ACCUMULATORI & SISTEMI DI ALIMENTAZIONE IN EMERGENZA

SOLUZIONI D'ENERGIA

MANUAL OF OPERATION
AND MAINTENANCE FOR

NICKEL-CADMIUM POCKET TYPE ALKALINE STORAGE BATTERY

CONTENTS

1. Applications

Nickel-cadmium pocket type alkaline storage batteries can be divided into low rate and medium rate based on their application (various discharge current). They can be operated at the temperature of -40℃~45℃ after charging at normal charge rate at an ambient temperature of 25±1℃. They are widely used in the electric equipment, tele-communications, lighting&UPS as the standby or DC power supply. They can also be used in oil motor or DC electric motor for starting, in transport vehicles and solar energy cells.

2. Main properties of the battery

The cells are characterized by excellent electrical performance, long cycle life. Strong construction, good resistance to overcharge and overdischarge, low self-discharge. High reliability, easy maintenance, etc.Their electrodes construction can be varied by different discharge current rates.

2.1 Cell construction:

The positive and negative active materials are pocketed respectively in the perforated steel strips and pressed into the plates which form into positive and negative electrodes. There is a separator between the positive and negative electrodes. The electrode groups are firmly mounted in the plastic container. There is an electrolyte filling hole in the cover; this hole is usually equipped with a plastic gas-plug. It can be opened at any time when it is needed to fill electrolyte. The plug can release the gas which generated inside the battery and also can keep the impurities and dust from entering the battery.

2.2 Battery construction

The required individual cells are firmly installed in steel, wooden or plastic frames and are connected in series by steel(or copper) intercell connectors. The construction has a high mechanical strength; it can be operated under the condition of shock and vibration.

2.3 Operating principle of the battery

On charge, oxide reaction takes place in the positive electrode, and reduction occurs in the negative electrode. On discharge, the opposite reactions take place. The reactions of charge and discharge can be illustrated by the following simplified equation:

$$2Ni(OH)_2 + Cd(OH)_2 \underset{\text{Discharge}}{\overset{\text{Charge}}{\rightleftarrows}} Cd + 2\beta NiOOH + 2H_2O$$

3. Main performance of the cell(batteries)

Low rate nickel-cadmium pocket type cell is suitable for 0.1~0.5C_5A Current discharge; the medium rate Ni-Cd cell is preferred to 0.5~3.5C_5A current discharge.

3.1 Nominal voltage of the cell

The cell nominal voltage is 1.20V, the battery nominal voltage 1.20V×n (n is the number of the cells which are connected in series)

3.2 The cell discharge performance

3.2.1 The cell should be charged for 8h at $0.2C_5$A and an ambient temperature of 20 ℃.The discharge duration at various discharge rates should be not less than the minimum specified in Table 1.

Table 1

Discharge conditions		Minimum discharge duration	
Rate constant of current(A)	Final voltage(V)	Low rate	Medium rate
$0.2C_5$	1.0	5h	5h
1 C_5	0.9		40min
2 C_5	0.9	10min	

3.2.2 Discharge performance at -18℃

The cell should be charged for 8h at an ambient temperature and $0.2C_5$A.The cell shall be then discharged at temperature of –18℃, the discharge duration shouldn't be lower than the requirements in Table 2.

Table 2

Discharge conditions		Minimum discharge duration	
Rate of constant current(A)	Final voltage(V)	Low rate	Medium rate
0.2 C_5	1.0	2h 30min	3h
1 C_5	0.9		10min

Note: the data show in Table1 and Table2 conform to the discharge performance standards. The approach actual practical data are included in the discharge curves of Appendix 6.

3.3 Self-discharge of the cell

The cell can be charged at 0.2 C_5A for 8h at an ambient temperature of 20±5℃, then store it in the same conditions for 28 days and nights. Then discharge it at $0.2C_5$A to end voltage of 1.0V, its discharge duration should not be less than 4h.

3.4 Cycle life

One cycle means a cell is fully charged and discharged. The cell's cycle life should not be less than 900 cycles. According to IEC Standard, it should be 500 cycles at least. In case of float charge application, its cycle life may be longer.

3.5 Storage

The electrical performance of the cell which is stored for 4 years in accordance with the storage specifications should meet the requirements of items of 3.2, 3.3, and 3.4.

4. The battery's start using and preparation before start using.

The battery leaves factory in discharged state without electrolyte. Before start using, it is needed to do following preparation:

4.1 Check

4.1.1 Check accessories as specified in the packing list, check if there is damage on the battery case, if the damaged is found, pick them out.

4.1.2 Measure the cell's open circuit voltage one by one, If the value is lower than 0.5V, a small amount of electrolyte can be filled in, then measure it again, if the voltage goes up to 0.5V.it will be regarded as the qualified.

4.1.3 Check the tightening parts of cell, if necessary, tighten them again.

4.2 Filling with the electrolyte

Unscrew the battery plug, fill the required electrolyte into the battery with funnel and graduated cylinder (electrolyte standard and preparation method is shown in Appendix 1.) Adjust electrolyte level between two limit lines. Clean the electrolyte which flow out of the battery.

