Application Manual and Product Information

for

NSB Series Valve-Regulated Lead Acid Batteries

First Edition
May 2002

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Introduction

The NSB series of premium high density valve-regulated lead acid (VRLA) batteries from NorthStar Battery has been specifically designed to offer ten to fifteen years' trouble free service in standby emergency power (float) applications as well as delivering high power and cyclic capability.

This document has been written with two goals in mind. The first is to provide comprehensive technical information on the full range of batteries from NorthStar Battery Company. Using this information the reader will be able to select the right battery for a particular application. Step-by-step examples in the Appendix illustrate the battery sizing process.

The second goal of this manual is to outline factors that affect battery life and performance. An understanding of these factors is critical to getting the most out of these premium batteries.

NSB Series Benefits

In addition to the benefits offered by its valve regulated technology the NSB battery offers a long list of features that serve to increase the reliability and overall performance of your system.

- **Specifically designed for indoor/outdoor telecom cabinet applications**
- **10 year float life @ 25ºC (77ºF) or 15 year float life @ 20ºC (68ºF)**
- **Long cycle life capability – up to 500 cycles to 80% DOD at C/3 rate**
- **Rapid recharge capability**
- **2 year shelf life**
- **High power output makes the NSB series ideal for UPS systems**
- **3 step terminal seal ensuring leak-free operation**
- **Wide operating temperature range of –40ºC to 60ºC *(Continuous operation at or above 55°C requires an optional metal jacket)***
- **Industrial standard footprints assure mechanical interchangeability**
- **Non-halogenated flame retardant (UL94-V0) PC/ABS case and cover**
- **High conductivity female M8 terminals (female M6 on the NSB40)**
- **High charge acceptance**
- **Can be installed in any orientation *(inverted is not recommended)***

NSB Approvals and Certifications

NSB products have been designed to meet the following international telecommunication requirements:

- **Telcordia SR-4228 (formerly Bellcore TR-NWT-000766)**
  VRLA Battery String Certification Levels Based on Requirements For Safety and Performance

- **British Standard BS 6290: Part 4: 1997**
  Lead-acid stationary cells and batteries. Part 4 Specification for classifying valve regulated types

- **Bellcore GR-63-Core, Issue 1, Compliance Test Program**
  Requirement includes seismic zone 4 operation

- **Telkom Specification SP-AP0016**
  Network Stationary Batteries

- **DOT 49CFR173.159(d) (i) and (ii)**
  Non-hazardous shipping

- **Eurobatt**
  Design life >15-years @ 20°C

- **UL Approval**
  All NSB products meet the UL requirements for flame retardancy, UL V-0, and proper venting operation

ISO Certifications

In addition NorthStar Battery Company has been fully tested and approved to **ISO9001 and 14001** standards making it one of the most environmentally friendly lead-acid battery manufacturing facilities in the world today.

NSB Product Specifications

Industrial Range

	NSB40	NSB70	NSB75	NSB90
Height	**176mm** 6.93”	**176mm** 6.93”	**200mm** 7.87”	**213mm** 8.39”
Length	**197mm** 7.76”	**331mm** 13.03”	**261mm** 10.27”	**341mm** 13.42”
Width	**165mm** 6.50”	**165mm** 6.50”	**173mm** 6.80”	**173mm** 6.80”
Weight	**16.0kg** 35.3lbs	**26.7kg** 58.9lbs	**27.3kg** 60.2lbs	**35.1kg** 77.6lbs
Terminal	**M6 x 1.25**	**M8 x 1.25**	**M8 x 1.25**	**M8 x 1.25**
C/10 Cap	**40Ah**	**67Ah**	**67Ah**	**90Ah**
Impedance (1kHz)	**4.5mΩ**	**2.7mΩ**	**2.6mΩ**	**2.0mΩ**
Admittance* (23Hz)	**1,000Ω^{-1}**	**1,700Ω^{-1}**	**1,700Ω^{-1}**	**2,000Ω^{-1}**
Short-circuit Current	**2,000A**	**3,200A**	**3,200A**	**4,300A**

