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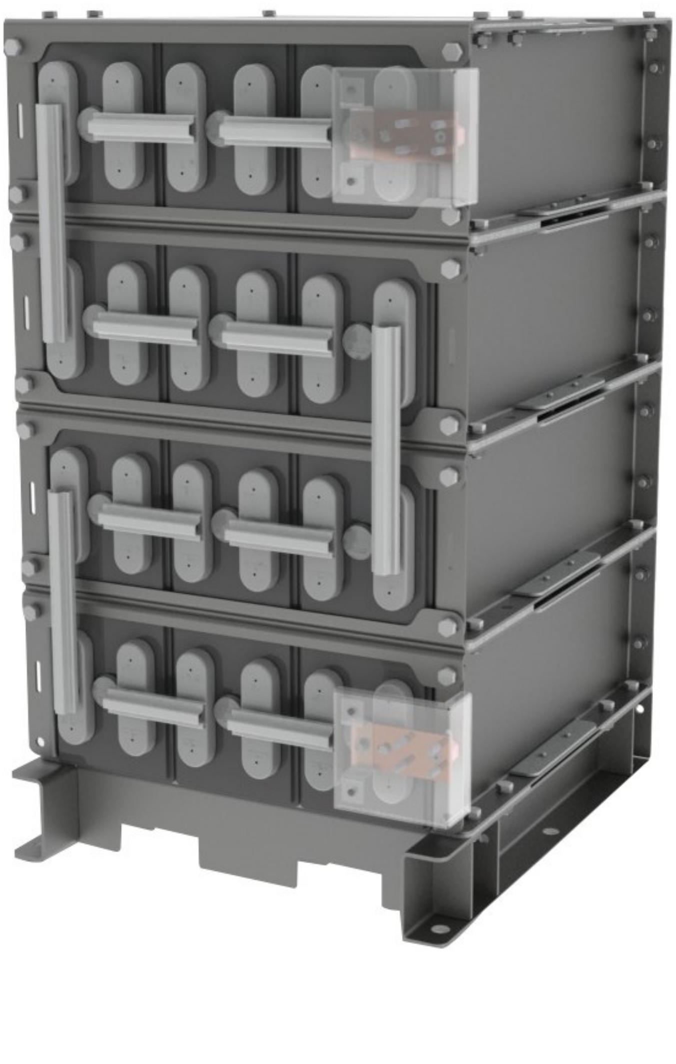

EnergyCell Nano-Carbon High Capacity Batteries

Owner's Manual

OutBack POWER
member of The alpha Group™

About OutBack Power Technologies

OutBack Power Technologies is a leader in advanced energy conversion technology. Our products include true sine wave inverters/chargers, maximum power point tracking charge controllers, and system communication components, as well as circuit breakers, accessories, and assembled systems.

Audience

This manual is intended for use by anyone required to install and operate this battery. Be sure to review this manual carefully to identify any potential safety risks before proceeding. The owner must be familiar with all the features and functions of this battery before proceeding. Failure to install or use this battery as instructed in this manual can result in damage to the battery that may not be covered under the limited warranty.

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Date and Revision

January 2016, Revision A

Part Number

900-0193-01-00 (01/2016)

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Important Safety Instructions

READ AND SAVE THESE INSTRUCTIONS!

This manual contains important safety instructions for the EnergyCell Nano-Carbon High Capacity battery. These instructions are in addition to the safety instructions published for use with all OutBack products. Read all instructions and cautionary markings on the EnergyCell Nano-Carbon High Capacity battery and on any accessories or additional equipment included in the installation. Failure to follow these instructions could result in severe shock or possible electrocution. Use extreme caution at all times to prevent accidents.

WARNING: Personal Injury

- Some batteries can weigh in excess of 100lb (45kg). Use safe lifting techniques when lifting this equipment as prescribed by the Occupational Safety and Health Association (OSHA) or other local codes. Lifting machinery may be recommended as necessary.
- Wear appropriate protective equipment when working with batteries, including eye or face protection, acid-resistant gloves, an apron, and other items.
- Wash hands after any contact with the lead terminals or battery electrolyte.

WARNING: Explosion, Electrocution, or Fire Hazard

- Ensure clearance requirements are strictly enforced around the batteries.
- Ensure the area around the batteries is well ventilated and clean of debris.
- Never smoke or allow a spark or flame near the batteries.
- Always use insulated tools. Avoid dropping tools onto batteries or other electrical parts.
- Keep plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, or eyes.
- Wear complete eye and clothing protection when working with batteries. Avoid touching bare skin or eyes while working near batteries.
- If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters the eye, immediately flood it with running cold water for at least 20 minutes and get medical attention as soon as possible.
- Never charge a frozen battery.
- Insulate batteries as appropriate against freezing temperatures. A discharged battery will freeze more easily than a charged one.
- If a battery must be removed, always remove the grounded terminal from the battery first. Make sure all devices are de-energized or disconnected to avoid causing a spark.
- Do not perform any servicing other than that specified in the installation instructions unless qualified to do so.

Additional Resources

These references may be used when installing this equipment. Depending on the nature of the installation, it may be highly recommended to consult these resources.

Institute of Electrical and Electronics Engineers (IEEE) guidelines: IEEE 450, IEEE 484, IEEE 1184, IEEE 1187, IEEE 1188, IEEE 1189, IEEE 1491, IEEE 1578, IEEE 1635, and IEEE 1657 (various guidelines for design, installation, maintenance, monitoring, and safety of battery systems)

Introduction

The EnergyCell Nano-Carbon High Capacity batteries referenced in this document are stationary, lead-acid batteries. There are four battery models for the EnergyCell Nano-Carbon High Capacity series:

- 1100NC (48 Volt System)
- 1600NC (48 Volt System)
- 2000NC (48 Volt System)
- 2200NC (48 Volt System)

The batteries are constructed with an absorbent glass mat (AGM) and are characterized as Valve Regulated Lead-Acid (VRLA). As VRLA, there is no free flowing electrolyte. They are constructed with lead-calcium alloy grids, dilute sulfuric acid (electrolyte) enclosed in a flame retardant thermoplastic container (non-flame retardant container also available) with a safety vent and a flame arresting disk to prohibit a spark from entering the head space of the cell. This type of battery is nearly 100% recyclable. At the end of life, dispose of the battery properly or consult OutBack Power for recycling information.

The EnergyCell Nano-Carbon High Capacity batteries are designed to provide reliable service life with minimal maintenance when used in accordance with this manual. The battery is a single cell unit producing a nominal two Volts Per Cell (VPC), which is connected in series for the desired system voltage. The cells are housed in steel modules, coated with acid resistant paint.

This manual addresses systems installed horizontally with terminal connections accessible from the front of the modules.

The EnergyCell Nano-Carbon series is designed for cycling applications. Typical applications include off-grid/unreliable grid telecom, renewable energy or other stationary applications requiring a high number of cycles throughout the life of the cell.