4.3 Connection

The battery must be soaked for 4 hours after filling, with electrolyte, and then regulate the electrolyte level. Connect the battery in series with connecting plate (lines). The positive terminal should be connected with the neighbor battery's negative terminal; the rest may be deduced by analogy. In the end, connect the last positive terminal with the positive lead of charger, and the negative terminal is connected with the charger's negative lead. Mistake connection is forbidden.

4.4 Initial charge

After the above connection, check to ensure that there is no mistake, the charge the battery as the following:

4.4.1 The battery which has been stored for 3-6 months should be charged at $0.2C_5$A for 15 hours, and then they can be put into operation.

4.4.2 The new battery and the battery which stored for more than 6months should be charged at $0.2C_5$A for 12 hours, and then discharged to 1.0V/cell. Repeat the above charge and discharge for 3-5 cycles. If the discharge duration isn't less than 5 hours and the battery voltage isn't less than 1.0V/cell, the battery can be put into the normal operation according to Table 3.

5. Battery operation and maintenance

5.1 Charge (See Table 3)

Table 3.

Charge regime	Charge current-A	Charge voltage(V)	Charge duration(h)	Charge temperature(℃)
Normal charge	0.2 C_5		8	20±10
Over-charge	0.2 C_5		12	
Complementary charge	0.2 C_5		Not stipulate	
Fast charge	0.4C_5 turn into 0.2 C_5		2.5	
			2.5	
Float chart		1.48~1.50V/cell (for medium rate cell)		
		1.42~1.45V/cell (for medium rate cell)		
Equilibrium charge		1.55~1.60V/cell	12	

Note: The voltage of power supply for one cell is 1.90V in the normal charge. In the cold region, the voltage should be set 2.20V/cell.

5.1.2 The selection of various charge regimes:

Usually, the battery can be charged by normal charge rate. In the case of emergency, the fast charge method can be used. The battery must be overcharged when it is overdischarged, reverse charged at small current, interval discharged or when the capacity is not enough in case of long time not use. When battery is stored for 1-3 months after charge, it is needed to charge by complementary method before its operation.

If the battery is used as standby power supply and is connected parallel with load, float charge should be used, when float charge and load supply is stopped, equilibrium charge should be used firstly, then change into float charge; if the battery is in float charge for a long time, it should be charged by equilibrium method for 1~3 times every year.

5.2 Discharge

The low rate battery can be discharged at the current of $0.1C_5A$~$0.5C_5A$ (1 C_5A is for short time discharge). The medium rate battery can be discharged at 0.2 C_5A~3.5 C_5A. During discharge, the temperature of electrolyte shouldn't exceed 45℃. If exceed, reduce the discharge current or take cooling measures immediately. The battery discharge regime is shown in Table 4.

Table 4.

Constant discharge current(A)	Discharge end voltage(V)	Discharge duration	Remarks
0.1 C_5	⩾1.10	About 10h	
0.2 C_5	⩾1.0	About 5h	
0.33C_5	⩾1.0	About 3h	Final discharge voltage is 0.9v/cell for low rate cell
0.5 C_5	⩾0.9	About 2h	Final discharge voltage is 0.7v/cell for low rate cell
1 C_5	⩾0.9	About 40min	Only for medium rate cell
2C_5	⩾0.8	About 10min	Only for starting application of the medium rate cell

5.3 Maintenance during operation

5.3.1 Water replenish of battery

The electrolyte density will increase because the water evaporating and charge electrolysis, it's necessary to check the electrolyte level and density. In case of continuously constant current charge and discharge, it must be checked. In case of constant voltage charge, check it one time every three months. In case of float charge, check one time every half a year (the water replenish may depend on the temperature), the water requirements of electrolyte should be comply with the standard.

5.3.2 If the battery is used at the temperature of 20±10℃, its electrolyte should contain LiOH. Otherwise, its service life will be reduced.

5.3.3 If battery is used at the temperature of above 35℃, its electrolyte should be NaOH electrolyte contained with LiOH, it will be good for battery's capacity and life. Because of the high ambient temperature, the battery charge efficiency will decline; it is good to take cooling measures during charge.

5.3.4 If the battery is used at the temperature of –40~0℃, the electrolyte of No.3 or No.4 in Table 6 should be used, this will keep electrolyte from freezing, so that the charging efficiency will not be effected.

Because low temperature will affect charge efficiency, it is better to charge at the normal temperature, and then operates in the cold temperature; this will be good for the battery performance. If the battery has to be charged at low temperature, overcharge rate should be adopted.

5.3.5 During the storage, storage room should be dry and ventilated with temperature of 25±10℃; it is prohibited to store the alkaline battery with the acid battery or other acid materials in the same room. All the tools and instruments should not be used for acid battery.

5.3.6 The battery can't be struck by metal tool. When tightening the nuts, the tool can't touched positive and negative terminals in the same time. Negative pole should not contact with the metal container of the battery to protect from short-circuit. During charge, it is forbidden to make a fire near the battery.

5.3.7 The battery should be clear and if electrolyte leak outside, clean them quickly. The plastic container can be cleaned by clear water, alcohol is forbidden to use.

