NorthStar

HELIOS
POWER SOLUTIONS

NSB HT Red Battery®

Pure Lead - High Temp

NSB HT Red Battery® Application Manual

99.9% PURE LEAD

15+ YRS DESIGN LIFE

PROUDLY MADE IN THE USA

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Pure Lead – High Temp Technology

1 Introduction

1.1 Pure Lead – High Temp Technology

NSB HT Red Battery batteries have been designed with thin plate pure lead electrodes that ensure long float life due to the enhanced corrosion resistance afforded by the pure lead grid material.

In addition, the design has been optimized for continuous operation at elevated temperature, up to 45°C, by employing heat resistant plastics for the battery containers and lids. These plastics take advantage of non-brominated flame retardant agents whilst maintaining the highest V0 Flame Retardancy level.

The benefits of the design also include exceptional high rate capability, rapid & efficient recharge and recovery from extended deep discharges.

1.2 Definitions

The following is a list of the definitions of the terms and abbreviations that are employed throughout this document.

Monobloc: Set of electrochemical cells electrically connected in one plastic container. For NSB products this typically 6-cells housed in one container giving a nominal 12V-monobloc.

Battery: Functional unit for the storage of electrochemical energy comprising of at least one or several monoblocs connected in series and or parallel.

DOD: Depth of Discharge. Fraction of total capacity used in discharge. 0-100 %

SOC: State of Charge. Fraction of total capacity that is still available for discharge. O-100%. In most cases SOC = 100%-DOD

EODV: End of Discharge Voltage

VPC: Volts per cell

Electrolyte: In the case of lead-acid batteries an aqueous solution of sulfuric acid.

String: Set of cells or monoblocs connected in series.

Note some terms may be used interchangeably given the circumstance.

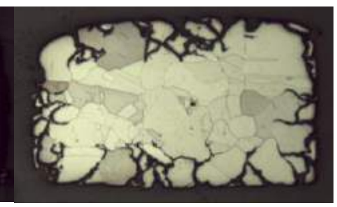
1.3 Benefits of pure lead

The positive grid is composed of highly pure lead without any alloying agents.

The electrode grids are manufactured via a continuous casting process that yields a defect-free polycrystalline substrate. The use of a pure lead material ensures that the grain boundaries, found within the polycrystalline structure, corrode at the same slow rate as the lead grains themselves. Alloyed lead will always experience a much quicker rate of corrosion at the grain boundaries, known as intergranular grid corrosion, which will prematurely undermine the mechanical and electrical integrity of the electrode grids.

Pure lead, however, is totally free of intergranular corrosion prolonging the mechanical and electrical integrity of the current carrying backbone of the plates. The net result is that the very low internal resistance of the NSB product is maintained throughout life. This behavior can be seen in microscope pictures (below) of battery grids that have been cross-sectioned following an accelerated corrosion test:


Pure lead


Lead Calcium

Clearly the pure lead grid retains all of its mechanical and electrical integrity while the lead calcium grid is severely penetrated by intergranular corrosion and is causing the battery to fail.

2 Charge

Following a discharge, typically a power outage, the batteries will require recharging. The following section outlines the best way to efficiently recharge the NSB HT Red product to ensure maximum life.

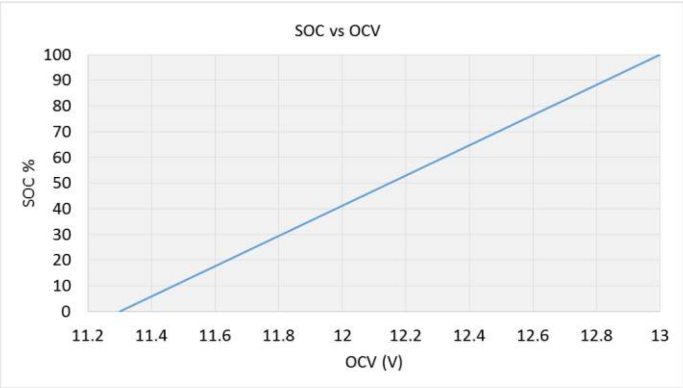
2.1 Charge & Discharge Rate

In this document, the charge and discharge rates (amps) are expressed as multiples of I10, where I10 is the current for a 10-hour discharge to 100% depth-of-discharge (DOD). These values serve to normalize the current across a range of monobloc sizes. Consider the following example:
10-h discharge capacity NSB 100FT = 100 Ah (EODV =1.80 VPC @ 25°C).