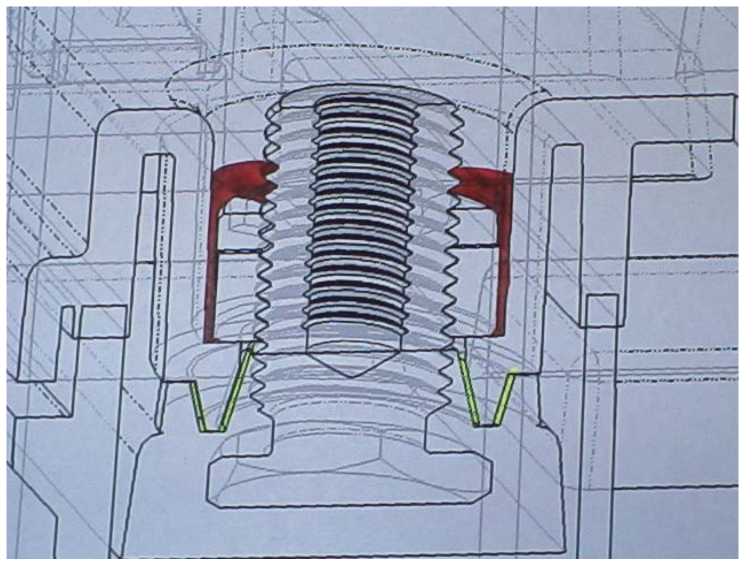
Front Terminal Range

	NSB60FT	NSB90FT	NSB100FT	NSB110FT	NSB170FT
Height	**263mm** 10.35”	**255mm** 10.04”	**287mm** 11.30”	**227mm** 8.94”	**320mm** 12.60”
Length	**287mm** 11.30”	**396mm** 15.59”	**396mm** 15.59”	**560mm** 22.05”	**560mm** **22.05”**
Width	**108mm** 4.25”	**108mm** **4.25”**	**108mm** **4.25”**	**125mm** 4.92”	**125mm** **4.92”**
Weight	**20.6kg** 45.4lbs	**30.0kg** 66.1lbs	**33.1kg** 73.0lbs	**38.3kg** 84.2lbs	**58kg** 128lbs
C/8 Cap	**60Ah**	**90Ah**	**100Ah**	**110Ah**	**170Ah**
Impedance (1kHz)	**4.1mΩ**	**2.9mΩ**	**2.5mΩ**	**2.2mΩ**	**1.5mΩ**
Admittance* (23Hz)	**1,300Ω^{-1}**	**1,700Ω^{-1}**	**1,900Ω^{-1}**	**2,000Ω^{-1}**	**2,500Ω^{-1}**
Short-circuit Current	**2,000A**	**3,000A**	**3,500A**	**4,000A**	**5,000A**

* Admittance is an electrical term that quantifies the AC conductance of a circuit (or indeed an electrochemical system) to an imposed AC signal; it is dependent upon frequency and is the reciprocal of impedance so that its units are ohms^{-1} or Siemens. The term conductance rather than admittance is often used when applied to several commercially available battery testers.

Leak Free Terminations

NorthStar batteries are produced with rugged highly conductive brass terminals. To take advantage of the design and insure a long life low resistance connection, the battery terminals should be coated with NO-OXID or similar material. Stainless steel hardware, with a minimum of 6mm engagement, torqued to 6.0 Nm/53 in-lbs is recommended. In portable applications, or installations where periodic retorquing of terminals is limited, a spring washer is recommended. This will reduce the loosening effects of material creep, temperature expansion and vibration.



Open Circuit Voltage and State of Charge

The following figure shows the relationship between the open circuit voltage (OCV) and the state of charge (SOC) as determined experimentally for the NSB range of VRLA batteries.