The rust points in the steel container or metal parts can be cleaned by a cloth with electrolyte, then paste a thin layer of Vaseline oil.

5.4 Electrolyte replacement

5.4.1 Electrolyte replacement period

During the operation, the electrolyte within the battery absorbs the CO_2 in the air easily and turns into carbonate. This will increase internal resistance. When the carbonate content exceeds 60g/L, or the electrolyte is contaminated and it will cause capacity decreased, replace new electrolyte. In case of float charge, check the carbonate content every 3 year, if necessary, replace the electrolyte.

5.4.2 Method of electrolyte replacement

When is discharged to 1.0V/cell, open the plug and place the battery upside down and shake to pour the electrolyte out, if the electrolyte is very dirty, wash the battery 2-3 times with water (used for electrolyte), then fill new electrolyte.

5.5 Performance check

During operation, if the individual cell capacity is found to decrease, it should be replaced. Otherwise, it will affect the performance of the battery.

5.6 When battery is being used, special person should be assigned for maintaining it, especially during charge, the accuracy of charge current and enough charge time must be guaranteed. Otherwise, the battery will not be charged enough.

5.7 Instruments calibration

The gavanometer, voltmeter and thermometer hydrometer etc, must calibrated periodically so as to keep their accuracy.

6. The storage of Batteries

The storage of the batteries could be affected by storage condition, ambient temperaturem, air humiditym, their state prior to storage. Storage and maintenance of the batteries should meet the specified requirement so as to prolong their service life.

6.1 Long-time storage

If the battery is stored for a long time, it is advisable to screw the gas-plug tightly in discharge state, clean the metalwares, coat them with Vaseline oil and store them in a dry, acidless, and well-ventilated room where the temperature is not higher than 35℃, where the relative humidity is not higher than 75℃.

6.2 Short-time storage

The battery which is stored within one year can be stored with electrolyte. Adjust the electrolyte level and screw the vent before storing. Keep the battery in a dry, acidless and well ventilated room where the temperature is not higher than 35℃.

7. Troubles and Trouble shootings

Table 5. Troubles and Trouble shootings.

Troubles	Causes	Trouble shootings
The capacity of the battery decreases	1.The electrolyte has been used for a long time and the carbonate content in it is too high.	Replace the electrolyte
	2. The electrolyte is improperly used.	Replace the electrolyte
	3. The electrolyte isn't enough, and the level of the electrolyte is below the top of the plates.	Add distilled water, and adjust the density, then overcharge it.
	4. Hurmful impurities contained in the electrolyte is too high.	Replace the electrolyte after cleaning
	5. The charge/discharge mechanism is not correct.	Use the correct charge/discharge mechanism.
	6.Short-circuit or slight-short circuit in the cell	Replace the short-circuit cell.
	7. Short-circuit or slight-short circuit occurs out of the cell.	Keep the cells in a dry temperature
	8. The instruments used are not correct.	Check and rectify the galvanometer and voltmeter.
Voltage is incorrect	1. The inner circuit of the cell is short or cut, the electrolyte has been run out.	Clean the cell, or change the electrolyte
	2. The out circuit of the battery is short or cut.	Keep the cell dry, and check
	3.Contact fault	Check and repair

Bubbles appear in the inside of the cell	The electrolyte contains organic impurities	Replace the electrolyte
The cell container swells	1. The positive plate swells.	If necessary, change the cell.
	2. The vent is blocked up.	Clean with hot water or replace it.
	3. The inner circuit of cell is short, or there are too many impurities in the electrolyte.	Check and replace the electrolyte.
Creeping of electrolyte	1.The level of electrolyte is too high	Drain out the superfluous electrolyte.
	2.The vent of terminal is unsealed	Replace the sealing parts and screw tightly.
	3. Too much electrolyte overflows.	Clean and keep dry
Electrolyte leaks out from plastic container	There are pores or cracks caused by transportation or operation. Or the container and the cover haven't adhered well.	Adhere the cracks with adhesive which is made up by dissolving ABC resin in dichloromethane or in acetone. Clean the alkaline away from the adhering zone before adhering.
Electrolyte leaks out from steel container	1. There are pores or the welding seam of the container and the cover rends.	Dip the battery in dilute alkaline solution after pouring out the electrolyte, the welding seam should be emerged 10~15mm above the alkaline solution. Reweld the cracks by small type welding torch No.4 or No.5 welding tip. It is advisable to seal the filling vent when putting the battery upside-down. The container should be replaced if electrolyte leaks from other place besides of the welding seam on the connection of container and the cover.
	2.Leakage caused by electrochemical corrosion during operation	If corrosion is on the welding seam of the bottom and cover, it can be rewelded with small type welding torch. If corrosion is on other parts of the container, the container must be replaced and kept isolated and dry.

Appendix 1. The electrolyte selection, preparation, and storage.

