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CHANGHONG®

CHANGHONG NF-S Series Nickel-Iron batteries for solar PV application

SICHUAN CHANGHONG BATTERY CO., LTD.

The Power Of Energy

1.1 Introduction

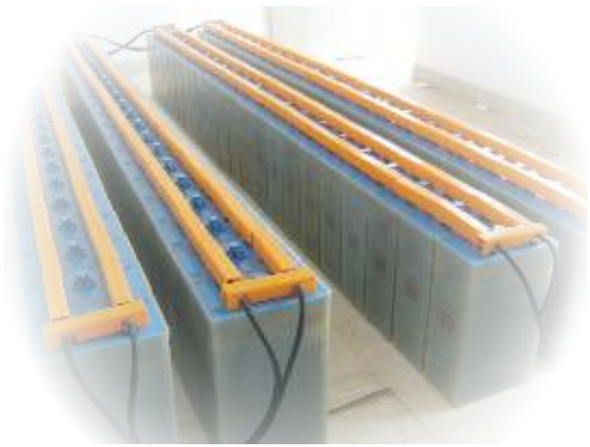
Nowadays, more and more people have realized the importance of environmental protection and are actively advocate green energy. Because of its long service life, high reliability, lower cost, environmental friendliness and other characteristics, Nickel-Iron (Ni-Fe) batteries are gradually replacing the lead-acid batteries in a wide range of applications, especially for solar PV and renewable energy power systems.

This manual details the technical characteristics of Changhong Solar Nickel-Iron NF-S series battery.

The NF-S series Solar NiFe batteries manufactured by Sichuan Changhong Battery Co., Ltd are specially designed for solar PV and renewable energy applications. It has long cycling life, low operation cost, environmental friendliness (no lead, cadmium, or acid and is highly recyclable), high safety with almost no possibility of burning or thermal runaway, etc. It can withstand deep discharge, wide temperature variations, mechanical & electrical abuses, and still show excellent and reliable performance over a long period of time.

NF-S series solar NiFe batteries are suitable for all solar photovoltaic power systems. They are widely used as storage power supply for solar photovoltaic systems, commercial and residential buildings, offshore oil platforms, railway transportation, crossing guards lighting, signaling, isolated BTS station, cathodic protection for pipelines and radio navigation systems. NF-S series solar Ni-Fe batteries can last longer than 20 years if they are operated with the

recommended practice. Special features include a steel frame with welded plates, shock-resistant polypropylene or MBS casing material and special flame arresting flip-top vent. In addition, the generous electrolyte reserve prolongs the topping-up interval period. With the aid of advanced manufacturing methods and excellent design, the NF-S series Ni-Fe batteries are especially suitable for remote and isolated locations requiring minimal maintenance.



1.2 Photovoltaic System

The power generated by solar photovoltaic systems is widely used for different applications: from commecial and residential power supply to railroad signaling to telecommunication and microwave transmission tower. The battery system is used to supply the power for the load on cloudy days and at nights. The solar photovoltaic system is ideal for field & unmanned applications due to easy installation, minimal maintenance requirement, and high reliability.

1.2.1 Photovoltaic Applications

Commercial and Residential Buildings

Railway and Light Trains
- Crossing Gates
- Lighting and Signaling

Navigation Aids
- Remote lighthouses
- Beacons
- Offshore

Utilities
- Electric Power Supply for Remote Areas/Islands

Oil and Gas Fields
- Emergency Lighting on Offshore Platforms
- Cathodic Protection for Pipelines

Telecommunication Systems
- Base Stations
- Radio Repeater Stations
- Emergency Telephone Posts

1.2.2 Components of the Photovoltaic System

A photovoltaic system consists of three main parts:
1. Photovoltaic array
2. Electronic components, e.g. blocking diodes, logic circuits in power conditioners & controllers.
3. Batteries

Thus, the ideal photovoltaic power system is a reliable installation which requires infrequent maintenance. The batteries play a crucial role, as premature failure of the battery could result in the failure of whole system.

1.2.3 Suitability for photovoltaic applications

- Environmental friendliness (no lead, cadmium, or acid and is highly recyclable)
- Long cycling life
- Able to withstand abuse and wide temperature variation
- High safety, high reliability, low maintenance
- Resistant to withstand failure of electronic control systems
- Higher charge ratio and utilization ratio
- Easy to transport and install in remote and harsh areas

1.3 Construction features

1.3.1 Plate Construction

Changhong NF-S series NiFe cell consists of two groups of plates, the positive plates containing nickel hydroxide and the negative plates containing iron oxide. These active materials are retained in pockets formed from nickel plated steel strips which are double-perforated by a mechanical rolling process. These pockets are mechanically linked together, cut to the size corresponding to the plate length and compressed to the final plate dimension. Then, these plates are welded to a current carrying bar which further ensures high mechanical strength and electrical stability.

Because the structural component of the plate is made of steel, the plates cannot be gradually weakened by repeated cycling, which gives Changhong NF-S series NiFe batteries an exceptionally good cycle life. Besides, the alkaline electrolyte inside does not react with steel, which means that the supporting structure of the NF-S series NiFe batteries stay intact and unchanged during their whole life. Since there is no corrosion, there is no risk of “sudden death”, therefore, NF-S series NiFe batteries can meet the special requirements of solar photovoltaic applications. In contrast, the structure and the active material of the lead plates bring about shedding of the positive plate material and eventual structural collapse of lead acid batteries.