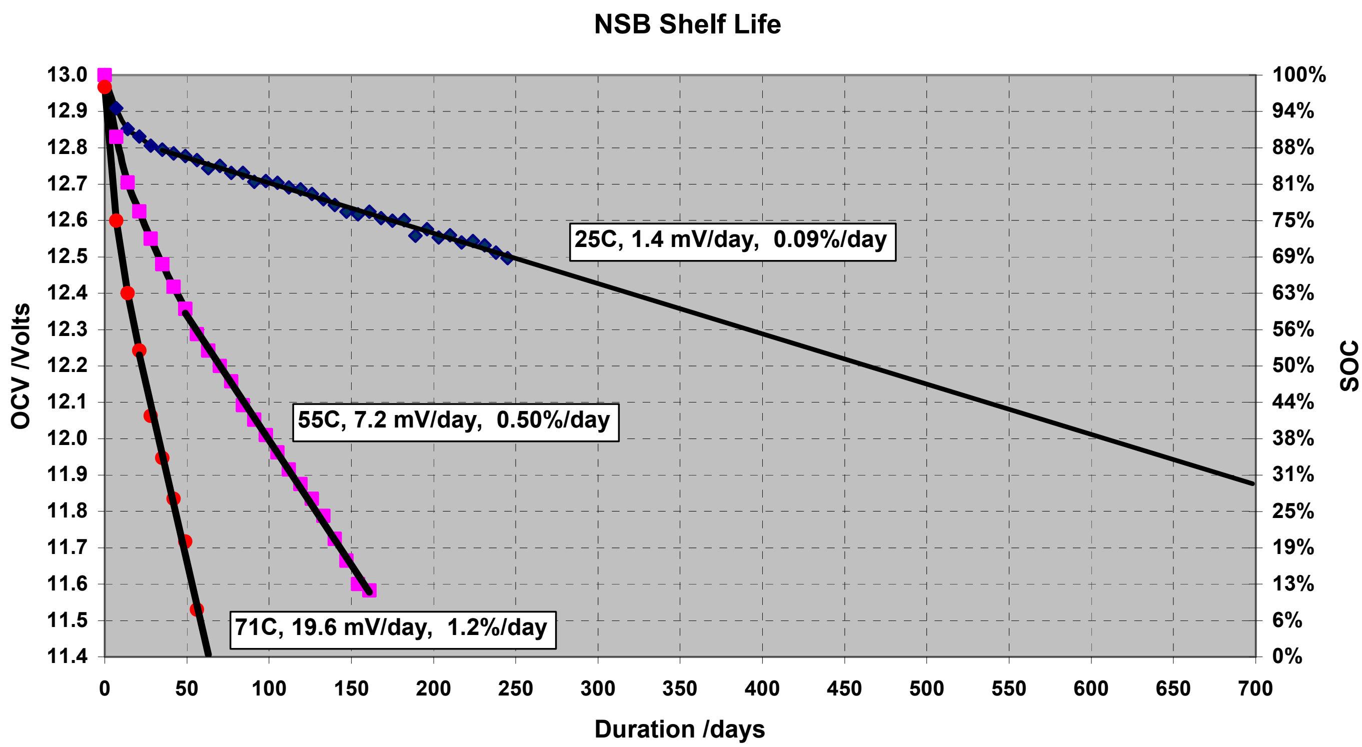


Figure 1: Effect of temperature on OCV and SOC

Measuring the open-circuit voltage is an excellent way of estimating the %SOC of NSB batteries, since the open-circuit voltage is a direct function of the concentration of electrolyte within the battery. As the concentration of electrolyte decreases so too does the %SOC. The relationship can be linearly approximated by the following equation:

$$\%SOC_{@\ C/20} = OCV \times 62.5 - 712.5$$

In order to be accurate the open-circuit voltage should not be measured within a minimum of 4-hours of being discharged or recharged.

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Charging

Charging is one of the most critical factors that determine the life expectancy of a valve regulated lead acid (VRLA) battery and the NSB series from NorthStar Battery is no exception. There are two broad categories of charging, constant current (CC) charging or constant voltage (CV) charging.