1. The selection of electrolyte.

1.1 The density, compostion or additives are determined by operating temperature of the battery. See Table 6.

Table 6

No.	Operating temp. (℃)	Density (g/cm^3)	Composition of electrolyte	Weight ratio (alkaline : water)
1	10~45	1.18±0.02	NaOH+20g/L LiOH	1 : 5
2	-10~35	1.20±0. 02	KOH+40g/L LiOH	1 : 3
3	-25~10	1.25±0. 01	KOH	1 : 2
4	-40~15	1.28±0. 01	KOH	1 : 2

1.2 The technical requirements of electrolyte see Table 7.

(The reference density is 1.20±0. 02g/cm^3)

Table 7

Items	Technical requirements	
	New electrolyte	Limiting value during operation
Outward appearance	Colourless,transparent,no suspended substance	
Density(15℃)	1.20±0. 02	1.20±0.02
Content(g/L)	KOH : 240~270,NaOH : 215~240	KOH : 240~270,NaOH : 215~240
Cl^-(g/L)	< 0.1	0.2
K_2CO_2(g/L)	< 20	60
Ca^{2+}•Mg^{2-}(g/L)	< 0.19	0.3
Fe/KOH(NaOH)(%)	< 0.05	0.05

1.3 Technical requirements for raw material

KOH: chemical pure (GB2306-80) or industrial grade (GB1919-80)

NaOH: chemical pure (GB629-81) or industrial grade (GB209-84)

LiOH•H_2O: industrial pure, LiOH contented should not be less than 50%.

Water: distilled water, ion-exchange water, softened water or electro osmosis water

2. Vessels and implements

The vessels for preparation of the electrolyte should be plastic, porcelain enamel wares or restless steel. The tools include: buoyant meter (range of 1.10~1.30), thermograph, graduate cylinder, funnel, plastic scoop, platform scale, stirrer or plastic rod.

3. Preparation and storage

3.1 According to Table 6, weigh the needed amount of alkaline. Put water into the vessel, add alkali slowly with constant stirring, then add the required lithium hydroxide into the vessel, stir to dissolve thoroughly. Cool to 20±5℃. Finally, determine the density and adjust to the required value.

3.2 Storage

The prepared electrolyte or electrolyte in storage must be well-sealed in plastic or porcelain vessels. Keep away from acid or other impurities.

4. Safety attention points

When preparing electrolyte, the alkali should be put into water slowly. It is prohibited to put water into alkali. In preparation of electrolyte, one should put on goggles, rubber gloves, rubber overshoes and work clothes to protect one's skin from being harmed by alkali. If one's skin is touched by alkali, he must at once wash it off with 3% boric acid solution.

Appendix 2 External dimensions, weight & other data of Model GN22~GN100 cells (batteries) with steel case.

No	Model	Nominal voltage (V)	Nominal capacity (Ah)	Max. dimensions (mm)			Thread of pole	Max.weight with electrolyte (Kg)	Quantity of electrolyte (L)
				L	W	H			
1	GN22	1.2	22	128	34	216	M5	1.78	0.27
2	GN45	1.2	45	128	55	216	M5	2.78	0.45
3	GN60	1.2	60	155	47	349	M10×1	4.70	0.75
4	GN100	1.2	100	155	72	349	M10×1	0.63	1.20
5	2GN22	2.4	22	164	137	257	M5	4.20	0.54
6	10GN22	12	22	468	164	257	M5	20.90	2.70
7	10GN22A	12	22	524	152	259	M5	21.40	2.70
8	17GN22	20.4	22	478	301	257	M5	35.70	3.89
9	20GN22	24	22	521	301	257	M5	40.50	5.40
10	3GN45	3.6	45	241	164	257	M5	11.73	1.35
11	3GN45A	3.6	45	297	152	259	M5	12.24	1.35
12	4GN45	4.8	45	308	155	253	M5	14.30	1.80
13	4GN45A	4.8	45	364	152	259	M5	14.80	1.80
14	5GN45	6.0	45	375	155	253	M5	17.34	2.25
15	5GN45A	6.0	45	431	152	259	M5	17.90	2.25
16	6GN45A	7.2	45	498	152	259	M5	21.00	2.70

17	7GN45	8.4	45	511	164	257	M5	23.90	3.15
18	7GN45A	8.4	45	567	152	259	M5	24.50	3.15
19	10GN45	12.0	45	710	168	257	M5	34.20	4.50
20	10GN45A	12.0	45	766	156	256	M5	34.70	4.50
21	14GN45	16.8	45	553	295	257	M5	38.50	6.30
22	4GN60	4.3	60	261	188	393	M10×1	24.00	3.00
23	4GN60A	4.8	60	327	176	395	M10×1	24.50	3.00
24	5GN60	6.0	60	318	188	393	M10×1	29.60	3.75
25	5GN60A	6.0	60	384	176	395	M10×1	30.10	3.75
26	6GN60A	7.2	60	441	176	395	M10×1	35.50	4.50
27	10GN60	12.0	60	603	188	393	M10×1	57.60	7.50
28	10GN60A	12.0	60	669	176	395	M10×1	57.63	7.50
29	4GN100	4.8	100	377	195	393	M10×1	33.70	4.80
30	4GN100A	4.8	100	443	183	395	M10×1	34.20	4.80
31	5GN100	6.0	100	452	195	393	M10×1	39.30	6.00
32	5GN100A	6.0	100	528	183	395	M10×1	39.80	6.00
33	10GN100	12.0	100	887	195	393	M10×1	76.50	12.00
34	10GN100A	12.0	100	953	183	395	M10×1	77.00	12.00

Appendix 3. External dimensions, weight & other data of Model GN100~1000 batteries with steel case.