Cell Characteristics

Under normal float operation, EnergyCell Nano-Carbon High Capacity batteries can be installed in proximity to electronic equipment and in computer rooms with occupied space. However, if subjected to excessive overcharge voltage, hydrogen and oxygen can be vented into the atmosphere. Therefore, lead acid batteries should never be installed in an airtight enclosure. Sufficient precautions must be taken to prevent excessive overcharge and containment of potential explosive off-gases. All Lead-Acid batteries, including EnergyCell Nano-Carbon High Capacity, are capable of generating excessive potentially explosive gases when charged for prolonged periods at voltages higher than initial or equalizing charge. The EnergyCell Nano-Carbon High Capacity cells are equipped with a flash arrestor and pressure relief valve assembly that seals the cells during normal charge and operation but allows it to safely vent in case of overcharge. Removing the valve assembly can cause the release of potentially explosive gases and will void the warranty.

Materials Required

Tools (use insulated tools only)

- Torque wrenches
- Voltmeter

Accessories

- Hardware kit
- Interconnect cables as needed

Storage and Environment Requirements

Store batteries indoors in a cool, well ventilated, clean, dry location. Place the batteries in service as soon as possible.

The recommended temperature for storage is 50°F (10°C) to 77°F (25°C). The batteries can be stored at these temperatures for approximately six months; longer storage is detrimental to the cell and can void the warranty if not given a freshening charge within that time period. A convenient measurement to check the condition of the cell during storage is to measure the Open Circuit Voltage (OCV). A fully charged EnergyCell Nano-Carbon High Capacity cell has an approximate OCV of 2.16 volts. If the EnergyCell Nano-Carbon High Capacity series cell OCV drops more than 0.04 volts from its received voltage or measures less than 2.12 volts, a freshening charge is required. Be sure to record dates and conditions (voltage, current and recharge times) for all charges during storage.

Avoid exposure of a partially discharged cell to temperatures less than 0.0°F (–18°C), as this may cause the battery electrolyte to freeze. This can permanently damage the battery and can cause potentially hazardous leakage.

Higher than normal storage temperature (77°F [25°C] nominal) will accelerate internal self-discharge of a cell by a factor of two for each 15°F (10°C) over nominal 77°F (25°C) storage temperature. This, in turn, will reduce the allowable time before initial and/or boost charging.

If a freshening charge is required, it is very important that boost or freshening charges (see Table 1 on page 23) be given at the appropriate time to avoid major remedial action or loss of product.

Installation

Install the batteries in a clean, cool, and dry location. Avoid areas with direct sunlight and heat sources, including electrical equipment vents or exhausts. The recommended battery room temperature of 77°F (25°C) provides the best combination of performance and life. Lower temperatures will reduce battery performance, while higher temperatures will improve battery performance but reduce battery service life.

Avoid sources of hot or cold air that could cause temperature variations of ±5°F (3°C) within the battery assembly. Such variations will compromise optimum battery performance such as the float voltages of individual cells.

When considering room layouts and determining the necessary floor space required for mounting a given system the below diagram is a guide to Outback Power's recommended system clearances. Should a question or concern arise please contact an Outback Power sales representative for further details. Each system is shipped with an Applications Engineering System layout which goes into further detail on system layouts and floor anchoring.

Dimension Requirements for the System Installation

» 2" from the back of any system to a wall or any other obstruction/equipment is recommended.

» 4" between systems (side to side) where no side termination is being used is recommended. Reference the supplied OutBack Power system drawing for additional details.

» 6" between systems (side to side) where side termination is being used is recommended.

» 4" spacing from any wall/equipment to the side of any system is recommended.

» When installing systems back to back, 4" spacing is recommended from module to module as shown in the diagram below.

» Aisle clearances should be consistent with common safety practices and any and all federal and local codes.

» There may be a de-rating of anchor bolt load ratings due to the proximity of anchor holes. Reference anchor bolt manufacturer's data for additional information.