1.3.2 Electrolyte

The electrolyte used in NF-S series NiFe battery is a combined solution of potassium hydroxide and lithium hydroxide, which can improve the battery's performance (e.g. cycling life, energy efficiency, wide operational temperature range, etc), allowing it to reach the optimum level. The different standard concentrations of electrolyte allow NF-S series NiFe battery to be operated within a temperature range of -20^{0}C~60^{0}C, which makes the battery able to withstand very high temperature fluctuation that exists in some remote regions.

1.3.3 Terminal Poles

Nickel plated terminal poles made of threaded steel bars are welded onto the current carrying bar to assemble plate groups. The cell cover and terminal pole are sealed by compression rubber washers, which are designed to provide satisfactory sealing throughout the whole life of the battery.

1.3.4 Vents

Changhong NF-S series NiFe batteries are fitted with special flame arresting flip-top vents to ensure the battery works safely and reliably while providing good ventilation during chargin.

1.3.5 Cell Container

The cell container is made of corrosion-free, translucent or transparent polypropylene or MBS engineering plastic material.

1.4 Benefits of the Changhong NF-S series NiFe Battery

- Long cycle life (maximum service life can reach 20 years or more, if operated correctly)
- Environmental friendliness (no lead, cadmium, or acid. Highly recyclable)
- High safety with little possibility of burning or thermal runaway
- Wide operating temperature range
- Low maintenance

With its generous electrolyte reserve, the topping-up frequency is reduced so the Changhong NF-S series NiFe battery can be left in remote sites without maintenance for long periods of time.

- High resistance to mechanical and electrical abuse
- Low transportation and installation cost

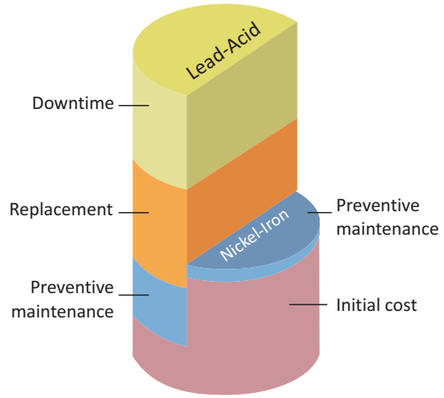
Because of its high mechanical strength, NF-S series NiFe battery is able to withstand harsh treatment during transportation and installation.

1.5 Comparison Between VRLA and NF-S Series NiFe Cell

1.5.1 Table1 Characteristic comparison Sheet

Item Name	Lead Acid Battery	NF-S Battery
Norminal Voltage	2V	1.2V
Floating Charge Voltage	2.23V/cell~2.3V/cell	1.45V/cell~1.50V/cell
Temperature factor during floating charge	-3mV/^{0}C per cell	-3mV/^{0}C per cell
Operating voltage	Average	Good
Standard charge and discharge current	0.1C_{10}A	0.25C_5A
High rate discharge performance	Poor	Good
Overcharge performance	Poor	Good
Over discharge performance	Extremely Poor	Good
Effect from floating charge voltage	When the charge voltage exceeds 2.35V/cell, the service life of VRLA cell will be reduced by 1/2 for every 0.1V/cell increase.	Not affected
Operation life	3 years	20 years
Storage life	2 years	4 years
High temperature performance	When the ambient temperature exceeds 50^{0}C, there is capacity decrease risen from the reduction of the charge acceptance performance, which greatly effect the service life of the VRLA cell.	Not affected
Low temperature performance	Great effect on the service life of VRLA cell	Little effect on the service life of NF-S series NiFe cell
Thermal danger if shorted	Yes	No
Premature capacity loss	Yes	No
Environmentally friendly	No	Yes

1.5.2 Cost Comparison Between VRLA and NiFe Cell



Life-cycle Cost Comparison After Ten Years

Cost effectiveness

There are three distinct parts contribute to the cost of a battery system:

- Initial investment: including the cost of purchase, spares, tools, and installation.
- Maintenance cost: including unexpected and expensive downtime costs,
- Replacement cost: including dismantling, shipping, disposal and administrative costs.

VRLA batteries:

In the case of lead acid batteries, this can also include frequent replacement and all the costs associated with an unexpected battery failure.

NiFe batteries:

NiFe batteries may cost more than lead-acid cells on the basis of initial investment alone. As for stand-by, like solar photovoltaic applications with large capital investment installed in remote locations, maintenance and replacement cost factors can greatly outweigh the initial cost of the battery.

The performance of NiFe cells is similar to Ni-Cd cells. In addition, NiFe cells are environmentally friendly. The true maintenance requirements and the life cycle costs should be the main factors to be considered to make a cost effectiveness calculation. Adding the extra costs caused by the sudden or premature failure of lead acid batteries, Ni-Cd and Ni-Fe batteries are cheaper in the long-term.