Constant current (CC) charging

As the name implies, in CC charging a current of constant magnitude is forced into the battery, regardless of the state of charge of the battery. While CC charging rapidly replaces the ampere-hours lost by the battery, it is very easy to dangerously overcharge the battery with this method of charge. This is the main reason why CC charging on a regular basis is not recommended for the NSB battery.

Since a CC charge provides each battery in the series string with exactly the same amount of ampere-hours this charge technique is well suited to equalize a series string that comprises cells in various states of charge.

As the battery charges, its terminal voltage increases. Since the CC charger is designed to provide the same current throughout the charge cycle, its voltage must increase in order to overcome the rising battery voltage and push a constant current into the battery.

Constant voltage (CV) charging

In contrast to CC charging it is the charge voltage rather than the charge current that remains constant during the charge cycle. As the battery charges its terminal voltage increases, the charge current drops as the charger's output voltage remains constant. This automatic regulation of the charge current makes CV charging the preferred charge technique for VRLA batteries.

The charge voltage should be controlled to within ±1% of the values shown in Figure 2 below for optimum performance.

Figure 2 also shows that the charge voltage should be compensated for temperature. The thermal compensation coefficient for float and cycling applications is ±4mV per cell per ºC variation from 25ºC. Note that the compensation coefficient is negative, meaning that the charge voltage must be decreased as the temperature goes up and vice versa.

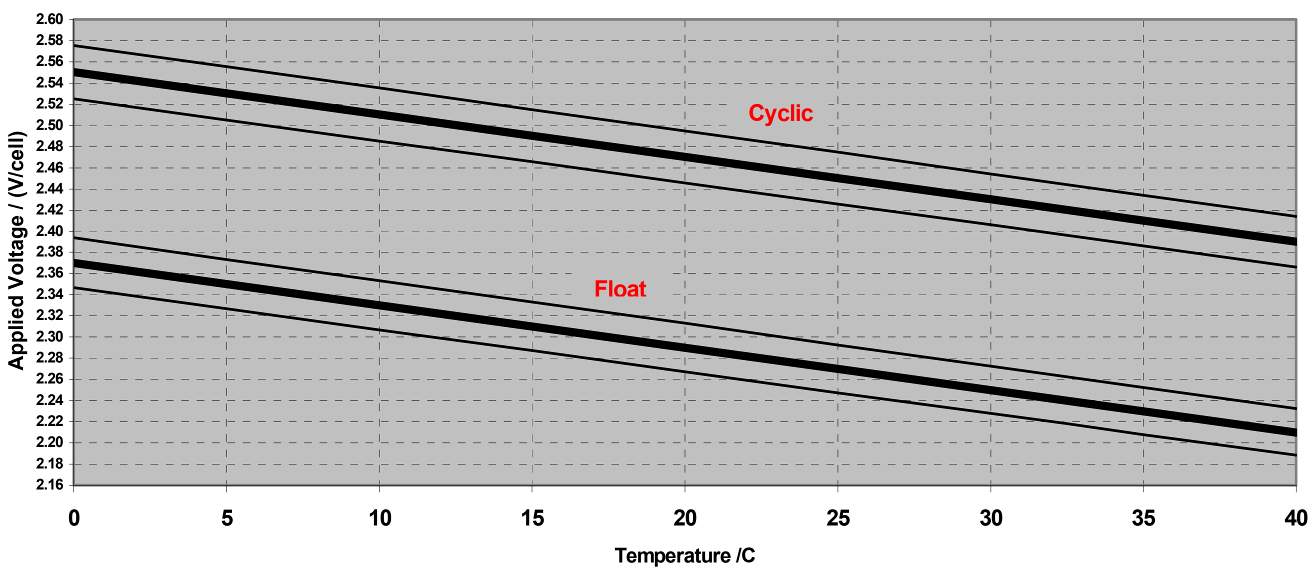

Figure 2: Charge voltage compensation for NSB batteries

Temp /°C	Minimum Float Voltage /VPC	Nominal Float Voltage /VPC	Maximum Float Voltage /VPC	Minimum Cyclic Voltage /VPC	Nominal Cyclic Voltage /VPC	Maximum Cyclic Voltage /VPC
0	2.35	2.37	2.39	2.52	2.55	2.58
5	2.33	2.35	2.37	2.50	2.53	2.56
10	2.31	2.33	2.35	2.49	2.51	2.54