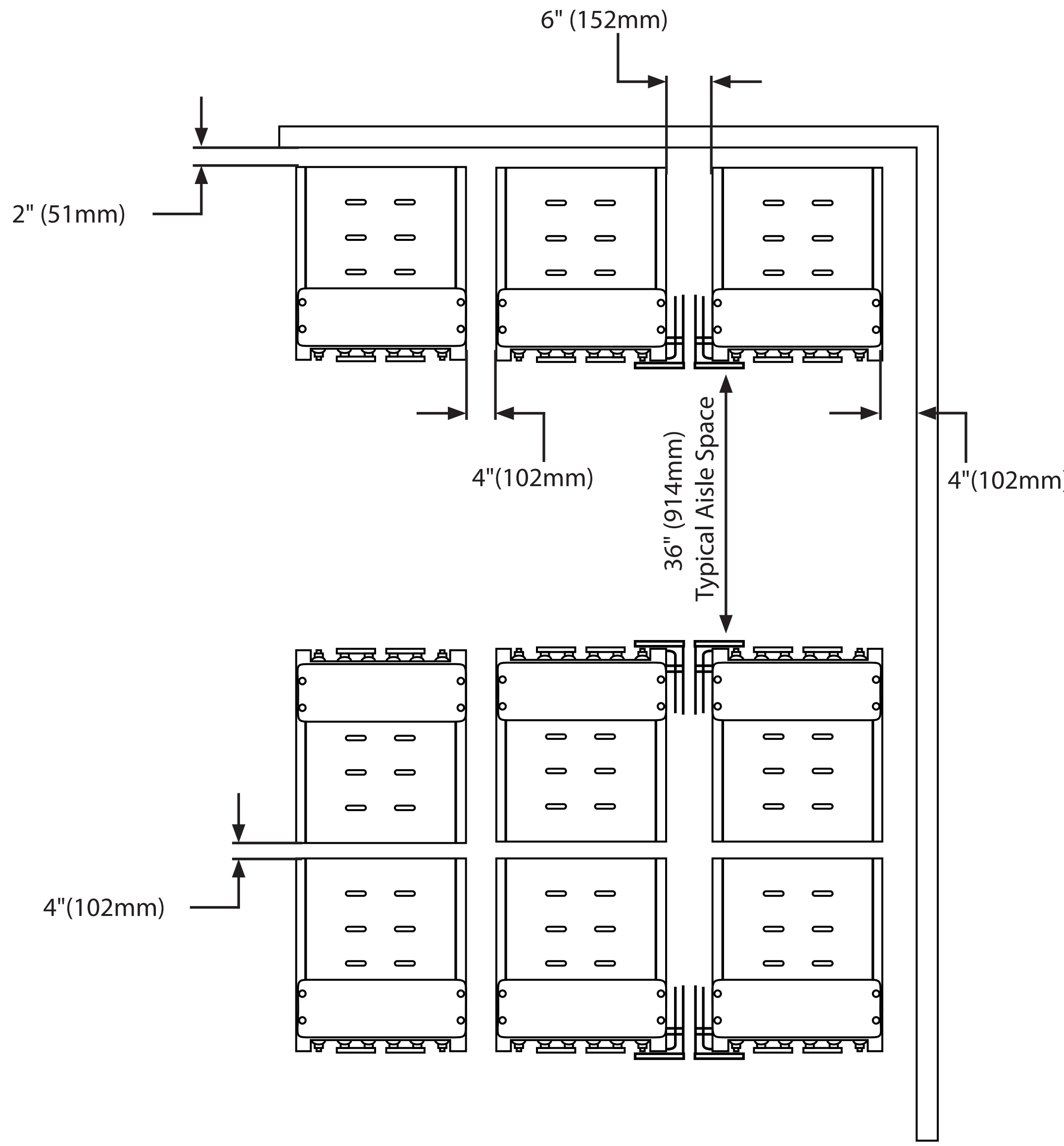

Figure 1 System Installation Dimensions

Ventilation

Although the EnergyCell Nano-Carbon High Capacity batteries are valve regulated, they can produce minimal gas emissions during normal operation. If exposed to abnormal high voltage charging, the cells may vent potentially explosive hydrogen gas. Hydrogen gas when accumulated in a confined area that exceeds four (4%) percent by volume in air is explosive. OutBack Power recommends not allowing hydrogen gasses of greater than one (1%) percent by volume to accumulate. Consult local code and regulation to determine what codes and levels are applicable to the installation. Lead acid batteries should never be installed in a sealed, non-ventilated cabinet or enclosure.

VRLA batteries subjected to extreme overcharge voltages have the potential to release hydrogen gas at a rate of 0.000269 cubic feet per minute per ampere of charging current at 77°F (25°C). The EnergyCell Nano-Carbon High Capacity series testing shows that they recombine at nearly 99% efficiency under normal conditions. However, compliance with appropriate safety measures regarding hydrogen evolution is essential for the safety of the equipment and personnel.

Installation

Installation of Modules

The EnergyCell Nano-Carbon High Capacity battery systems can be shipped with the cells installed into the modules or separately. Modules with cells installed are stacked vertically and bolted to pallets for ease of transportation (see Figure 2). When the cells are packed separately, they are packaged in foam for safe transport and installed into modules on site. It is essential and the responsibility of the customer/installer to be properly trained and have suitable equipment to handle these heavy products. It is the responsibility of the customer/installer to provide a room properly designed for a battery system, including appropriate ventilation, aisle space, egress, floor load capabilities and a level mounting surface.

Figure 2 Module Packaging and Transportation

Unpacking and Handling

Do not remove shipping materials if a storage period is expected. The battery modules are shipped in varying groups depending on cell size. Lag bolts are used to attach the modules to the pallet along with a protective honeycomb hood, cardboard packaging and shrink wrap (see Figure 2).

CAUTION: Equipment Damage

Do NOT tilt the module forward. The cells are tightly fit, however, they are not completely restrained until the system is completely assembled.

Carefully remove all shipping materials and dispose of properly. Once all shipping materials are removed unbolt the system from the shipping pallet. Each system will be provided with one base assembly for floor anchoring and should be removed first followed by any other bolted connection leaving only the module rivets (see Figure 3). The design of the module allows for handling by a fork lift, portable crane or by a battery lift table. When handling modules it is very important to use a piece of insulating material such as shipping cardboard, plywood or rubber insulating mat between handling equipment & battery terminals. Always verify the lifting capacity of the equipment being used and never lift more than one module at a time. Always use both lifting straps in an "X" pattern as shown throughout this manual. The module assembly can be lifted by either the front flanges or by a combination of holes on both flanges.

Figure 3 Module Unpacking and Handling

Floor Loading and Anchoring

Floor loading and anchoring requirements are the responsibility of the user/installer and all applicable building codes and regulations must be followed. OutBack Power provides connection drawings, weights, dimensions, and floor loading information on our system drawings for reference which is supplied with every shipment.

The EnergyCell Nano-Carbon High Capacity floor-mounting base has provisions for floor anchoring. Consult the applicable building codes and regulations for specific requirements. In all cases, floor anchoring is considered mandatory with floor anchors to be installed in all locations provided unless otherwise specified. Floor anchor sizing and hardware are the responsibility of the user/installer.

1. Where floor anchoring is required, place the base assembly into position and mark the anchor locations using the base as a template (see Figure 4).

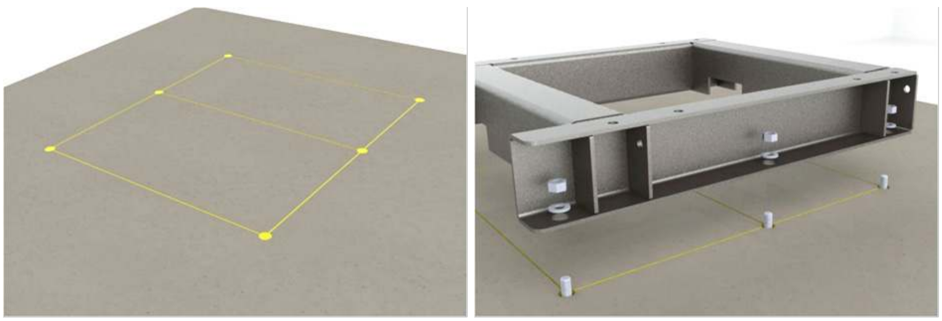

Figure 4 Marking the Anchor Locations

2. Six or four (100 Series and 50 Series respectively) 13/16” (21mm) holes are provided in the system base for floor anchoring.
3. Install the floor anchors and reposition the base onto the anchors.
4. Install the anchor hardware and verify that the top surface of the base assembly is level in both axes. If necessary, install shims to level the base.
5. Once the base assembly is level, torque the anchor bolts to the proper rating based on the manufacturer’s specification (See Figure 5). A standard 3/8" extension can be used as shown if tool clearance is an issue.

Figure 5 Torque the Anchor Bolts

Module Stacking and System Assembly

With the base properly installed, modules unpackaged and in the horizontal position, refer to the OutBack Power issued system diagrams (see page 21) to verify proper cell orientation when stacking modules.

OutBack Power recommends the following two methods for handling EnergyCell Nano-Carbon High Capacity modules:

Portable Crane/Fork lift

In the case of limited access in the rear of the module, install only the four (4) 10mm bolts in the rear flanges prior to hoisting. Connect optional lifting straps in a "X" pattern as shown and hoist carefully (see Figure 6).

Note:

Depending on the battery type some sagging may occur while lifting.