Operation Characteristics

1.6.1 Rated Capacity

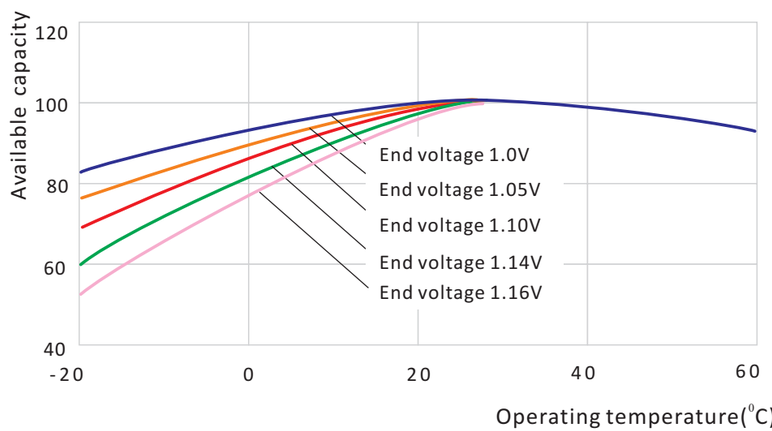
The capacity of the Changhong NF-S series NiFe battery is rated in ampere hours (Ah), which is the quantity of electricity discharged by 5-hour discharge rate (C_5) current to 1.0V end voltage at 20^{0}C after being fully charged.

1.6.2 Nominal Voltage

The nominal voltage of the Changhong NF-S series NiFe battery is 1.2V/cell.

1.6.3 Effect of temperature on performance

Variations in ambient temperature affect the performance of a battery. The capacity de-rating factors, which are required in sizing cell to compensate for temperature variations, are given in the following figure.



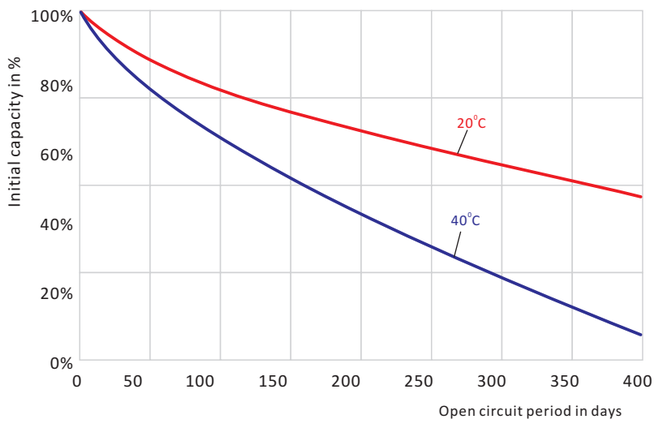
Typical Capacity De-rating Factors Versus Temperature

1.6.4 Short Circuit Current

The short circuit Current of Changhong NF-S series NiFe cell is approximately 10 times of the ampere-hour capacity.

1.6.5 Open Circuit Loss

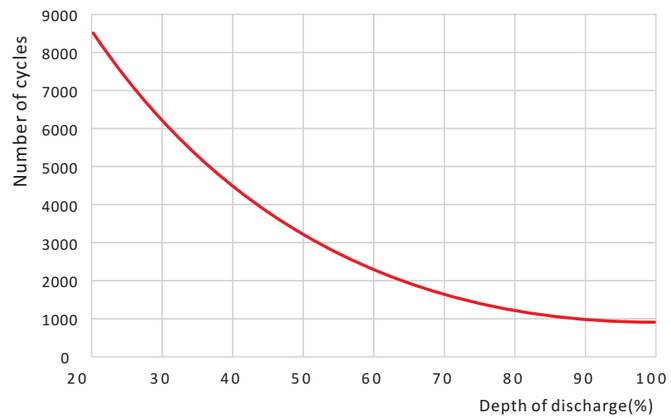
Because of self-discharge, the state of charge in the open circuit state will decrease slowly with time. The open circuit loss value at different temperatures, which may be experienced in photovoltaic application, is shown in the figure at right.



Open circuit loss at 20°C and 40°C

1.6.6. Cycling

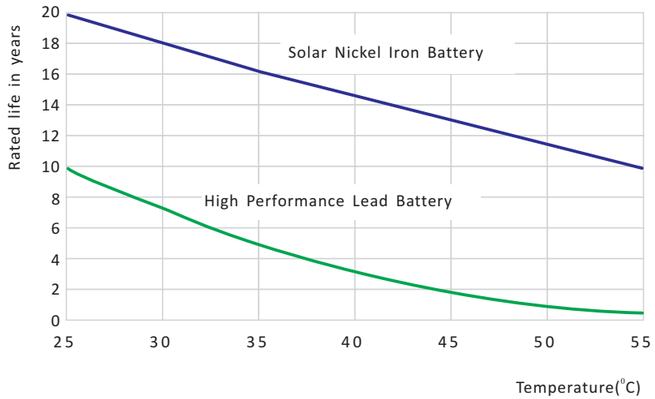
The Changhong NF-S series NiFe cell is adaptable to a wide range of depth of discharge (DOD). The number of cycles varies with DOD required. The lower the DOD is, the higher the cycle number. The numbers of cycles reach thousands in shallow discharge applications, while it can only reach hundreds of cycles during deep discharge. The figure at right shows the effect of DOD on the available cycle life. .