1 x I10 = 1 x (10-h discharge current) 1
x I10 (NSB 100FT) = 1 x 10A = 10 A
2 x I10(NSB 100FT) = 2 x 10A = 20 A

2.2 Determining State of Charge (SOC)

The SOC of a monobloc can be estimated by measuring the open-circuit-voltage (OCV) of the monobloc. If the monobloc has been recently recharged, a rest period of at least 12 hours after completion of recharge is required before taking measurements. If measured earlier the voltage is slightly higher and will indicate a too high SOC. This graph shows the relationship between OCV and SOC.

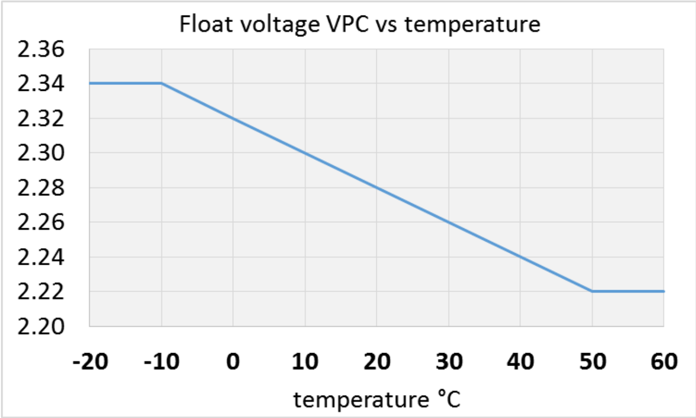


2.3 Float charge and thermal compensation

Thermal compensation is the control of charging voltage depending on temperature. This serves to decrease the amount of overcharge that the batteries absorb at higher temperatures. Higher temperatures lead to quicker aging of the batteries. Temperature compensation cannot off-set all the detrimental effects that higher temperatures have.

The optimum level for float charging an NSB HT Red Battery is 2.27 VPC ±0.02VPC at +25°C (+77°F). If the monobloc temperature increases above this level, a thermal compensation of -2 mV/cell/°C is recommended for safe operation and achieving optimal life. Conversely, if the temperature decreases below 25°C, the voltage should be increased by 2 mV/cell/°C.

Most modern charge rectifiers have integrated temperature monitoring and voltage regulation which should be used in any environment where temperature is not precisely controlled. The graph below shows values for an individual cell. The tolerance is ±0.02 V per cell.



2.4 Recharging

If the charging system is properly sized, a fast charging regime will serve to minimize the time needed to recharge NSB HT Red Batteries.

There are two factors governing the recharge time: energy balance and charge acceptance. Batteries have charge acceptance – When the charging voltage is applied to the batteries a current will flow into the battery. The more current the battery can accept the higher the charge acceptance. The charging current is dependent on factors like the SOC, the temperature and the charging voltage and actual design of the battery.

To some extent the charge acceptance is also defendant on the nature of the preceding discharge. If the battery is freshly discharged the battery has a higher charge acceptance than when it has been stored a long time.

The energy in the battery needs to be restored when recharging the battery. This achieved by inputting the charge. The ratio between charge input and the preceding discharge is called charge return. The voltage during charge is higher than during the discharge this will cause the energy for recharge to be substantially higher than for the discharge. The ratio between the energy output and input is referred to as energy efficiency our round-trip efficiency.

In the case with a battery with very high charge acceptance it is the energy balance/charge balance that determines the charging time. When making rough estimates of size of charger and charging times this is the first consideration to look at – charging times will always be longer than what is stated from the charge/energy balance.