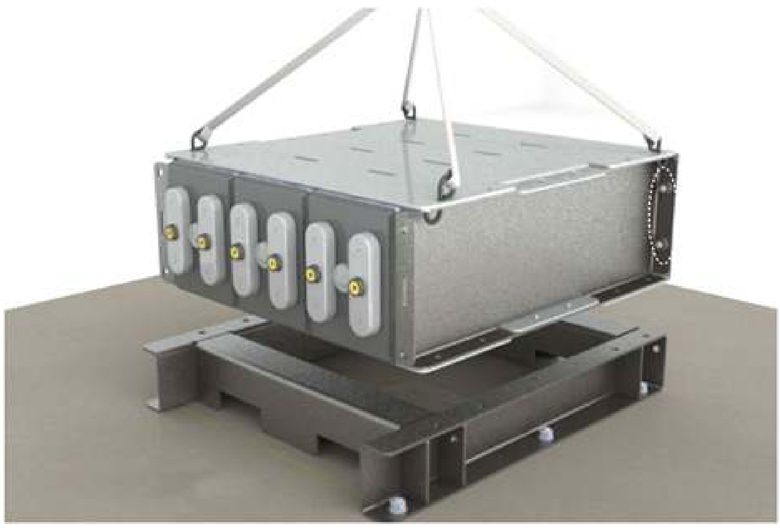

Figure 6 Portable Crane / Fork Lift

Battery Lift Table

Prior to hoisting, install only the four (4) 10mm bolts in the rear flanges. Verify module orientation then position the module on the lift table, keeping metal surfaces isolated from battery terminals. The modules flat top and bottom surfaces allow it to easily slide from the lift platform to the base with little effort (see Figure 7).

Note:
When lifting battery modules, always verify the lifting capacity of the equipment being used and never lift more than one module at a time.

Figure 7 Battery Lift Table

Make the lower tier Module-to-Base connections using eight (8) 10mm bolts (4 per side). Torque to 40 ft-lb [55 Nm].

Note:
Only the Module-to-Base connection requires the use of all (8) bolt connections.

Figure 8 Module-to-Base Connection

1. Using either of the two lifting methods described, continue with stacking modules for tiers two on up. Reference the OutBack Power connection diagram while stacking modules to ensure proper cell orientation.
2. Once the module is in position and the bolt holes are in alignment, make the Module-to-Module connection using four (4) 10mm bolts (2 per side) in the horizontal plane. Torque to 40 ft-lb [55 Nm]. (see Figure 9).

Note:
Module-to-Module connections only require the use of (4) bolt connections per tier in the horizontal plane.

Figure 9 Module-to-Module Connection

3. Follow these steps for any additional modules.

System Restraints

All systems are supplied from the factory with two types of restraints. These restraints are critical in maintaining the seismic rating of the system and must be installed properly.

Front Restraint

Front restraints are installed between each tier of the system to prevent cells from shifting in the event of an earthquake. With all of the modules properly stacked and in agreement with the OutBack Power layout drawing, attach the restraint bar using four (4) 10mm bolt assemblies (see Figure 10).

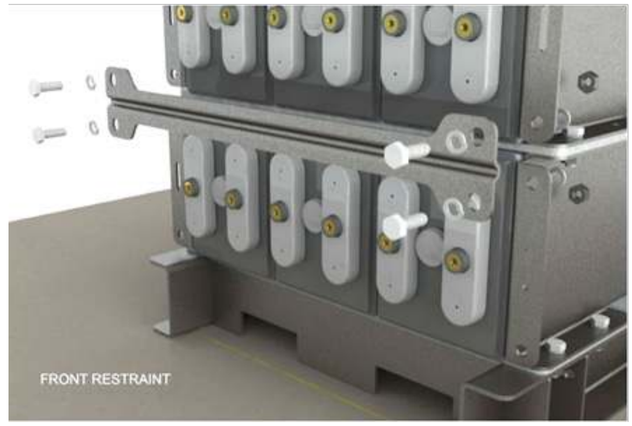

Figure 10 Front Restraint

Top Restraint

Each system/stack will be supplied with one top restraint. The top restraint will be installed on the upper most module to complete the assembly. The restraint will be installed using six (6) 10mm bolt assemblies (see Figure 11).

Figure 11 Top Restraint

Final Check

Once the top restraint is attached, the system assembly is complete. Before attaching terminal plates and making series connections, verify the cell orientation matches the supplied OutBack Power connection diagram.

Figure 12 Final Check

Handling and Replacement of Individual Cells

A key design feature of the EnergyCell Nano-Carbon High Capacity battery is the provision for servicing individual cells. With a minimum amount of handling and downtime, individual cells can be changed in the field. In addition, disassembly and reassembly of the stack modules may accommodate installation of a new battery if necessitated by a hard-to-access location. Once the battery string has been removed from service, the technician must use properly insulated tools and adhere to all appropriate battery safety methods.

1. Remove the connector covers from the subject module.
2. Disconnect the system ground connection.
3. For each connector attached to the cell, loosen (but do not remove) the terminal bolts at either end.
4. While holding the connector in one hand, remove the terminal bolts completely. Remove the connector and set aside. Repeat for other connectors.
5. Remove cell retaining bar, shown in Figure 13.

Figure 13 Cell Retaining Bar Removal

6. Attach the cell puller tool. This tool, shown in Figure 14, is available from an OutBack Power Technologies Representative.

Important:
Before removing the cell, note the orientation of the cell in the module (positive terminal up or down).

Figure 14 Cell Puller Tool

7. Prepare for cell removal by moving a platform lift or equivalent lifting apparatus in proximity to the bottom of the stack module from which the cell is to be removed. Make sure all exposed metal on the platform is insulated. Verify the capacity of the lifting apparatus is sufficient to safely lift the cell.

8. Pull the cell straight out onto the platform, shown in Figure 15.

Figure 15 Cell Removal

9. Follow Steps 2, 3 and 4 in reverse order to physically install the replacement cell or reinstall a new disassembled battery. Do not perform the electrical connections at this time.

> **Note:**
> There is also a connection drawing supplied with each battery that will aid in cell orientation and installation.

10. When all cells for a given module have been installed, reinstall the cell-retaining bar.
11. Perform terminal and connector preparation.
12. Perform polarity check.
13. Reinstall connections.
14. Re-install connector covers.

> **Note:**
> EnergyCell Nano-Carbon High Capacity cells should never be lifted by the terminals. Do not use the cell puller tool as a lifting device.

15. Never remove more than one cell per tier at a time.

Stack Module Disassembly and Re-Assembly Procedure

1. Starting with the uppermost module in the stack, remove the individual cells following the instructions in the section "Handling and Replacement of Individual Cells" (see page 17).
2. Repeat until all the cells have been removed.
3. Disassemble the stack modules. Transport the bottom stack module to the desired installation location. Mark the location of the floor anchors and install, again matching the anchor holes in the floor-mounting base.
4. Be sure the floor mounting base or assembly is in position and level, and then torque the floor anchors. If the base is not level, use shims.
5. If the assembly requires additional modules, use the lifting slings. Place additional modules, one at a time, on top of modules already in place. Properly align modules and mounting holes, and insert the M10 bolts, washers and nuts. When all bolts are in place, check that assembly is plumb and level, then tighten the bolts to 40 ft-lb (55 Nm) using a torque wrench.
6. Reinstall the cells starting with the bottom module and working up. Perform the electrical connections last.