Typical cycle life versus DOD(20°C)

1.6.7 Effect of Temperature on Lifetime

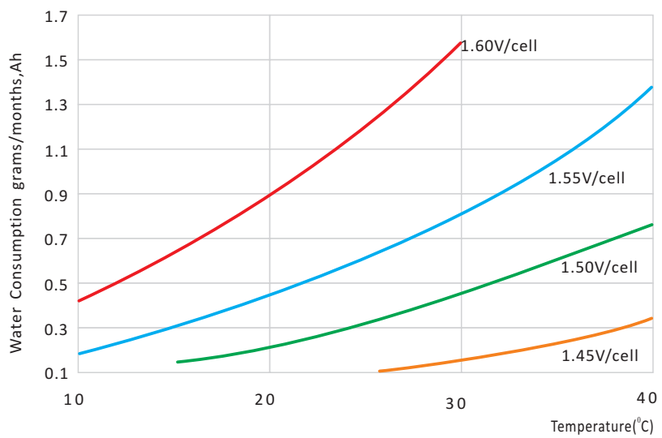
Changhong NF-S series NiFe cell is designed for 20- year service life, but the increase in the temperature of electrolyte will reduce the expected life. In general, every 9°C increase in temperature over the normal ambient temperature of 25°C reduces the service life of Changhong NF-S series NiFe cell by 20%. For lead-acid batteries, it will be 50%. The following figure shows the comparison graph of life expected at high temperature for both Ni-Fe and lead-acid batteries.



Typical battery life expected at high temperature

1.6.8 Water Consumption and Gas Evolution

Overcharging a NF-S battery will break down the water of the electrolyte into oxygen and hydrogen, so pure distilled water should be added to compensate for water loss. In theory, the quantity of water consumed can be calculated according to the Faradic equation that each Ah of overcharge breaks down 0.366cc of water. The electrolysis of 1cc water generates 2000cc of mixture gas in the proportion of 2/3 hydrogen and 1/3 oxygen. In reality the water loss is less due to the fact that some overcharge current is consumed by the self-discharge of the electrodes. The following graph gives typical water consumption values over different ranges of voltages and various temperatures.



Typical Water Consumption

1.7 Charging

1.7.1 Charge Method

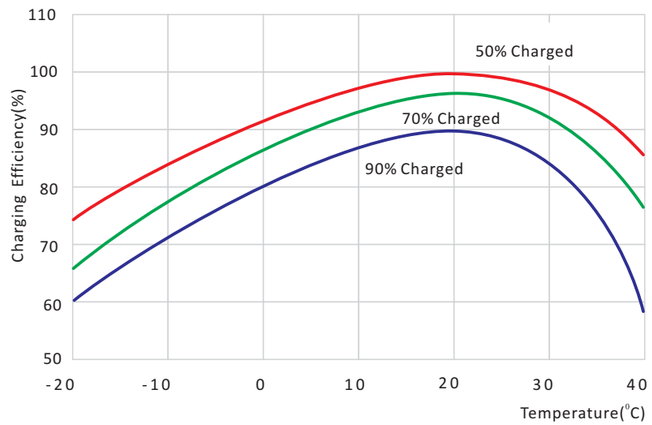
First charge method -- The charge current depends on the capacity of solar panels. When charge voltage of battery reaches the limited values set, the charge current will diminish gradually. The upper charge voltage limit of Changhong NF-S series NiFe cell battery is usually controlled at the range of 1.65V/cell~1.75V/cell.

Second charge method -- Firstly, charge the battery up to a high voltage fixed and then drop it to a lower level voltage, so as to reduce the water consumption. In the first state, the recommended charge voltage is 1.65V/cell~1.75V/cell. In the second state, it should be controlled at the range of 1.42V/cell~1.45V/cell.

If deep discharge cycling is frequently carried out, it is recommended that you turn up the charge voltage. When the battery is operated outdoors or beyond the temperature range of 10°C ~ 30°C, the charge voltage compensation coefficient of -3mV/°C should be taken into account.

1.7.2 Charge Efficiency

Charge efficiency depends on the state of charge and ambient temperature. The graph below shows the charge efficiency to reach 50%, 70%, and 90% state of charge under various ranges of temperature.



Charging Efficiency As A Function Of Temperature

1.8 Battery Sizing Principle

The "Autonomy sizing principle" is the most popular battery sizing method for photovoltaic system application. This type of sizing method takes the number of autonomy working days (based on the maximum number of low insolation days expected) into consideration. On assumption that the cell is fully charged every day, the battery can be sized according to the following formula.

Capacity required = R x A x KT x KDOD x KA

R=Autonomy working hours required

A = Average daily Load (Amps)

KT =Temperature compensation factor

KDOD=Allowable Max. DOD

KA=Aging compensation factor

All parameters can be found from this manual according to its respective working conditions.

Let's take an example to understand this better. Assuming battery is required for autonomy work for 7 Days (168 hours), will be discharged to end voltage of 1.14V/cell at ambient temperature of 40°C and the average daily load is 90W/48V, that is

Autonomy working time R=168hours

Average daily load =90W/48V, A =1.875A

Temperature compensation factor KT =1/0.98=1.02

The Max. DOD allowable calculated from the 20-year life requirement (52times/year)=1040

so, the DOD allowable =85%

The Max. compensation factor of DOD allowable

KDOD =1/0.85=1.176

Ageing compensation factor at 40°C

KA =20/14.2=1.408

Thus, the capacity required =168 x 1.875 x 1.02 x 1.176 x 1.408=532.01Ah

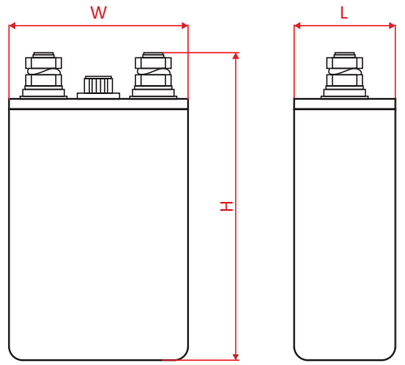
The numbers of cells required =48V/1.2V (nominal voltage) =40

Conclusion: We chose 40 cells of NF600-S batteries for this application.