No	Model	Nominal voltage (V)	Nominal capacity (Ah)	Max. dimensions (mm)			Thread of pole	Max.weight with electrolyte (Kg)	Quantity of electrolyte (L)
				L	W	H			
1	GN125	1.2	125	131	71	349	M10×1	6.80	1.20
2	GN250	1.2	250	171	136	368	M16	18.10	3.00
3	GN250-(4)	1.2	250	232	115	338	M16	15.00	3.00
4	GN300	1.2	300	171	136	451	M16	24.00	4.00
5	GN350	1.2	350	171	159	531	M16	27.60	5.00
6	GN400	1.2	400	171	159	531	M16	28.00	5.00
7	GN500	1.2	500	171	159	561	M16	30.60	6.00
8	GN600	1.2	600	392	167	455	M20×1.5	50.50	11.00
9	GN800	1.2	800	392	167	520	M20×1.5	63.00	15.00
10	GN1000	1.2	1000	392	167	575	M20×1.5	73.00	18.00
11									

Appendix 4. External dimensions, weight & other data of various low-rate cells (batteries) with plastic case.

No	Model	Nominal voltage (V)	Nominal capacity (Ah)	Max. dimensions (mm)			Thread of pole	Max.weight with electrolyte (Kg)	Quantity of electrolyte (L)
				L	W	H			
1	GN10-(2)	1.2	10	85	39	126	M5	0.66	0.12
2	2GN10-(2)	2.4	10	85	78	126	M5	1.34	0.24
3	2GN10-(2)A	2.4	10	170	38	126	M5	1.34	0.24
4	4GN10-(2)	4.8	10	160	91	135	M5	3.12	0.48
5	5GN10-(2)	6.0	10	197	91	135	M5	3.81	0.60
6	6GN10-(2)	7.2	10	235	91	135	M5	4.52	0.72
7	GN40	1.2	40	145	54	248	M10×1	2.70	0.60
8	GN50	1.2	50	142	67	223	M10×1	3.20	0.70
9	5GN50A	5.0	50	375	153	259	M10×1	18.10	3.50
10	5GN50B	5.0	50	375	153	259	M10×1	18.10	3.50
11	GN60-(2)	1.2	60	135	49	373	M10×1	3.90	1.00
12	GN100-(2)	1.2	100	139	79	362	M16	6.50	1.70
13	3 GN100-(2)	6.0	100	391	152	392	M16	35.00	8.50
14	5 GN100-(2)A	6.0	100	434	152	392	M16	36.50	8.50
15	GN150	1.2	150	167	162	343	M20×1.5	13.00	3.30
16	GN200	1.2	200	167	162	343	M20×1.5	14.00	3.30
17	GN250-(2)	1.2	250	174	161	557	M20×1.5	17.00	4.00
18	GN250-(3)	1.2	250	277	139	420	M16		
19	GN300-(2)	1.2	300	176	161	557	M20×1.5	22.80	4.00
20	GN300-(3)	1.2	300	277	139	450	M16	21.50	6.00
21	GN350-(2)	1.2	350	176	161	450	M20×1.5	23.00	4.00
22	GN400-(2)	1.2	400	176	161	557	M20×1.5	25.00	4.20
23	GN400-(3)	1.2	400	232	172	557	M16	24.50	5.00
24	3GN400-(3)	3.6	400	555	241	410	M16	80.00	14.00
25	GN500-(2)	1.2	500	290	172	435	M20×1.5	39.00	5.00
26	GN600-(2)	1.2	600	291	174	505	M20×1.5	50.00	6.00
27	GN800-(2)	1.2	800	399	184	562	M20×1.5	63.00	18.00
28	GN1000-(2)	1.2	1000	398	184	572	M20×1.5	73.00	18.30
29	3GN200	3.6	200	563	209	362	M20×1.5	63.00	10.00

Appendix 5. External dimensions, weight & other data of various medium rate alkaline cells (batteries)

No	Model	Nominal voltage (V)	Nominal capacity (Ah)	Max. dimensions (mm)			Thread of pole	Max.weight with electrolyte (Kg)	Quantity of electrolyte (L)
				L	W	H			
1	GNZ15	1.2	15	124	40	205	M10×1		
2	GNZ30	1.2	30	142	66	227	M10×1	3.50	0.83
3	GNZ50	1.2	50	139	79	291	M16	5.00	1.30
4	GNZ75	1.2	75	139	79	361	M16	6.50	1.67
5	GNZ100	1.2	100	164	104	345	M20×1.5	9.30	1.75
6	GNZ150	1.2	150	163	80	450	M20×1.5	12.50	2.50
7	3GNZ150	3.6	150	284	185	465	M20×1.5	40.00	7.50
8	GNZ150-(2)	1.2	150	165	160	338	M20×1.5	13.50	3.08
9	GNZ150-(3)	1.2	150	163	80	450	M20×1.5		
10	GNZ120	1.2	120	167	162	343	M20×1.5	12.50	2.92
11	GNZ200	1.2	200	286	174	348	M20×1.5	24.50	5.83
12	GNZ250	1.2	250	286	174	348	M20×1.5	26.00	5.83
13	GNZ300	1.2	300	184	168	554	M20×1.5	23.00	5.00
14	GNZ300-(2)	1.2	300	176	161	540	M20×1.5	23.00	4.17
15	GNZ500	1.2	500	291	174	501	M20×1.5	39.00	7.50
16	GNZ600	1.2	600	390	176	557	M20×1.5		
17	GNZ700	1.2	700	390	176	557	M20×1.5		
18	GNZ800	1.2	800	390	176	557	M20×1.5		