Spill Containment

Although the EnergyCell Nano-Carbon High Capacity batteries contain no free-flowing electrolyte, it is the sole responsibility of the user/installer to follow all local building and fire codes applicable to the battery installation. OutBack Power recommends consulting the local fire marshal or building inspector to determine if spill containment is required.

Terminal Plates (If Applicable)

For reasons of safety, it is recommended that terminal plates be installed before connector installation. Interconnect cells and modules with tin-plated (standard) copper connectors and 6mm stainless steel hex head bolts and washers in accordance with the connection diagram supplied with each battery shipment.

Prior to installation, lightly brush (with a plastic brush or abrasive cleaning pad) the battery terminals and terminal plate contact surfaces. Then apply a thin coating of electrical contact lubricant. The EnergyCell Nano-Carbon High Capacity battery terminals are made of a brass alloy with a tin coating cast inside a lead terminal. Terminal plates are made of copper with a thin tin coating. Once coated with protective electrical contact lubricant, any exposed areas will be protected from oxidation by the grease. If desired, preheat and apply the warm electrical contact lubricant. Always wash hands after working with any lead component.

Numbering Cells

For ease of identification and for record keeping, all cells of a battery should be numbered. Plastic peel-and-stick numbers are furnished in the accessory kit. Common practice is to start with "1" on the cover of the incoming (+) positive terminal of the battery and follow the electrical circuit with succeeding numbers on the cell covers.

Interconnection

Cell series connection is made from the (+) of one cell to the (–) of the next sequential cell. It is essential that the cell location and orientation match the included drawing. All connections must be made as indicated on the drawing with no deviations. If no drawing is provided or it is lost, contact OutBack Power before making any connections.

The cells ship with electrical contact lubricant applied by the factory to the terminals; however, it may be necessary to rework prior to connecting the cells with the supplied inter-cell connectors.

Installation

The top row of connectors is to be installed first, then the second row down and so on, working from the top down. When installing connectors, install the top (upper most) bolt first. Complete connector installation by torquing all connections to 110 in-lb [12.4 Nm], using an insulated torque-wrench.

CAUTION: Equipment Damage

Over-torquing can damage the post seal and degrade connection integrity.

After torquing all connections and with the battery still on open circuit (not connected to the charging source), take post-to-post resistance measurements. Start at one end of the string and work to the other end, recording micro-ohm resistance of each inter-cell connection between cells. Clean and re-torque connections of similar size connectors which exceed ±10% percent of the average resistance of battery connections or five micro-ohms, whichever is greater.

Important:

Record and retain the resistance readings with the initial charge information for future reference.

CAUTION: Equipment Damage

It is the sole responsibility of the user to check connections. Never operate a battery with loose or corroded connections.

When checking connections, disconnect the battery from the load and the charging equipment and follow all the precautionary measures outlined above and in the general safety references. Some resistance measurement equipment may cause a spark when the probes are applied to the cell posts. Use appropriate safety precautions when conducting this measurement.

After connecting all cells of the battery, check the battery voltage using a calibrated digital DC voltmeter with at least three digits and 0.25% accuracy minimum. Battery voltage should equal the open circuit voltage of an individual cell multiplied by the number of cells in the battery.

Example: (24 cells) x (2.16 Volts Per Cell) = 51.84 OCV. If the OCV does not equal the expected value, inspect the sequence of (+) to (–) connections. Further investigation may require re-inspecting each cell voltage to confirm an acceptable value.