Trouble Shooting

Trouble	Cause	Solution
Drop in the cell capacity	The electrolyte has been used for a long time and the carbonate content inside is too high.	Replace the electrolyte.
	The electrolyte is exhausted.	Replace the electrolyte.
	No enough electrolyte, and the level of electrolyte is below the minimum level line.	Add distilled water, adjust the electrolyte density then overcharge the cell
	Harmful impurities in electrolyte	Replace the electrolyte after cleaning. Overcharge the cell. For other causes, repair the cell accordingly.
	The charge/discharge parameters are not correct.	Charge or discharge the cell in strict accordance with the supplier's requirements.
	Short-circuit or slight short-circuit inside the cell.	Replace the electrolyte or repair the cell after cleaning.
	Short-circuit or slight short-circuit occurs from outside the cell.	Keep the cells in a clean and dry environment and check wiring.
	The instruments are out of calibration.	Check and rectify the galvanometer and voltmeter.
Voltage is abnormal	Short or open circuit in a cell or no electrolyte inside cell.	Clean the cell, or change the electrolyte.
	Short or open circuit outside the battery.	Keep the cells dry, and check for wiring errors.
	Poor wire connection or disconnection.	Check and repair.
The cell container swells	The positive plate swells.	If necessary, change the cell.
	The vent is blocked up.	Clean with hot water or replace the vent.
	There is a short-circuit inside the cell, or there are too many impurities in the electrolyte.	Check and replace the electrolyte.
Bubbles appear in the inside of the cell	The electrolyte contains organic impurities.	Replace the electrolyte.
Alkaline corrosion caused by electrolyte leakage	The level of electrolyte is too high.	Drain out the superfluous electrolyte.
	The vent of terminal is unsealed.	Replace the sealing parts and screw tightly.
	Electrolyte overflows.	Clean the area of corrosive electrolyte fluid.

Selection Table



Model	Rated Voltage V	Rated Capacity I_t Ah	Max. External Dimension mm			Max. Weight kg	Volume of Electrolyte L	Terminal Thread	Container Material
			Length	Width	Height				
NF10-S	1.2	10	38	84	138	0.80	0.2	M6	MBS or PP
NF20-S	1.2	20	32	113	220	1.2	0.3	M6	MBS or PP
NF30-S	1.2	30	68	134	245	2.8	0.8	M1x1	MBS or PP
NF40-S	1.2	40	68	134	245	3.0	0.8	M10x1	MBS or PP
NF50-S	1.2	50	68	134	245	3	0.7	M10x1	MBS or PP
NF60-S	1.2	60	70	134	285	4.2	0.9	M16	MBS or PP
NF80-S	1.2	80	80	141	365	5.8	1.7	M10¡1	MBS or PP
NF100-S	1.2	100	80	141	365	6.2	1.6	M10¡1	MBS or PP
NF120-S	1.2	120	80	141	365	6.4	1.4	M10¡1	MBS or PP
NF150-S	1.2	150	106	164	345	9	2.5	M20	MBS or PP
NF200-S	1.2	200	106	164	345	10	1.8	M20	MBS or PP
NF250-S	1.2	250	138	276	425	18.5	4.6	2xM16	PP
NF300-S	1.2	300	138	276	450	21	5.9	2xM16	MBS or PP
NF400-S	1.2	400	138	276	490	17	5.9	2xM16	PP
NF500-S	1.2	500	138	276	490	27	6.1	2xM16	PP
NF600-S	1.2	600	176	291	510	38	9.2	2xM20	MBS
NF700-S	1.2	700	176	291	510	39	8.4	2xM20	MBS
NF800-S	1.2	800	186	398	570	59	17.2	3xM20	MBS
NF900-S	1.2	900	186	398	570	60	15.6	3xM20	MBS
NF1000-S	1.2	1000	186	398	570	61	15.0	3xM20	MBS

Remarks: 1) We can manufacture other models according to the clients' requirements.
2) We can supply battery crates according to the clients' requirements.

