH battery, which passed the standard tests executed by National Light Industry Battery Quality Supervision and Test Center. The test results showed that SPK batteries are completely coincident with national requirements in discharge performance, over-discharging and safety devices etc. SPK lead advanced stage of domestic Ni-MH market. Compared with its minimum value 2300mAh of Sanyo' so-called AA2500mAh batteries, which were internationally highest capacity, it is clear that our SPK products can be nominally considered as AA2500mAh and keep up the same step with the world.
At the same time, we had made great progress in discharge platform, cycle life, over-discharging resistance of high capacity batteries after several months measurement and amendment. For this type of batteries, SPK adopted special positive electrode, negative electrode and separators. Many fundamental production improvements were also carried out as well as internal structure adjustment. The measuring results displayed that the chargeability retention capability could be increase greatly and the open voltage of battery stored for six months could also maintain a high level.

5.5 Freudenberg nonwovens group separator test center

At present, Germanic Freudenberg Company is the biggest separator manufacturer for Ni-MH battery. In May, 2004, Freudenberg investigated most of Chinese high capacity Ni-MH battery companies with the help of international professional test centers and drew the following conclusion that: SPK batteries took great advantages in cycle life, discharge platform, self-discharge and consistency over corresponding products of other companies. Simultaneously, a high affirmation was give to SPK for our nice management after extemporaneous evaluation.
According to the agreements of both sides, Freudenberg will build Freudenberg nonwovens group separator test center in our SPOWERKING company. It is the only test center of Freudenberg set in mainland.
Our task is to test the up-to-date separators developed by Freudenberg, while Freudenberg gives corresponding resources and technical supports. As this center lasts, the advantages of SPK Ni-MH batteries in high capacity/high power/high temperature fields could be further guaranteed.

5.6 Postdoctoral workstation of Tianjin University

Our company had persistently attached importance to talents and took great efforts on introducing and cultivating talents. In September of 2004, SPK signed a long period cooperation agreement with Tianjin University, a state university, to establish postdoctoral workstation of it.

Tianjin University is the first institution of higher learning in modern Chinese education. It is one of Chinese important bases to cultivate high quality talents and develop high technical researches. At present, there are one doctor student and two master students of Tianjin University taking research work in SPK. They are responsible for high capacity/high power/high temperature Ni-MH batteries respectively and special scientific research outlay have been asked from Shenzhen Dummy University District for these projects.

5.7 What is our main developing direction?

SPK has made grandeur achievements on Ni-MH battery after ten years of continuous production and research exploration. In order to maintain our predominance on high capacity Ni-MH batteries, we will spare no efforts. The 2004 major target of SPK is to Explore and develop dynamic batteries for electric tools and high temperature batteries for solar lamps, lamp lights and emergent head lights as well as to increase market quotients gradually.

All SPK persons will go ahead with rechargeable batteries under the guidance of the corporation. We will try our best to satisfy clients so far as to exceed their expectation and establish SPK irresistible in overmatches for ver.