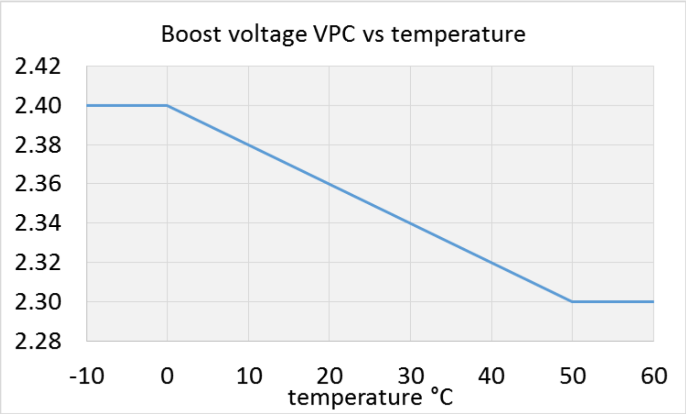
Batteries will need a charge return of a little more than a 100% in order to compensate for the coulometric-charge inefficiencies. Depending of the temperature and DOD this may vary from 0.5-6%, i.e. charge return of 100.5-106%. The higher the DOD and the higher the temperature is the higher this overcharge need to be to fully charge the battery.

2.4.1 Boost voltage

A charging voltage higher than the float voltage is recommended in situations where there are frequent power interruptions. This increases the charge acceptance and is especially helpful to shorten the time to full charge return and will speed up the achievement of a proper over charge. This is the boost voltage.

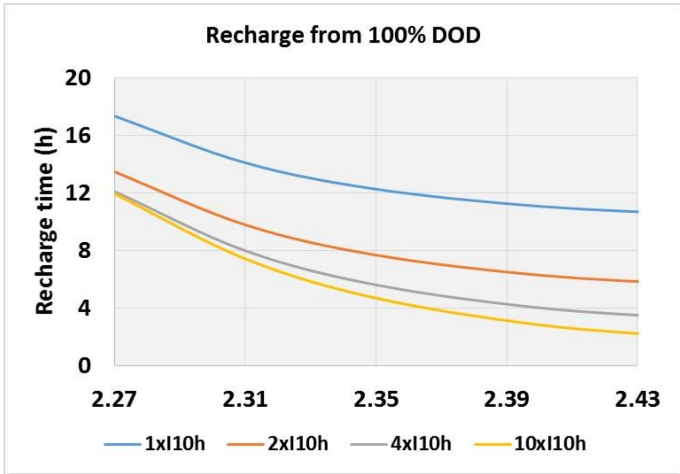
We recommend 2.35 VPC as boost voltage. This voltage is normally acceptable in 48 V power system used in telecomm application. Where higher voltage is available up to 2.43 VPC can used. This will give shorter charging times as depicted in the recharge figure.

We recommend that the boost charge voltage shall be temperature controlled (temperature compensated) according to the graph below.



We also strongly recommend that the boost charge voltage shall be limited to 5 hours of duration. This is counted from the time the battery voltage reaches the boost voltage and the charging current starts to decrease.

The following chart shows the time required to give a 100% charge return to a battery from a complete 100% DOD discharge, as a function of applied average voltage and available current. Note for repeated cycles the charge return has to be above 100%!



2.4.2 Equalizing charge

Equalizing charge has the purpose of equalizing all the batteries or cells in a string by applying a higher voltage for a limited time. The individual objects in a string, batteries, can become unbalanced i.e. the cells have slightly deviating voltages due to various reasons: cell differences, exposed to different temperatures for instance. The equalizing charge shall commence first when the batteries have been charged by normal means. The voltage should be the same as for the boost and same temperature controls shall be applied. Batteries shall be charged for 12-24 hours.

It shall be limited to the boost voltage level and shall not be longer than 16 hours.

3 Heat and Temperatures

Batteries will evolve heat especially during cycling, the charging and discharging. As a rule of thumb 15% of the turned over energy shall be assumed to be heat in a charge discharge cycle. This number will apply when the total time for a full turn-over is at least 24 h. The climate system has to provide this cooling. A high operating temperature will be more stressful to the battery and active cooling is recommended.