Discharge Data Table

Discharge currents and duration when battery is fully charged at 20°C ± 5°C

Final voltage =1.16V/C

Cell Type	18h	20h	1d 24h	2d 48h	3d 72h	4d 96h	5d 120h	6d 144h	7d 168h	8d 192h	9d 216h	10d 240h
NF10-S	0.50	0.46	0.39	0.20	0.14	0.10	0.08	0.07	0.06	0.06	0.05	0.05
NF20-S	1.00	0.92	0.78	0.40	0.27	0.21	0.17	0.14	0.12	0.11	0.10	0.09
NF30-S	1.50	1.38	1.16	0.61	0.41	0.31	0.25	0.21	0.19	0.17	0.15	0.14
NF40-S	2.00	1.84	1.55	0.81	0.54	0.41	0.33	0.28	0.25	0.22	0.20	0.18
NF50-S	2.50	2.30	1.94	1.01	0.68	0.52	0.42	0.35	0.31	0.28	0.25	0.23
NF60-S	3.00	2.76	2.33	1.21	0.82	0.62	0.50	0.43	0.37	0.33	0.30	0.28
NF70-S	3.50	3.22	2.71	1.41	0.95	0.72	0.58	0.50	0.43	0.39	0.35	0.32
NF80-S	4.00	3.68	3.10	1.62	1.09	0.83	0.67	0.57	0.50	0.44	0.40	0.37
NF90-S	4.50	4.14	3.49	1.82	1.23	0.93	0.75	0.64	0.56	0.50	0.45	0.41
NF100-S	5.00	4.60	3.88	2.02	1.36	1.03	0.83	0.71	0.62	0.55	0.50	0.46
NF120-S	6.00	5.52	4.65	2.43	1.63	1.24	1.00	0.85	0.74	0.66	0.60	0.55
NF150-S	7.50	6.90	5.81	3.03	2.04	1.55	1.25	1.06	0.93	0.83	0.75	0.69
NF200-S	10.0	9.20	7.75	4.04	2.72	2.06	1.67	1.42	1.24	1.10	1.00	0.92
NF250-S	12.5	11.5	9.7	5.05	3.40	2.58	2.08	1.77	1.55	1.38	1.25	1.15
NF300-S	15.0	13.8	11.6	6.06	4.08	3.09	2.50	2.13	1.86	1.66	1.50	1.38
NF350-S	17.5	16.1	13.6	7.07	4.76	3.61	2.92	2.48	2.17	1.93	1.75	1.60
NF400-S	20.0	18.4	15.5	8.08	5.44	4.13	3.33	2.83	2.48	2.21	2.00	1.83
NF500-S	25.0	23.0	19.4	10.1	6.81	5.16	4.17	3.54	3.10	2.76	2.50	2.29
NF600-S	30.0	27.6	23.3	12.1	8.17	6.19	5.00	4.25	3.71	3.31	3.00	2.75
NF700-S	35.0	32.2	27.1	14.1	9.53	7.22	5.83	4.96	4.33	3.86	3.50	3.21
NF800-S	40.0	36.8	31.0	16.2	10.9	8.25	6.67	5.67	4.95	4.42	4.00	3.67
NF900-S	45.0	41.4	34.9	18.2	12.3	9.28	7.50	6.38	5.57	4.97	4.50	4.13
NF1000-S	50.0	46.0	38.8	20.2	13.6	10.3	8.33	7.08	6.19	5.52	5.00	4.58

Discharge currents and duration when battery is fully charged at 20°C ± 5°C

Final voltage =1.14V/C

Cell Type	18h	20h	1d 24h	2d 48h	3d 72h	4d 96h	5d 120h	6d 144h	7d 168h	8d 192h	9d 216h	10d 240h
NF10-S	0.52	0.48	0.40	0.21	0.14	0.11	0.09	0.07	0.06	0.06	0.05	0.05
NF20-S	1.04	0.96	0.81	0.42	0.28	0.21	0.17	0.15	0.13	0.11	0.10	0.10
NF30-S	1.57	1.44	1.21	0.63	0.43	0.32	0.26	0.22	0.19	0.17	0.16	0.14
NF40-S	2.09	1.92	1.62	0.84	0.57	0.43	0.35	0.29	0.26	0.23	0.21	0.19
NF50-S	2.61	2.40	2.02	1.05	0.71	0.54	0.43	0.37	0.32	0.29	0.26	0.24
NF60-S	3.13	2.88	2.43	1.26	0.85	0.64	0.52	0.44	0.39	0.34	0.31	0.29
NF70-S	3.66	3.36	2.83	1.47	0.99	0.75	0.61	0.52	0.45	0.40	0.36	0.33
NF80-S	4.18	3.84	3.23	1.68	1.13	0.86	0.69	0.59	0.51	0.46	0.41	0.38
NF90-S	4.70	4.32	3.64	1.89	1.28	0.97	0.78	0.66	0.58	0.52	0.47	0.43
NF100-S	5.22	4.80	4.04	2.10	1.42	1.07	0.87	0.74	0.64	0.57	0.52	0.48
NF120-S	6.27	5.76	4.85	2.53	1.70	1.29	1.04	0.88	0.77	0.69	0.62	0.57
NF150-S	7.83	7.20	6.06	3.16	2.13	1.61	1.30	1.10	0.96	0.86	0.78	0.71
NF200-S	10.4	9.60	8.08	4.21	2.83	2.15	1.73	1.47	1.29	1.15	1.04	0.95
NF250-S	13.1	12.0	10.1	5.26	3.54	2.68	2.17	1.84	1.61	1.43	1.30	1.19
NF300-S	15.7	14.4	12.1	6.31	4.25	3.22	2.60	2.21	1.93	1.72	1.56	1.43
NF350-S	18.3	16.8	14.1	7.36	4.96	3.76	3.03	2.58	2.25	2.01	1.81	1.66
NF400-S	20.9	19.2	16.2	8.42	5.67	4.29	3.47	2.94	2.57	2.29	2.07	1.90
NF500-S	26.1	24.0	20.2	10.5	7.08	5.36	4.33	3.68	3.21	2.86	2.59	2.38
NF600-S	31.3	28.8	24.3	12.6	8.50	6.44	5.20	4.42	3.86	3.44	3.11	2.85
NF700-S	36.6	33.6	28.3	14.7	9.92	7.51	6.07	5.15	4.50	4.01	3.63	3.33
NF800-S	41.8	38.4	32.3	16.8	11.3	8.58	6.93	5.89	5.14	4.58	4.15	3.80
NF900-S	47.0	43.2	36.4	18.9	12.8	9.66	7.80	6.63	5.79	5.16	4.67	4.28
NF1000-S	52.2	48.0	40.4	21.0	14.2	10.7	8.67	7.36	6.43	5.73	5.19	4.75