Intercell Connection Diagrams

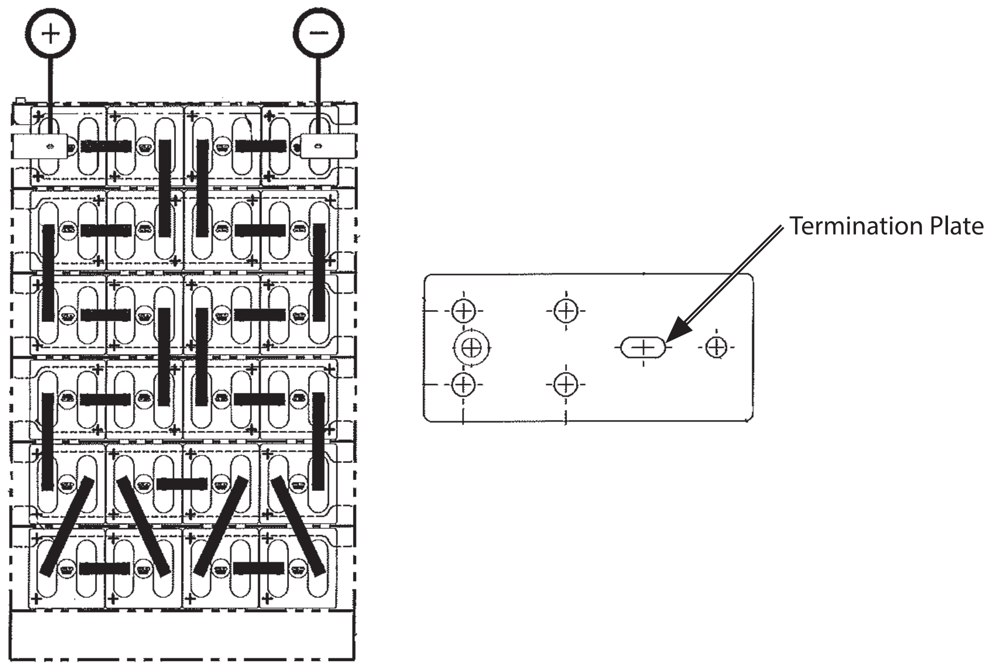

Figure 16 48 Volt System - 1100NC

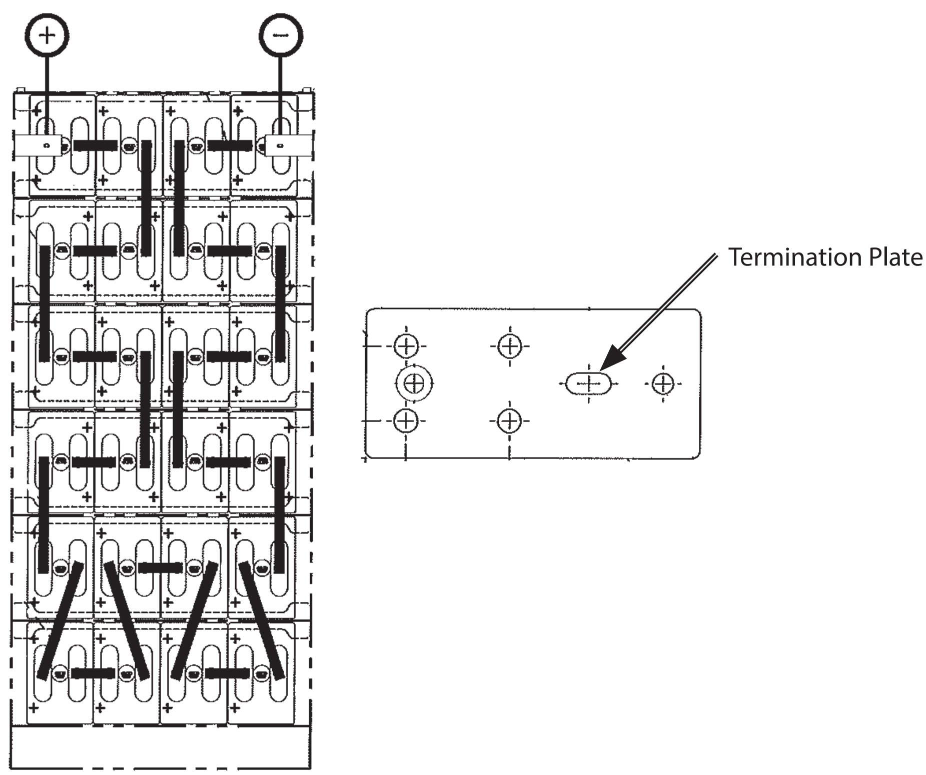

Figure 17 48 Volt System - 1600NC

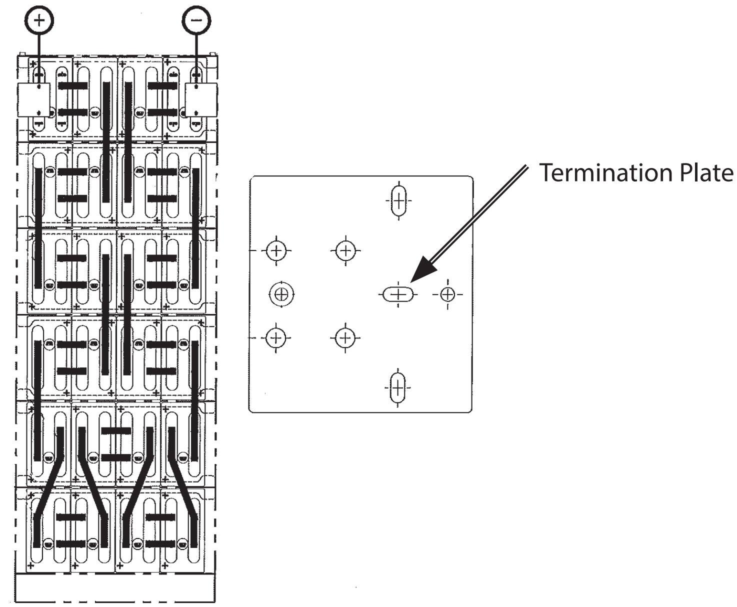

Figure 18 48 Volt System - 2000NC

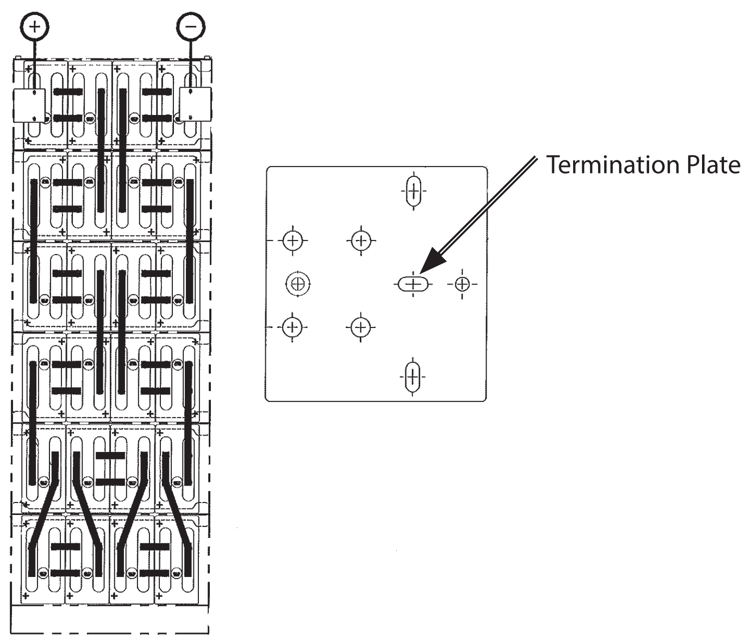

Figure 19 48 Volt System - 2200NC

Tap Connections

> **CAUTION: Equipment Damage**
>
> Tap connections can electrically unbalance the system, leading to equipment damage, if performed incorrectly.

If a center tap is used, each side must have its own charging unit.

Initial Charging

To safely charge the EnergyCell Nano-Carbon High Capacity batteries and avoid damaging the battery and/or connected equipment, observe the following:

- Use a constant voltage charger with only direct current (DC). AC ripple current from charger shall not exceed (5%) of the 8-hour (ampere-hour) rating of the battery.
- Verify that the charger is turned off before making electrical connections between the battery and system.
- Connect via the appropriate size cable. Verify polarity with a volt meter before making final charger connections and turning on the charger.
- Verify that all connections are tight and secured before turning on the charger.

The recommended method of providing an initial/freshening charge is to first determine the maximum allowable voltage that may be applied by the connected equipment. Divide this by the number of cells in the battery to obtain maximum average voltage per cell allowed by the equipment. Adjust this number to a recommended value found in Table 1 and continue charging at this voltage.

Note:

Charging current to the battery should be limited based on the Ampere Hour capacity of the battery. Refer to Table 1 for maximum charging current. Higher charging current can cause overheating that subsequently increases the internal resistance of the battery, which requires additional current to compensate for the increased internal resistance. This cycle is referred to as "thermal runaway", which has the potential to destroy the battery and cause damage to equipment.

All cells are shipped fully charged from the factory with no need for an initial freshening or equalization charge. The cells should be constant voltage charged at the average float voltages as noted in Table 1 below. However, when in storage or transit for an extended period (especially at temperatures above 77°F/25°C) or when the number of cells is greater than 24 cells; it is recommended the battery system be given an initial freshening charge (see Table 1) at installation.

Table 1 Charging Requirements

Average String Float Voltage 77°F (25°C)	Average String Cycle Service Voltage 77°F (25°C)	Average String Freshening Voltage	Freshening / Equalization Charging Time	Maximum Charge Current
2.25 to 2.27 VPC	2.35 to 2.40 VPC	2.35 to 2.40 VPC	12 to 24 Hours	50 - 60 Amps per 100Ah Battery Rating

Note:

- Battery float voltage should be set at Table 1 average cell voltage multiplied by the number of cells in the battery string. Individual cell float voltages may vary by +0.10/–0.05 volts from the average in a single string.
- Average string float voltage must be adjusted based on temperatures which are above or below 77°F (25°C).
- Charging time will vary due to temperature if cell temperature is below 60°F (16°C), double the charge time for initial or equalize charge.
- If a battery load test will be performed within 90 days of installation, an initial freshening charge followed by a 72-hour float charge (per IEEE 1187) is required to ensure full capacity.