The batteries need to be spaced and arranged so that the cooling of the monoblocs will be as uniform as possible. When batteries are placed on different shelves it is important that the air flow to the different shelves shall be arranged so that the batteries on different shelves have as uniform temperatures as possible.

3.1 Battery high temperature cut-off

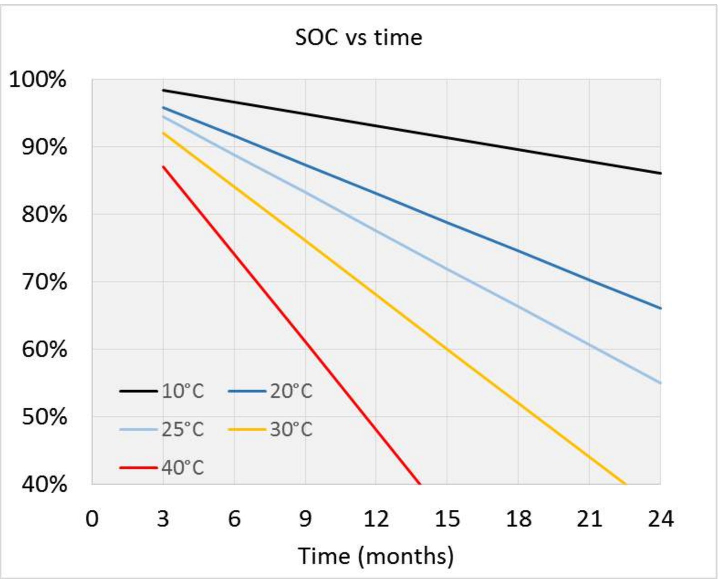
It is highly recommended to have a system which disconnects the battery at a pre-set high temperature. The pre-set temperature shall be in the interval 60-75 °C. This is in order to avoid thermal damage to the battery and as well in order to avoid thermal runaway.

4 Discharge

4.1 Storage and Self Discharge

During storage, lead-acid batteries will gradually self-discharge. It is recommended that monobloc SOC be maintained above 12.20 V at all times, while the battery is in storage, in order to avoid irreversible capacity loss. The rate of self-discharge increases with increasing temperature.

For example: a monobloc at 25°C will drop from 90% to 60% in 15 months, whereas the same monobloc at 40 °C will take just 6 months. As a result, maintenance charging needs to be performed more frequently at higher temperatures



The 50% SOC limit corresponds to 12.2 V for a monobloc recharge before this limit is passed.

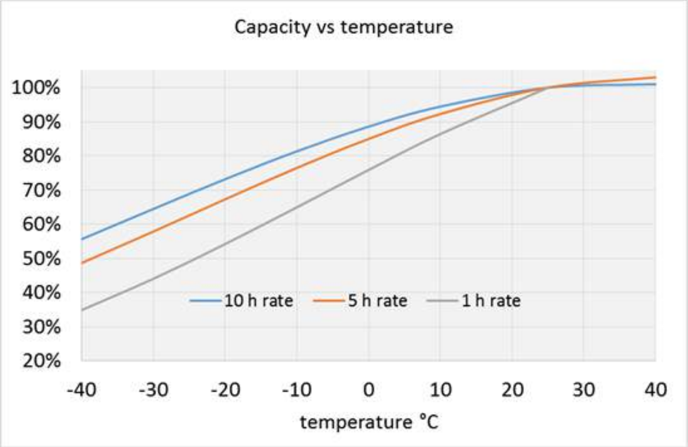
4.2 End of Discharge Voltage (EODV)

In the event of a deep discharge, a recommended minimum end-of-discharge voltage (EODV) should be used to avoid over discharge. The EODV should be adjusted based on the discharge rate, the following table provides a guide for EODVs at various discharge rates.