Discharge currents and duration when battery is fully charged at 20°C ± 5°C

Final voltage =1.10V/C

Cell Type	18h	20h	1d 24h	2d 48h	3d 72h	4d 96h	5d 120h	6d 144h	7d 168h	8d 192h	9d 216h	10d 240h
NF10-S	0.53	0.50	0.43	0.21	0.14	0.11	0.09	0.08	0.07	0.06	0.05	0.05
NF20-S	1.07	0.99	0.85	0.43	0.29	0.22	0.18	0.15	0.13	0.12	0.11	0.10
NF30-S	1.60	1.49	1.28	0.64	0.43	0.33	0.27	0.23	0.20	0.18	0.16	0.15
NF40-S	2.13	1.98	1.70	0.86	0.58	0.44	0.35	0.30	0.26	0.23	0.21	0.19
NF50-S	2.67	2.48	2.13	1.07	0.72	0.55	0.44	0.38	0.33	0.29	0.26	0.24
NF60-S	3.20	2.97	2.55	1.29	0.87	0.66	0.53	0.45	0.39	0.35	0.32	0.29
NF70-S	3.73	3.47	2.98	1.50	1.01	0.77	0.62	0.53	0.46	0.41	0.37	0.34
NF80-S	4.27	3.96	3.40	1.72	1.16	0.88	0.71	0.60	0.52	0.47	0.42	0.39
NF90-S	4.80	4.46	3.83	1.93	1.30	0.98	0.80	0.68	0.59	0.53	0.48	0.44
NF100-S	5.33	4.95	4.25	2.15	1.44	1.09	0.88	0.75	0.65	0.58	0.53	0.48
NF120-S	6.40	5.94	5.10	2.58	1.73	1.31	1.06	0.90	0.79	0.70	0.63	0.58
NF150-S	8.00	7.43	6.38	3.22	2.17	1.64	1.33	1.13	0.98	0.88	0.79	0.73
NF200-S	10.7	9.90	8.50	4.29	2.89	2.19	1.77	1.50	1.31	1.17	1.06	0.97
NF250-S	13.3	12.4	10.6	5.36	3.61	2.73	2.21	1.88	1.64	1.46	1.32	1.21
NF300-S	16.0	14.9	12.8	6.44	4.33	3.28	2.65	2.25	1.96	1.75	1.58	1.45
NF350-S	18.7	17.3	14.9	7.51	5.06	3.83	3.09	2.63	2.29	2.04	1.85	1.69
NF400-S	21.3	19.8	17.0	8.58	5.78	4.38	3.53	3.00	2.62	2.33	2.11	1.93
NF500-S	26.7	24.8	21.3	10.7	7.22	5.47	4.42	3.75	3.27	2.92	2.64	2.42
NF600-S	32.0	29.7	25.5	12.9	8.67	6.56	5.30	4.50	3.93	3.50	3.17	2.90
NF700-S	37.3	34.7	29.8	15.0	10.1	7.66	6.18	5.25	4.58	4.08	3.69	3.38
NF800-S	42.7	39.6	34.0	17.2	11.6	8.75	7.07	6.00	5.24	4.67	4.22	3.87
NF900-S	48.0	44.6	38.3	19.3	13.0	9.84	7.95	6.75	5.89	5.25	4.75	4.35
NF1000-S	53.3	49.5	42.5	21.5	14.4	10.9	8.83	7.50	6.55	5.83	5.28	4.83