Initial Charge Records

Leave the cells on float charge for approximately one week after the initial charge. Then record the voltages of the individual cells, the total battery voltage and ambient temperature. Retain this information for future reference. This information establishes a baseline for future reference.

The information below must be recorded. Make a photocopy of the form and use it whenever necessary to record readings taken on the battery.

Battery identifications

1. Date of readings
2. Battery total float voltage
3. Ambient operating temperature
4. Date and description of initial or last equalizing charge
5. General observations from visual inspection
6. Individual cell voltages
7. Connection resistance measurement
8. *Optional: One of the following for cell ohmic testers:
   - » Impedance
   - » Conductance
   - » Resistance
9. Name of inspection technician

If there are any unusual readings or visual indications, consult an OutBack Power representative with a copy of the latest maintenance report.

*Cell ohmic readings may vary by ±20% of the published values. This variation does not necessarily indicate a problem with the condition of the battery.

Important:

Initial charge records are essential for review by OutBack Power's sales/service representatives in the event of a problem. Since records can materially affect the warranty, be sure to maintain clear, signed, and dated copies.

Battery Operation

Float Charging

Standby batteries are connected to control circuits, which must be energized at all times. Connected to a load in parallel with a continuously operating power supply, these batteries assure instantaneous support of the load in the event of a power failure or brownout. In addition to operating the connected load, the power supply keeps the standby battery fully charged. This parallel interconnection and operation is called float service. Float charging is performed with the float voltage setting shown in Table 1. Maximum battery life can be expected in full float service, in which the frequency and depth of discharges are kept at a minimum. Deep and/or frequent discharges can shorten service life, even with proper battery maintenance.

Cycle Charging

Cycling applications are the most demanding applications that for lead acid batteries. In many cases, the batteries are in a constant state of either being charged or discharged.

In typical conditions, the battery is fully charged after every discharge cycle. Under these circumstances, the battery will be brought back to full charge using a charging rate designed to bring the batteries back to full charge before the next discharge. If the system cannot achieve a full charge between discharging cycles, or if the system is being utilized in a Partial State-of-Charge (PSoC) operation, then additional charging needs to be employed to bring it back to full charge at least once per month. The charging system should be capable of automatically adjusting the charging voltage based on the temperature of the battery. The measurement of the battery temperature must be taken at the battery; not ambient temperature.

In applications with deep or frequent discharges, battery life can be maximized by following charge voltages and currents as shown in Table 1. The cells can be either constant voltage or constant current charged, if a voltage limitation is set at the values in Table 1. PSoC operation is permissible if state of charge regulation is provided or periodic equalization charging is utilized.

In pure-cycle applications, with the depth of discharge (DoD) ranging from 5% to 90%, either a constant voltage charge algorithm or a constant current charge algorithm is permissible, if a voltage limitation is provided. Voltage and current limits provided in Table 1 should be utilized to ensure maximum service life. Pure-cycle applications will also require a periodic equalization or freshening charge, depending on the time between discharge cycles. Generally bi-weekly or monthly equalization charging is adequate for most applications including PSoC applications where the average state of charge is between 30% to 90% SoC.

Many pure-cycle applications utilize a three-stage cycle, which performs periodic charging at both constant-current and constant-voltage stages. The stages used in OutBack chargers are "bulk", "absorption" and "float" (as noted above).

- Bulk is a constant-current stage which uses the Service Voltage in Table 1. The current is maintained at a constant high level. The voltage will rise as long as the current continues to flow. This typically restores the battery to 85% to 90% SoC.
- Absorption is a constant-voltage stage. It is established upon reaching the desired voltage in the bulk stage. The charger limits the current flow to only what is necessary to maintain this voltage. This requirement will tend to decrease as the absorption is maintained, resulting in a tapering current. The absorption current will vary with conditions, but will typically decrease very low. This leaves the battery at 100% SoC. The battery is considered to be full when the following conditions are met: The current has tapered to between 1% and 2% of the total battery amp-hours (while maintaining the voltage). The charger is then allowed to exit to the next stage. Many chargers maintain absorption for a timed period (often two hours), under the assumption that the current will taper to the desired level. If the charger exits absorption before the current has tapered the battery may not reach 100% SoC. Repeated failure to complete a charge will decrease the battery life. It is recommended to use a DC ammeter to observe and time the current as it tapers down. The user can then set the charger's absorption timer accordingly.
- Float is a constant-voltage stage which keeps the batteries fully charged following the bulk and absorption stages. It is performed with the float voltage setting shown in Table 1.

Note:
Numerous cycle charge algorithms are permissible with the EnergyCell Nano-Carbon High Capacity cells. If the specific charge algorithm is not explicitly stated in this manual, contact an OutBack Power technical representative for further information.

Equalize or Freshening Charge

Equalize or Freshening Charge Float Applications

A Freshening charge refers to charging batteries during or after storage, when the voltage or specific gravity falls below a given level. An Equalizing charge is given to restore batteries that have been discharged, or to restore voltages to batteries whose voltage has fallen outside of the recommended range.

Under normal float charge operating conditions, it is not necessary to equalize or freshen the EnergyCell Nano-Carbon High Capacity batteries when used within the criteria described in "Initial Charging".

Note:
Some hydrogen gas may be released at equalize charging voltage.

An equalizing charge should be performed if individual cell voltages fall 0.05 volts below the average float voltage as specified in Table 1. Presence of a minimum voltage does not imply a battery is malfunctioning or that it will not provide the necessary power.

CAUTION: Equipment Damage
Charging current to the battery should be limited based on the Ampere Hour capacity of the battery. Refer to Table 1 for maximum charging current. Higher charging current could potentially destroy the battery by overheating that subsequently causes more current to flow creating a cycle referred to as "thermal runaway".

Equalize or Freshening Charge Cyclic Applications

In cycle charge applications, depending on how the system is designed the batteries are regularly discharged and regularly recharged. In these applications, the charging system should be sized so that, on average, the battery is returned to between 85 to 90% state of charge daily. On a bi-weekly to monthly basis the battery should be charged to 100% or fully charged state using the equalization parameters outline in Table 1 for equalization/freshening charge.

If the system is a solar-only system then the charging strategy is solely based on the photovoltaic panels returning all of the energy to the battery every day. The ratio of the photovoltaic array to the load during the worst conditions should be able to bring the batteries to full charge at least once a month.