Discharge time (h)	EODV (VPC)
20	1.85
10	1.80
5	1.75
1	1.70

4.3 Low Temperature Performance

As monobloc capacity decreases below the recommended operating temperature of +25°C (+77°F), the monobloc capacity decreases this chart:



5 Useful Life

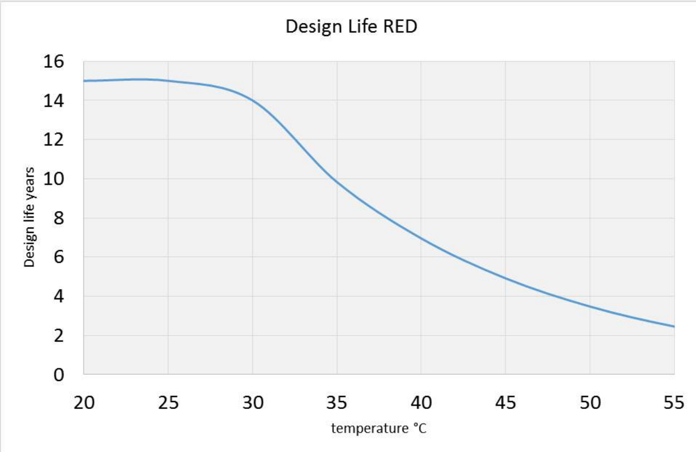
5.1 Shelf Life

NSB HT Red Batteries may be stored for up to 2 years, provided that the SOC is maintained above 50%. Failure to provide the required maintenance charging (see Section 4.1 Storage and Self Discharge) may lead to irreversible capacity loss.

5.2 Float Life vs. Temperature

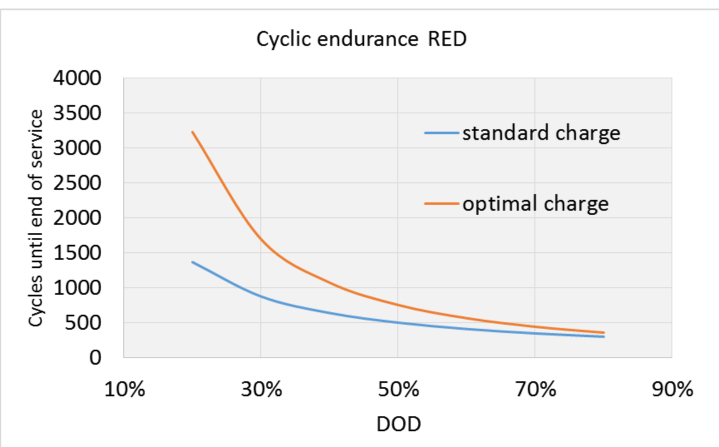
Due to constant float charging, the lead grids within the positive plates undergo slow corrosion, which is a normal aging mechanism. The rate of this process increases with increasing temperature and, as a result, the temperature of monoblocs has a large effect on their float life.

For example when increasing temperature with 10°C from 30°C to 40°C the corrosion accelerates greatly and life is halved as depicted in the diagram below. Also the dry out of the battery accelerates greatly. Other factors also influence the life of the battery such, as maintenance of full state of charge. The diagram below gives the life in the best possible conditions. Where charge is maintained at all times and cycling is minimal.



6 *Hybrid Operation Cyclic Operation*

NSB HT Red Batteries are recommended for stable to moderately stable mains. It is important to use optimal charging to get the maximum performance from the HT Red battery. Below a figure depicting the maximum amount cycles available under different conditions. The curve represents ideal conditions. The optimal charge represents the use of proper charge settings and good thermal environment for all monoblocs. Standard charge represents the use of float charge only.



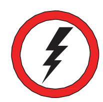
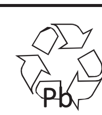
Red batteries are not recommended for hybrid operation.

7 *Installation and Operation*

7.1 Battery Safety and Environmental Information

For full information please read the Material Safety Data Sheet (SDS). The SDS document may be downloaded from the NorthStar website www.northstarbattery.com

When dealing with Valve Regulated Lead Acid Batteries (VRLA) some additional safety information is required.