Discharge currents and duration when battery is fully charged at 20°C ± 5°C

Final voltage =1.05V/C

Cell Type	18h	20h	1d 24h	2d 48h	3d 72h	4d 96h	5d 120h	6d 144h	7d 168h	8d 192h	9d 216h	10d 240h
NF10-S	0.54	0.51	0.43	0.22	0.15	0.11	0.09	0.08	0.07	0.06	0.05	0.05
NF20-S	1.09	1.01	0.86	0.43	0.29	0.22	0.18	0.15	0.13	0.12	0.11	0.10
NF30-S	1.63	1.52	1.29	0.65	0.44	0.33	0.27	0.23	0.20	0.18	0.16	0.15
NF40-S	2.18	2.02	1.72	0.87	0.58	0.44	0.36	0.31	0.27	0.24	0.21	0.20
NF50-S	2.72	2.53	2.15	1.08	0.73	0.55	0.45	0.38	0.33	0.30	0.27	0.25
NF60-S	3.27	3.03	2.58	1.30	0.88	0.66	0.54	0.46	0.40	0.36	0.32	0.30
NF70-S	3.81	3.54	3.00	1.52	1.02	0.77	0.63	0.53	0.47	0.42	0.38	0.34
NF80-S	4.36	4.04	3.43	1.73	1.17	0.88	0.72	0.61	0.53	0.48	0.43	0.39
NF90-S	4.90	4.55	3.86	1.95	1.31	0.99	0.81	0.69	0.60	0.53	0.48	0.44
NF100-S	5.44	5.05	4.29	2.17	1.46	1.10	0.90	0.76	0.67	0.59	0.54	0.49
NF120-S	6.53	6.06	5.15	2.60	1.75	1.33	1.08	0.92	0.80	0.71	0.64	0.59
NF150-S	8.17	7.58	6.44	3.25	2.19	1.66	1.35	1.15	1.00	0.89	0.81	0.74
NF200-S	10.9	10.1	8.58	4.33	2.92	2.21	1.80	1.53	1.33	1.19	1.07	0.98
NF250-S	13.6	12.6	10.7	5.42	3.65	2.76	2.25	1.91	1.67	1.48	1.34	1.23
NF300-S	16.3	15.2	12.9	6.50	4.38	3.31	2.70	2.29	2.00	1.78	1.61	1.48
NF350-S	19.1	17.7	15.0	7.58	5.10	3.86	3.15	2.67	2.33	2.08	1.88	1.72
NF400-S	21.8	20.2	17.2	8.67	5.83	4.42	3.60	3.06	2.67	2.38	2.15	1.97
NF500-S	27.2	25.3	21.5	10.8	7.29	5.52	4.50	3.82	3.33	2.97	2.69	2.46
NF600-S	32.7	30.3	25.8	13.0	8.75	6.63	5.40	4.58	4.00	3.56	3.22	2.95
NF700-S	38.1	35.4	30.0	15.2	10.2	7.73	6.30	5.35	4.67	4.16	3.76	3.44
NF800-S	43.6	40.4	34.3	17.3	11.7	8.83	7.20	6.11	5.33	4.75	4.30	3.93
NF900-S	49.0	45.5	38.6	19.5	13.1	9.9	8.10	6.88	6.00	5.34	4.83	4.43
NF1000-S	54.4	50.5	42.9	21.7	14.6	11.0	9.00	7.64	6.67	5.94	5.37	4.92

Discharge currents and duration when battery is fully charged at 20°C ± 5°C

Final voltage=1.00V/C

Cell Type	18h	20h	1d 24h	2d 48h	3d 72h	4d 96h	5d 120h	6d 144h	7d 168h	8d 192h	9d 216h	10d 240h
NF10-S	0.56	0.52	0.43	0.22	0.15	0.11	0.09	0.08	0.07	0.06	0.05	0.05
NF20-S	1.13	1.03	0.87	0.44	0.30	0.23	0.18	0.16	0.14	0.12	0.11	0.10
NF30-S	1.69	1.55	1.30	0.66	0.45	0.34	0.28	0.23	0.20	0.18	0.16	0.15
NF40-S	2.26	2.06	1.73	0.88	0.59	0.45	0.37	0.31	0.27	0.24	0.22	0.20
NF50-S	2.82	2.58	2.17	1.09	0.74	0.56	0.46	0.39	0.34	0.30	0.27	0.25
NF60-S	3.38	3.09	2.60	1.31	0.89	0.68	0.55	0.47	0.41	0.36	0.33	0.30
NF70-S	3.95	3.61	3.03	1.53	1.04	0.79	0.64	0.54	0.48	0.42	0.38	0.35
NF80-S	4.51	4.12	3.47	1.75	1.19	0.90	0.73	0.62	0.54	0.48	0.44	0.40
NF90-S	5.08	4.64	3.90	1.97	1.34	101	0.83	0.70	0.61	0.54	0.49	0.45
NF100-S	5.64	5.15	4.33	2.19	1.49	1.13	0.92	0.78	0.68	0.60	0.55	0.50
NF120-S	6.77	6.18	5.20	2.63	1.78	1.35	1.10	0.93	0.81	0.73	0.66	0.60
NF150-S	8.46	7.73	6.50	3.28	2.23	1.69	1.38	1.17	1.02	0.91	0.82	0.75
NF200-S	11.3	10.3	8.67	4.38	2.97	2.25	1.83	1.56	1.36	1.21	1.09	1.00
NF250-S	14.1	12.9	10.8	5.47	3.72	2.81	2.29	1.94	1.70	1.51	1.37	1.25
NF300-S	16.9	15.5	13.0	6.56	4.46	3.38	2.75	2.33	2.04	1.81	1.64	1.50
NF350-S	19.7	18.0	15.2	7.66	5.20	3.94	3.21	2.72	2.38	2.11	1.91	1.75
NF400-S	22.6	20.6	17.3	8.75	5.94	4.50	3.67	3.11	2.71	2.42	2.19	2.00
NF500-S	28.2	25.8	21.7	10.9	7.43	5.63	4.58	3.89	3.39	3.02	2.73	2.50
NF600-S	33.8	30.9	26.0	13.1	8.92	6.75	5.50	4.67	4.07	3.63	3.28	3.00
NF700-S	39.5	36.1	30.3	15.3	10.4	7.88	6.42	5.44	4.75	4.23	3.82	3.50
NF800-S	45.1	41.2	34.7	17.5	11.9	9.00	7.33	6.22	5.43	4.83	4.37	4.00
NF900-S	50.8	46.4	39.0	19.7	13.4	10.1	8.25	7.00	6.11	5.44	4.92	4.50
NF1000-S	56.4	51.5	43.3	21.9	14.9	11.3	9.17	7.78	6.79	6.04	5.46	5.00

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