If the system is a hybrid system where there is dispatchable battery charging capability, the batteries should be charged to between 85 and 90% of full charge on a daily basis (daily charge). On a monthly basis, the batteries should be given an equalization charge to insure that they were fully charged and the SoC is reset.

Note:
Use the Average String Freshening Voltage setting as shown in Table 1 for a period not exceeding the specified hours depending on service conditions.

Temperature Effects on Batteries

OutBack Power recommends that the battery be operated at 77°F (25°C) ± 10°F (5.5°C). For ambient temperatures outside the recommended temperature range, the float voltage must be adjusted by 2mV per cell per °F or 3.6mV per cell per °C. For temperatures above or below 77°F (25°C) subtract or add, respectively, the listed amount per cell.

If the battery is operated at temperatures below the recommended range, the capacity will be reduced even with temperature compensated charging, which must be accounted for during initial system sizing.

Maintenance

The EnergyCell Nano-Carbon High Capacity battery is a VRLA cell which does not require water addition and no specific gravities or water levels need to be checked throughout its life. However, it is recommended to properly follow the below maintenance procedure, to assure that the batteries are well maintained and ready for operation when needed.

1. Visual inspection of the battery for general appearance and connector conditions. Check for bulging jars, corrosion build up or any signs of heat damage to the jars/covers and connectors.
2. Measure and record the total system float voltage.
3. Measure and record the total system float current.
4. (Performed quarterly) Measure and record one of the following ohmic measurement: conductance, impedance, resistance or internal resistance of each battery. Changes over time of less than ±20 % are acceptable, changes of greater than 50 % require further attention (such as a load test).
5. (Performed quarterly) Measure and record the temperature of the negative terminal on each cell.
6. (Performed semi-annually) Measure and record the individual cell voltages.
7. (Performed annually) Torque cell bolts to 110 in-lb (12.4 Nm). Any disassembled connections should be re-torqued to110 in-lb (12.4 Nm).
8. (Performed annually) Measure and record connector resistance reading.
9. (Performed annually) If possible, measure and record the total and individual AC ripple current or voltage.

CAUTION: Equipment Damage

Never use solvents to clean a battery system. Only use a solution of water and sodium bicarbonate, 1 gallon to 1 lb.

Clean products with a solution of 1 lb of sodium bicarbonate to 1 gallon of water, if necessary

For more information, see IEEE 1188. This discusses the significance of connection integrity, further maintenance techniques, and testing information.

Performance Tests

If desired by the customer, a full-load performance test can be conducted at the user's original specified discharge rate or the appropriate rate based on connector sizing per the following procedure:

» Equalize charge the batteries.
» Let batteries float for 72 hours.
» Perform the annual inspection.
» Run a discharge test at the system designed rate per IEEE 1188.

Battery Degradation

General Information and Precautions

When properly maintained and charged, the EnergyCell Nano-Carbon High Capacity batteries should provide many years of trouble-free service. However, despite their inherent dependability, failure to operate and maintain them correctly can lead to damage, shortened service life and possible loss of service. The following sections address some of the most frequently encountered errors.

Float versus Cycle Life

The user is expected to maintain complete records of all battery testing and emergency discharges in order to comply with the requirements of the warranty.

EnergyCell Nano-Carbon cells are specifically designed for cycle service and while their robust design allows them to be used in numerous types of cycle applications from mild shallow DoD service to continuous PSoC service, battery service life can be maximized by following recommended cycle charge voltages and currents as shown in Table 1. In addition, following recommended equalization charging procedures, temperature compensation guidelines and maintaining accurate SoC and DoD limitations will ensure the EnergyCell Nano-Carbon cells provide long and reliable cycle service.

CAUTION: Equipment Damage

Recharge batteries as soon as possible after an emergency discharge. Failure to do so may lead to sulfation, or in the case of deep discharge, a complete battery failure due to hydration. If recharging at freshening/equalize voltage is impractical, promptly recharge at float voltage.

Low Float Voltage and Sulfation

Either because of incorrect charger voltage adjustment, excessive intermittent or static loads paralleling the charging source, low operating temperature or simply not fully recharged; a battery may not receive adequate charging voltage. In some cases, the charger may even be turned off, erroneously or by choice. The net result is a battery left in a partially discharged or undercharged condition. The first observable signs may be erratic cell voltages. Although not visible to the observer, the plates will become sulfated.

If the plates have become sulfated, contact the OutBack Power Technical Support for assistance. Sulfated batteries are not fully charged batteries thus have not completed the electrochemical reaction of recharge. Accordingly, they will have reduced capability. If allowed to remain in a partially charged condition for an extended period of time, sulfated batteries may suffer irreversible damage, requiring replacement.

Hydration

A battery that has been severely over-discharged and left in a discharged condition without immediate recharge is subject to damage known as hydration. This is a phenomenon in which the electrolyte specific gravity has been reduced to a value so low it permits the lead components to dissolve into the electrolyte.

The reaction of dissolution forms many compounds and salts, generically referred to as hydrate. On recharge these compounds react to clog separator pores and form metallic lead. As time passes thousands of short circuit paths are created in the separators placed between the positive and negative plates to provide electrical insulation. Very often, the effect of these short circuits goes unnoticed except for a slight increase in charging current. As the reaction continues, however, short circuits become so extensive it is almost impossible to keep the cells charged. Finally, the cells experience total failure. EnergyCell Nano-Carbon High Capacity batteries are more resistant to hydration than typical wet cells, largely because of the thick absorbent glass mat separator between the plates. However, in severe cases of hydration, internal short circuits can form.

Open Circuit – Late Installations

As soon as a battery is disconnected from a charger, local action (self-discharge) begins. This is caused by inherent internal losses within the cell. In the case of EnergyCell Nano-Carbon High Capacity cells, a self-discharge is expected to occur at a rate of up to 3% of full charge per month at 77°F (25°C). Therefore, if cells remain, for whatever reason, on open circuit (with no charge supplied) for prolonged periods of time, the affected cells may become sulfated and require corrective action in the form of a freshening charge.

Parallel Battery Strings

When strings of batteries of equal voltage are connected in parallel, the overall capacity is equal to the sum of the capacities of the individual strings. When paralleling valve-regulated batteries is necessary, the external circuit resistance should be matched for each battery. A wide variation in battery circuit resistance can result in unbalanced discharge (i.e. excessive discharge currents in some batteries and less discharge in others). As a consequence, cell failures in one battery string and the subsequent loss of performance capacities of that string will result in higher loads in the lower resistance interconnections of some parallel strings that may exceed the ratings of the battery interconnections and/or cables. OutBack Power recommends paralleling strings to obtain higher capacity, to increase system reliability and with properly installed disconnects, perform maintenance on one string at a time.

High Temperature Operation

Operating a battery at temperatures exceeding 77°F (25°C) will reduce the battery life. Elevated temperatures accelerate the electrochemical reaction within the lead acid battery.

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900-0193-01-00, Rev. A (01/2016)