Appendix 6 Reference charge & discharge curves (1~9) of low and medium rate Ni-Cd batteries

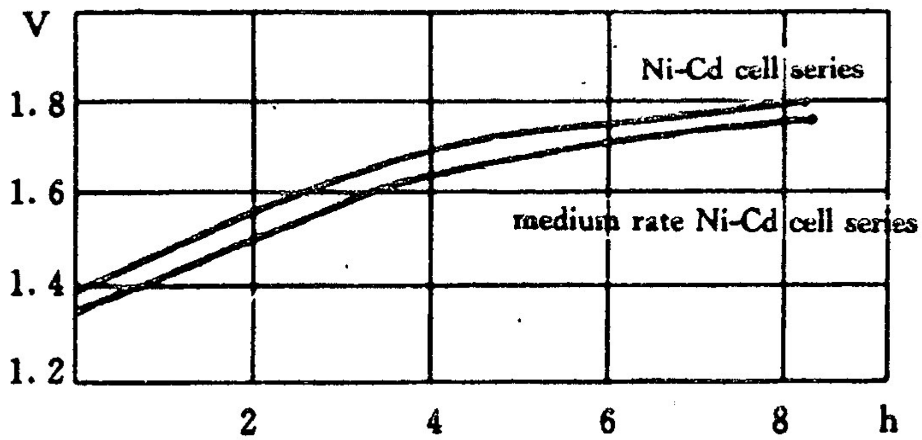

Fig 1. Charging curves of Ni-Cd pocket battery at $0.2C_5A$

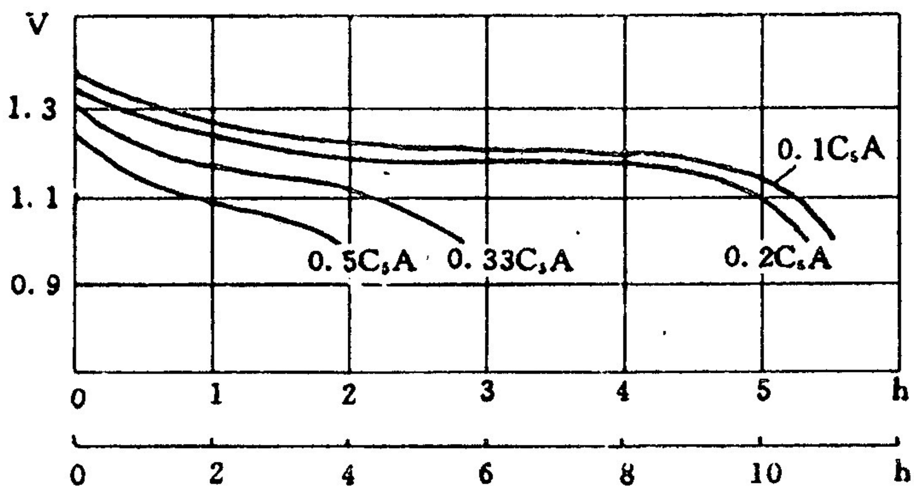

Fig 2. Various discharge curves of Ni-Cd battery at 20℃

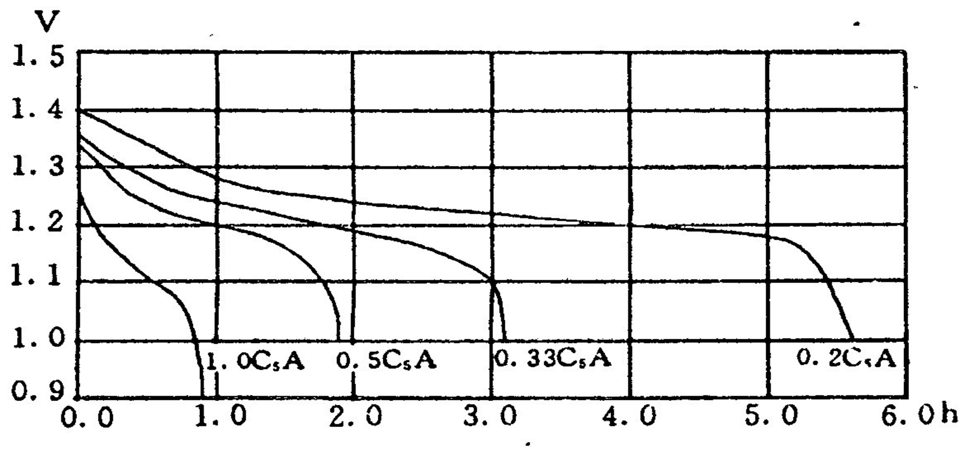

Fig 3. Discharge curves of medium rate Ni-Cd battery at 20℃