15	2.29	2.31	2.33	2.47	2.49	2.51
20	2.27	2.29	2.31	2.45	2.47	2.49
25	2.25	2.27	2.29	2.43	2.45	2.47
30	2.23	2.25	2.27	2.41	2.43	2.45
35	2.21	2.23	2.25	2.39	2.41	2.43
40	2.19	2.21	2.23	2.37	2.39	2.41
42	2.18	2.20	2.22	2.36	2.38	2.41
45	2.17	2.19	2.21	2.35	2.37	2.39
50	2.17	2.17	2.19	2.33	2.35	2.37

Figure 3: Charge voltage compensation for NSB batteries

The low internal resistance of the NSB battery allows for very high charge acceptance. These batteries also do not require the charge current to be artificially limited, as long as constant voltage (CV) charging is used. This characteristic helps the battery reach a very high (>85%) state of charge (SOC) in less than one hour with a charge current of the order of 1C amps, where C is the rated capacity of the battery. Thus, 1C for a 100Ah battery would be 100 amps.

Ambient Temperature and Battery Performance

Heat is the number one killer of batteries – it accelerates the failure mechanisms such as corrosion and dry-out. A good rule of thumb to use is that for every 10ºC increase in ambient temperature the float life of the battery is cut in half. The NSB battery, which has a float life expectancy of 10 years at 25ºC, will only have a useful life of 5 years at 35ºC. Figure 3 shows the relationship between temperature and battery life.

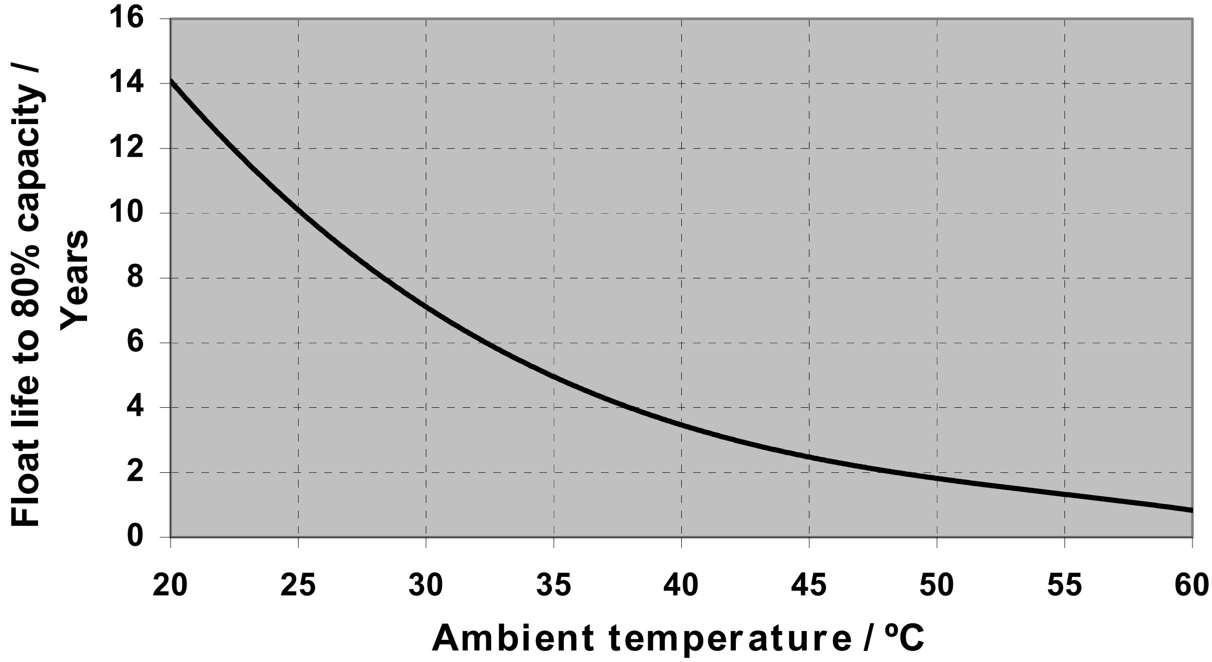

Figure 4: Effect of ambient temperature on float life

Cycle Life

The cycle life of a battery is dependent upon two discharge factors. The first factor is the depth of discharge while the second is the discharge rate. Figure 4 shows how these two factors can affect number the cycles you may expect from an optimally charged NSB battery.