	Please read and observe the installation and operation instructions.
	When working on batteries wear appropriate Personal Protective Equipment (PPE). Refer to battery SDS for complete list.
	Do not expose the battery to an open flame or other ignition source. During operation an explosive mixture of hydrogen gas may accumulate.
	Battery terminals are always energized and, if short-circuited, cause electrical arcing. Always use insulated tools.
	Batteries are heavy objects. Use proper handling equipment safety gear during installation.
 Pb	Inappropriate lead acid battery disposal can result in environmental contamination. Please dispose of batteries according to regulations.
 Pb	Battery may be returned, shipping pre-paid, to the manufacturer or any distributor for recycling.
	Batteries contain concentrated sulfuric acid in water. Any fluid found outside the batteries should be regarded as acid.
	Clean all acid splash in eyes or on skin with plenty of clean water. Then seek medical help. Acid on clothing is to be washed with water
	Risk of explosion or fire. Avoid any short circuit. Metallic parts under voltage on the battery, do not place tools or items on top of the battery.

8 Determining Battery Manufacturing Date

The battery serial numbers are located in two places on the battery case. The first is on the front of the battery. The manufacturing date is also located on this label below the serial number.

The second is on the positive terminal side towards the rear of the battery (see picture below).

Manufacturing codes are limited to 12 alphanumeric digits. The first two digits specify the model of the monobloc. The remaining ten digits are a random, non-sequential serial number which is unique to this particular monobloc and will not be duplicated.

8.1 Receiving the shipment

In addition to safety requirements (see section 7) special care should be taken when handling monoblocs. The following are some DOs and DON'Ts.

DO

Always use both handles on the monoblocs when lifting or carrying them.

Always have a straight back and lift using your legs when lifting or carrying monoblocs.

Always have appropriate safety gear (see section 7) available when handling monoblocs.

Always perform an Open Circuit Voltage (OCV) check on a monobloc PRIOR to installation, see section 10.2 Checking the Voltage Spread, and section 10.7 Charging.

Always perform a visual inspection of the monobloc prior to handling. If any damage or electrolyte leakage is detected during this inspection, do not install the monoblocs. Stop flow of material, contain/absorb small spills with dry sand, earth or vermiculite. Do not use combustible materials. If possible, carefully neutralize spilled electrolyte with soda ash, sodium bicarbonate, lime, etc. Wear acid- resistant clothing, boots, gloves, and face shield. Do not allow discharge of un-neutralized acid to sewer.

Acid must be managed in accordance with approved local, state, and federal requirements. Consult state environmental agency and/or federal EPA.

Always use the packing from new monoblocs for transporting old monoblocs for proper disposal. If unavailable, place batteries on a pallet and strap them down securely for shipping.

Always dispose of monoblocs in accordance with local and national requirements.

Always follow the instructions provided with the monoblocs when installing them.

Always use insulated tools when handling monoblocs. Failure to do so can lead to electric shock, burns and/or damage to batteries and equipment

DON'T

Don't drag a monobloc along the floor. Doing so could cause damage to the monobloc case leading to a possible leakage of electrolyte.

Don't install a monobloc that has been dropped into any application. A dropped monobloc could have damage to either its internal or external casing leading to a possible leakage of electrolyte and damage to equipment.

Don't make the final connection to an application until all batteries in the string have had their interconnections finished and properly torqued. Battery terminals are always energized and, if short-circuited, can cause electrical arcing as well as damage to the batteries and equipment.

Don’t dispose of batteries in unapproved sites. The batteries contain electrolyte and compounds of lead that are harmful to nature and can contaminate the environment if not disposed of properly.

Don’t drill, or in any other way attempt to breach the monoblocs case. Doing so could lead to a possible leakage of electrolyte.

Don’t force a monobloc into equipment. Forcing the monobloc into equipment can lead to a breach in the monoblocs internal or external casing causing a possible leakage or electrolyte or electrical short circuit.

Don’t move the monoblocs using the terminals. The terminals are not designed to support the weight of the monobloc, and damage to internal components could result.

9 Storage

9.1 Storage conditions

Below is a list of equipment that is recommended to beon hand in the area where monoblocs are stored.

1. DC volt meter
2. Battery chargers (with controlled voltage output setting +/- 0.05V)
3. Mechanical lifting device (such as a fork lift etc.)
4. Appropriate Personal Protective Equipment (PPE), as listed in the Battery Safety and environmental information section of this document.