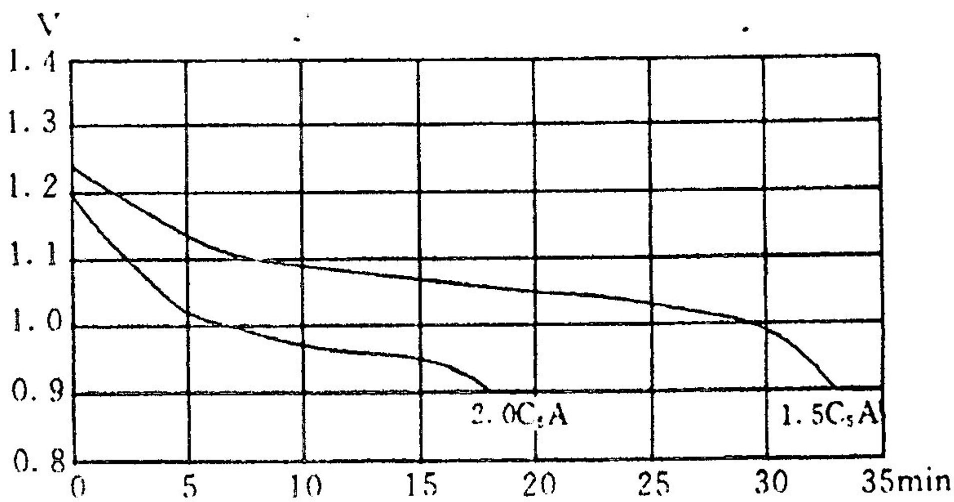

Fig 4. Discharge curves of medium rate Ni-Cd battery at 20℃

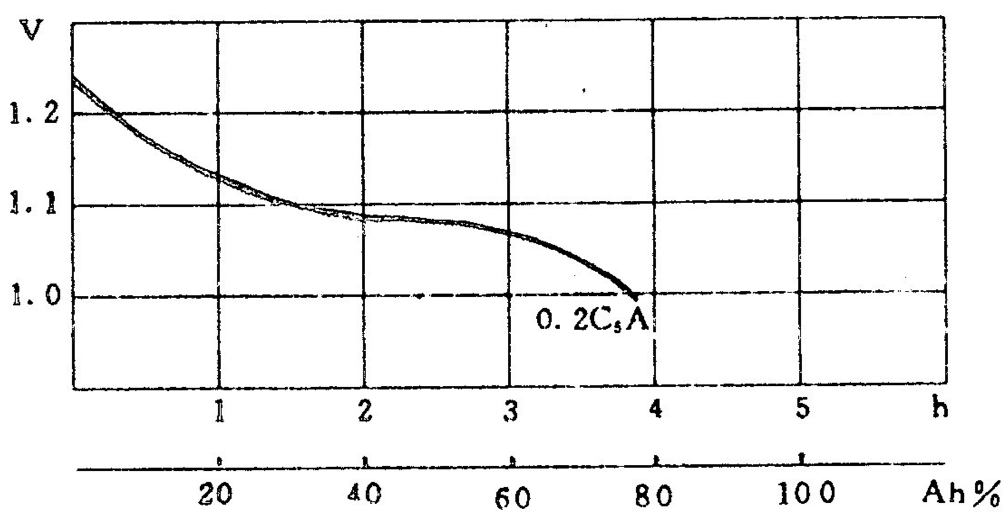

Fig 5. Low temperature (-18℃) discharge curve $0.2C_5A$ of Ni-Cd battery series.

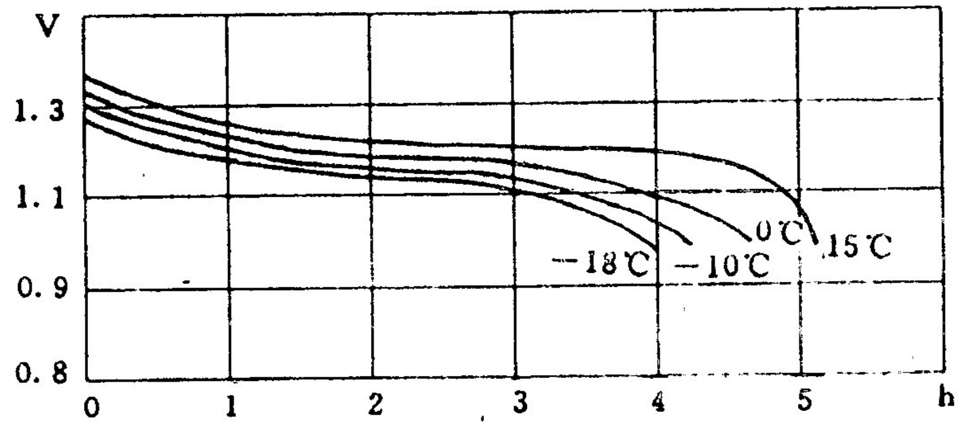

Fig 6. Discharge curves of $0.2C_5A$ and various low temperatures of medium rate Ni-Cd battery series.