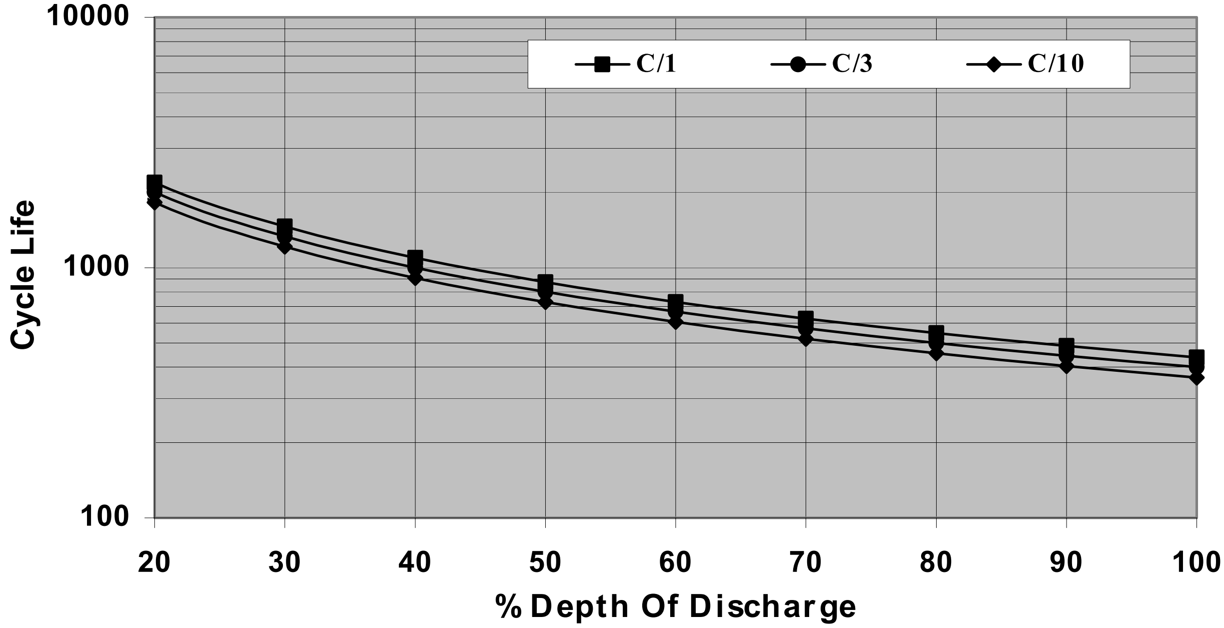

Figure 5: Effect of DOD and discharge rate on cycle life

Low Voltage Disconnect

Another key to optimizing battery performance is to ensure that it is not subjected to an overdischarged condition, particularly for any appreciable length of time. The only practical way to prevent this condition from occurring is to employ a low voltage disconnect (LVD) in the load circuit that prevents the battery from discharging to a level below the designed end of discharge voltage (EODV) value. Although 10.02V is a typical EODV for a 12V battery, the following chart may be used to set the LVD.