It is strongly recommended to store the monoblocs in a cool dry environment. For more information see section 4.1 Storage and Self Discharge

The monoblocs should be stored in the original containers. The packaging serves to protect the monoblocs from harsh environmental conditions and accidental damage. If they must be removed, palletize them, and utilize as much of the original packaging as possible.

9.2 Storage time

For more information see section 4.1 Storage and Self Discharge

Different ways to correctly store monoblocs

10 Commissioning

Always use the installation instructions provided with the monoblocs and follow all outlines for safety and handling mentioned earlier in this document.

10.1 Unpacking the Batteries

When received, a visual check should be made on the monoblocs. If the monoblocs show transportation damage, physical damage to the case, leaking electrolyte etc., they should not be installed, and a claim should be initiated immediately.
Make sure all the accessories are present in the delivery. Please observe the cardboard sleeves around the monoblocs has no bottom! The cardboard should be removed prior to lifting the monoblocs. Please keep all packing material for future use if possible.

If the monoblocs cannot be put into place directly and need to be put on the floor/ground, put some of the cardboard material under them in order to protect the monobloc from hard surfaces. An alternative material is to use the top of the crate that the monoblocs were shipped in.

10.2 Checking the Voltage Spread

Before connecting the monoblocs in series, the voltage variation must be checked and the voltages shall recorded. If the voltage varies more than 0.15 V between the highest and the lowest monobloc voltage, the monoblocs should be charged individually before being connected in series.

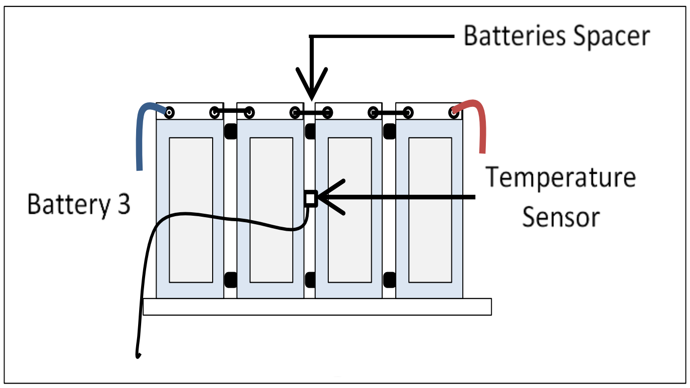
Alternatively the monoblocs may be matched in each string so that all the monoblocs have a voltage spread of less than 0.15V.

10.3 Putting the Batteries in Place

Make sure the monoblocs are all evenly spaced, aligned and rest on a flat surface. Resting the monoblocs on an acid resistant, electrically isolating surface is recommended to avoid possible ionic connection to ground and potential damage to equipment.

Monoblocs can be installed in any orientation, but inverted is not recommended.

Temperature sensors shall be installed in a proper way see figure for placement. The sensor shall be placed approximately at 2/3 of the height.



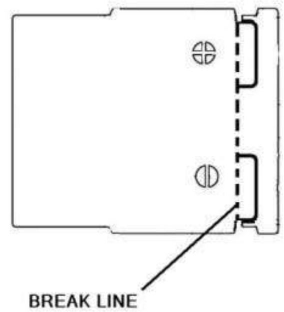
10.4 Connecting the Batteries

The monoblocs shall be connected in series using the cable and connectors designed for the particular layout of your application. Refer to the particular layout of the system. Please observe the risk for arcing and high currents when connecting the monobloc string to the system. Preferably the last connection should be made at distance from the monobloc string.

If the system comprises a monobloc circuit breaker or any other means of disconnection, this shall be in an off condition when connecting the monobloc to the system. Before connecting cables, clean contact surface and apply a light coating of anti- oxidizing grease to contact surfaces. A torque wrench must be used for tightening the bolts on the battery. Recommended torque will vary depending on the size of the battery. Refer to the product label applied directly to the battery for recommended torque values.