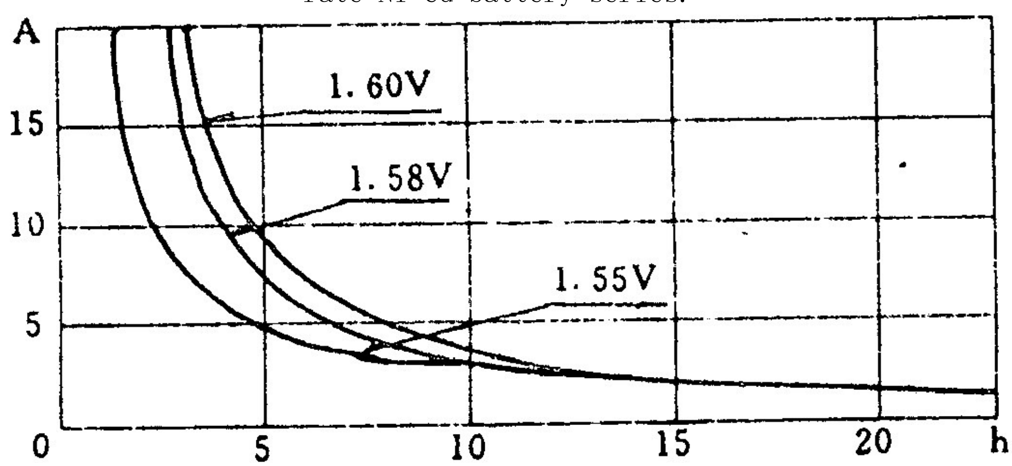

Fig 7. Constant voltage charging A-h curves of Ni-Cd battery series at 20℃

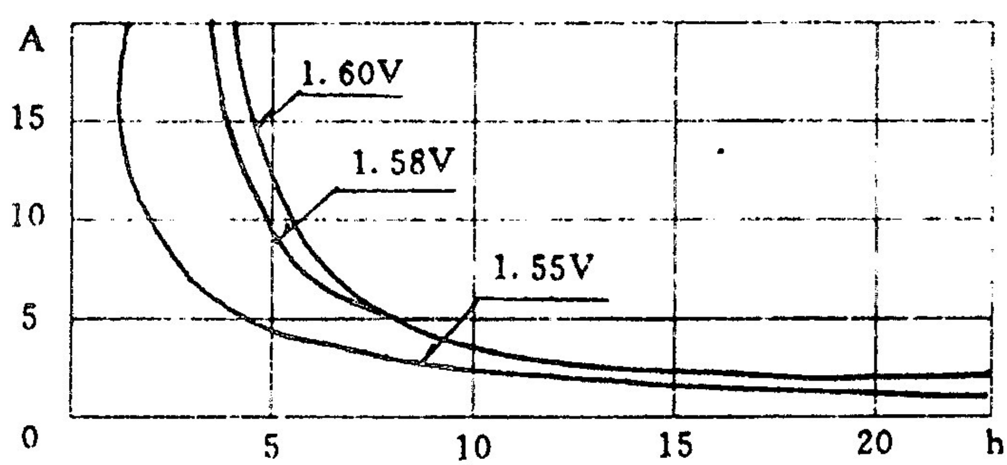

Fig 8. Constant voltage charging A-h curves of medium rate Ni-Cd battery series at 20℃

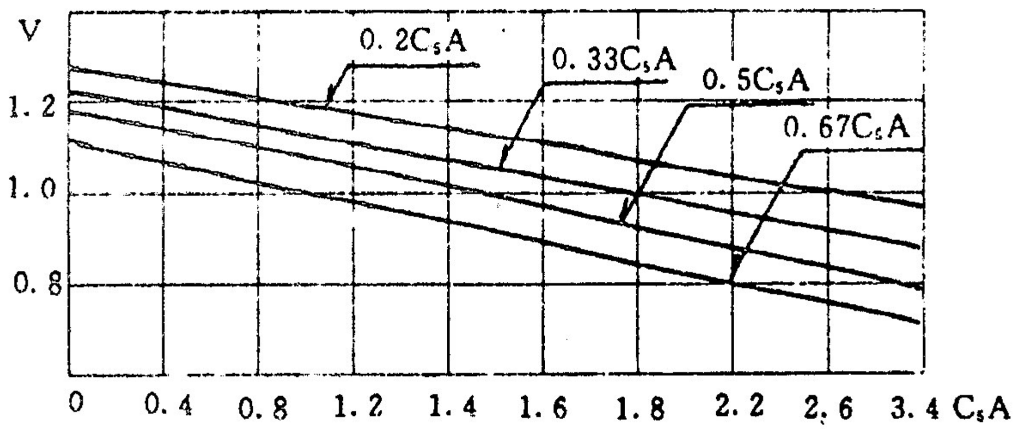

Fig 9. Instantaneous discharge curves after 1h of various discharge rates of the medium rate Ni-Cd battery series in the state of 1.45V/cell float charge