Discharge in amps	EODV per 12V battery
$0.05C_{10}$ ($C_{10}/20$)	≥ 10.5V

$0.1C_{10}$ ($C_{10}/10$)	≥ 10.2V
$0.2C_{10}$ ($C_{10}/5$)	≥ 10.02V
$0.4C_{10}$ ($C_{10}/2.5$)	≥ 9.9V
$1C_{10}$	≥ 9.6V
$2C_{10}$	≥ 9.3V
> $5C_{10}$	≥ 9.0V

Figure 6: Recommended EODV as a function of discharge rate

Optimizing Battery Life and Performance

To obtain maximum performance from your battery and get the longest life out of it is simply a matter of providing the right environment for the battery. The following checklist is designed to help you optimize your battery's overall performance. The checklist assumes that the battery is properly sized for the application.

- ***Temperature***

  Battery ambient temperature of 25ºC (77ºF) is ideal. A cooler temperature will extend battery life but may degrade capacity

  If battery temperature varies significantly from 25ºC (77ºF), compensating the battery charge voltage is necessary

- ***Charging***

Correct charge parameters are critical to battery longevity

Charge method must be matched to the application; check with the Technical Support department if you are unsure about the parameters for your application

- ***Overdischarge***

Repeated over-discharge is harmful to the battery

Use of a low voltage disconnect is recommended

Contact Information

Mailing address:

NorthStar Battery Company
4000 Continental Way
Springfield, MO 65803
Tel: (417) 575-8200
Fax: (417) 575-8250
Email: info@northstarbattery.com

Functional area	Telephone number
Customer Service	(417) 575-8201
Technical and Quality	(417) 575-8205
Sales and Marketing	(417) 575-8203

Appendix A - Battery/System Sizing Examples

In this section of the manual we will go through three examples to show how to select the correct battery size for your application. In the first example the constant current load is given in amperes and in the second case the battery load is a constant power in kilowatts. Finally, the third example is slightly more involved as inverter power factor and efficiency need to be accounted for.

Example 1: Constant current battery load

Load 180 amps

Support time 45 minutes

Battery voltage 240V

EODV 1.75 VPC

Calculation

The first step is to calculate the number of batteries per series string. In this case there will be twenty batteries per series string (240V/12V per module = 20 modules) since each battery has a nominal terminal voltage of 12V.

By looking up the discharge tables for an EODV of 1.75 VPC and a support time of 45 minutes, we find that no single battery is capable of delivering 180A for 45 minutes to 1.75 VPC. We next add a 240V string in parallel, so the load is halved to 90A per string. By going through the tables again we find that the NSB100FT will support 90.3A for 45 minutes; two parallel strings will support 180.6A for 45 minutes.

Therefore the right battery for this load is two strings of NSB100FT, with each string comprising twenty batteries in series or forty batteries per system.

Example 2: ***Constant power battery load***

Load *50 kilowatts (50,000 watts)*

Support time *20 minutes*

Battery voltage *360V*

EODV *1.67 VPC*

Calculation

Since the discharge tables give the constant power numbers in watts per cell (WPC) the first step is to calculate the number of cells per series string. In this case there will be 180 cells per series string (360V/2V per cell = 180 cells) since each cell has a nominal terminal voltage of 2V.

The next step is to convert the load to a per cell basis. In this example the load is 278 WPC (50,000 watts / 180 cells = 278 WPC). We can now look up the discharge tables corresponding to a support time of 20 minutes and an EODV of 1.67 VPC. The smallest battery that can support this load is the NSB90, which is capable of delivering 338.3 WPC for 20 minutes to 1.67 VPC.

Thus the system in this example will comprise 30 modules of the NSB90 battery.

Example 3: Constant kilovolt-ampere (KVA) battery load

Load	*50 KVA (50,000 VA)*
Inverter power factor	*0.85*
Inverter efficiency	*90%*
Support time	*20 minutes*
Battery voltage	*360V*
EODV	*1.67 VPC*

Calculation

The first step is to convert the KVA into an equivalent KW by using the following formula:

Kilowatt = (Kilovolt-ampere × Power Factor) ÷ Efficiency

Using this formula the above numbers translate into a kilowatt requirement of 47.2 kilowatts. The subsequent steps are identical to those outlined in the second sizing example given above.

Appendix B – Product Performance Specifications

Refer to the NorthStar Battery Company Product Specification Sheets for Current, Capacity, and Power Performance Figures.