The covers shall be put back after all connections have been completed. Please observe that when heavy cables are used, these need to be supported in order not to stress the monoblocs terminals. The isolation covers should be put back after all connections have been completed.

See the figures below:



10.5 Application of Grease after Tightening Electrical Connections

Electrical grade conductive grease is applied directly to the battery terminals as a corrosion preventative measure during manufacturing. In typical indoor installations no additional grease is required to protect the terminals and other electrical connections after installation. The bus bars and other hardware provided with the batteries are plated to protect from corrosion.

10.6 Cleaning

Batteries shall only be cleaned using a dry soft cloth or alternatively cloth moistened with water – Any other substances should not be used or sprayed on the batteries. The plastic used for the batteries is sensitive to many solvents and other substances. Especially pesticides, insect repellants should be avoided entirely as these are known to have caused the plastic to experience severe cracking.

10.7 Charging

Please note! Never charge the batteries in their packaging! Batteries need to be unpacked and positioned with space between them before any charging is started.

10.8 First charge commissioning charge

Depending on the state of charge of the batteries it may take some time before they reach full state of charge. Below recommended charge based on the OCV values of the monoblocs.

OCV	Recharge Time
>12.80 V	3 day charge 2.27 VPC
12.6 - 12.8 V	3 day charge 2.27 VPC
12.3 - 12.6 V	1 day charge 2.41 VPC
12.1 - 12.3 V	1 day charge 2.41 VPC

10.9 Setting charging voltages in the system

Charging systems for batteries need you to set the float voltage, temperature compensation values and boost voltage settings. For convenience we have added the settings for some of the most common configurations and temperatures below. Table 2 Float voltage using temp compensation -2mV/cell/°C

T °C / °F	V (float) 24 V	48 V
20 / 68 13.68 ± 0.12V	27.36 ± 0.24V	54.72 ± 0.48V
25 / 77 13.62 ± 0.12V	27.24 ± 0.24V	54.48 ± 0.48V
30 / 86 13.56 ± 0.12V	27.12 ± 0.24V	54.24 ± 0.48V
35 / 95 13.50 ± 0.12V	27.00 ± 0.24V	54.00 ± 0.48V

For the boost voltage setting please consult section 2.4.1.

10.10 Over temperature safety feature setting

When the system has a high temperature disconnect it shall be set to disconnect the battery at a temperature preferably at 65°C but not higher than 75°C.

10.11 Battery block position labeling

Some customers may require marking/labeling of each battery block's position within a battery string, i.e. block number 1through 4 for a -48VDC battery string. Mark each battery in accordance with customer requirement (some customers may require the battery block connected to the 0V lead to be block #1 and the block connected to the -48VDC lead to be #4 or vice versa).

If marking is made with stickers or marker, put the mark on the existing battery label to avoid possible reaction between the glue of the sticker and the plastic jar or the marker's solvent and the plastic jar.

11 Maintenance

In absence of automatic monitoring systems the following maintenance is recommended: Every 6 months check voltage of the power plant and individual voltages of the monoblocs. If the battery is judged to be fully charged no unit shall deviate more than 0.15 V from other units.

Check the batteries for integrity and cleanliness. If necessary clean the dirty units.

12 Technical Specifications

For detailed technical specification, please refer to the product datasheet at www.northstarbattery.com

13 NorthStar ACE® FCC / IC Specific Information

All our NorthStar ACE® batteries have been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the gateway.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult an experienced technician for help.

This device complies with Industry Canada's license-exempt RSSs. Operation is subject to the following two conditions:

1) This device may not cause interference; and
2) This device must accept any interference, including interference that may cause undesired operation of the device

Cet appareil est conforme aux RSS d'exemption de licence d'Industrie Canada. L'opération est soumise aux deux conditions suivantes:

1) *Cet appareil ne doit pas causer d'interférence ; et*
2) *Cet appareil doit accepter toute interférence, y compris les interférences pouvant entraîner un fonctionnement indésirable de l'appareil*

The ACE Gateway equipment operating in the 2.4 GHz band requires a separation distance of at least 20 cm. This distance must be maintained between the user and product when the product is operating.