MIL-SERIES
EXPANDER PAK 1000
INSTRUCTION MANUAL

SOLAR STIK™

MIL-SERIES EXPANDER PAK 1000

Safety Symbols

To reduce the risk of electrical shock, fire, or other safety hazard, the following safety symbols have been placed throughout this manual to indicate dangerous and important safety instructions.

WARNING: This symbol indicates that failure to take a specified action could result in physical harm to the user.

CAUTION: This symbol indicates that failure to take a specified action could result in damage to the equipment.

INFO: This symbol indicates information that emphasizes or supplements important points of the main text.

REMEDY: This symbol provides possible solutions for related issues.

Disclaimer of Liability

Since the use of this manual and the conditions or methods of operation, use and maintenance of the Mil-Series Expander Pak 1000 are beyond the control of Solar Stik™ Inc, this company does not assume responsibility and expressly disclaims liability for loss, damage or expense, whether direct, indirect, consequential or incidental, arising out of or anyway connected with such operation, use, or maintenance.

Due to continuous improvements and product updates, the images shown in this manual may not exactly match the unit purchased.

Restrictions on Use - The Expander Pak may be used in connection with life support systems, life saving or other medical equipment or devices; however, without limiting the generality of the foregoing, Solar Stik™, Inc. makes no representations or warranties regarding the use of the system in connection with life support systems or other medical equipment devices.

Important Product Safety Instructions

This manual contains important safety instructions that must be followed during the installation and operation of this product. Read all instructions and safety information contained in this manual before installing or using this product.

All electrical connections must be made using proper polarized connections.

While this product is designed for indoor / outdoor operation, the USER INTERFACE (control panel) must not be exposed to rain, snow, moisture or liquids.

This Expander Pak 1000 is Field Serviceable. If battery replacement or repair is needed, instructions are available from Solar Stik ™ Inc.

Always disconnect the batteries or energy source prior to installing or performing maintenance on the Expander Pak. Live power may be present at more than one point since the Pak may be connected to other active batteries. Turning off the master breaker on a single Pak in a series of Paks will not reduce this risk.

Table of Contents

Power Pak Introduction

The Solar Stik™ System is a Battery-based system. The Solar Stik™ generates DC Power and stores it in Battery Packs, which then delegate power to appliances only as they require it for operation.

The Solar Stik™ family of POWER PAKS provide multi-faceted power storage, and ensure that the entire Solar Stik™ System operates at very high levels of Efficiency.

The Solar Stik™ POWER PAKS currently available include the Lite-Series Power Pak 100, the Standard-Series Power Pak 50 & 100, the PRO-Series Power Pak 50 & 100, the MIL-Series Power Pak 500 & 1000, and the Expander Paks.

The Solar Stik™ Power Paks were designed and are constructed to meet the most demanding conditions. They are ideal for employment in disaster relief, mobile communications, mobile emergency operation centers, military applications, research & security sectors, construction industries, off-grid applications, and recreational uses.

The Paks can handle single or multiple loads simultaneously, and unlike a gasoline generator, which must be running to provide ANY power, they provide “POWER ON DEMAND” to the connected appliance(s). They can be used in conjunction with additional external lead-acid battery banks, and can also be recharged independently of the Solar Stik™ System. The simplicity of the Pak allows the novice operator to use the system for simple tasks, and the versatility of the Pak provides the experienced operator with a multi-faceted solution for nearly any power need.

Solar Stik™ Power Paks are manufactured and assembled in the U.S.A. with an extreme focus on quality. The Power Pak represents a serious investment and can outlast any other lead-acid battery power supply on the market today.

Congratulations on your purchase.

MIL-Series Solar Stik™ System Introduction

The Mil-Series Solar Stik™ System offers enhanced operational features such as 24VDC operation, supplemental wind power generation, programmable controls, complex power management features, and additional accessories that enhance the versatility of the system. The Mil-Series Power Paks also features environmentally sealed electrical components and additional internal gaskets that aid in preventing moisture and particle-intrusion.

MIL-Series Expander Pak 1000 Manual Overview

This guide is crafted to provide the user with a comprehensive understanding of the principles of operation, proper setup & use, operational tips, & safety procedures for the Mil-Series Expander Pak 1000. Successful operation and maintenance depends on a complete understanding of how the Expander Pak works, and how to effectively integrate the Pak into a given situation.

Throughout this manual you will find other Solar Stik™ accessories mentioned. These accessories enhance the versatility of the Solar Stik™ System by providing the operator with the ability to create power configurations that correspond to varying needs or applications. See our website www.solarstik.com for additional details on these and other accessories.

Warnings and Precautions

Explosion Hazard

WARNING: DO NOT USE this product in an environment where flammable fumes or gases may be present, such as near propane tanks or enclosed containers where fuel, fumes, or hazardous chemicals are stored. Exercise great care to avoid arcing caused by a direct short circuit across 24VDC terminals with a metal object.

Fire Hazard

WARNING: Never make direct contact across a battery terminal posts with a conductive object; A direct short will cause burns, sparks, and possibly fire and/or explosion. Always disable the Terminal Posts at the Master Breaker when not in use.

Explosion and Fire Hazard: Lead-acid Battery Operated Device

WARNING: Follow all instructions published by the battery manufacturer and manufacturer of the equipment in which the battery is installed. Make sure the area is well ventilated. Never smoke or allow sparks or flames near lead-acid batteries. Be careful not to drop a metal object onto the battery terminals or allow a metal tool to simultaneously touch the “positive” and the “negative” terminals of the battery. This could cause burns, sparks, fire, or explosion. Remove all personal items such as rings, bracelets, necklaces, and watches when working with lead-acid batteries. The battery produces a short circuit current high enough to weld a ring or other similar objects to metal, causing a severe burn.

If removing or rewiring a battery, be sure to remove the “positive” terminal first. Make sure that there is no load on the battery by turning off all accessories before disconnecting. This will prevent an arc. Always have someone within the range of the sound of your voice. Never work on a lead acid battery alone. Avoid direct contact with battery acid. Wear proper eye and skin protection. Be sure there is plenty of fresh water and soap nearby in case of clothing, skin, and eye contact with battery acid. If battery acid does directly contact clothing or skin, wash immediately with soap and water. If acid enters your eyes, flush immediately with running cold water for at least twenty minutes, and get medical attention immediately. Keep a supply of baking soda on hand in the area of the batteries. Baking soda will neutralize the lead-acid battery electrolyte.

Correct Polarity

WARNING: Always connect to DC Terminals using correct polarity. Failure to connect using correct polarity will trip the 100A Master Breaker

Discharging the Expander Pak

Do not discharge the Expander Pak to less than 19 volts. Damage to the batteries may occur. There is no “low-voltage disconnect” device installed to prevent a measured discharge.

CAUTION: Turn off the master breaker switch when not in use for long periods of time. It will drain the battery if left on without a source of charging current.

CAUTION: Never store a discharged battery. If the Expander Pak has discharged to less than 24 volts, battery charging should be performed within 48 hours.

Expander Pak Storage

Do not store a discharged battery. Fully charge the Expander pak before storage. Extended storage with the battery charge less than 19 VDC will cause damage. Turn off the Master Breaker for storage. If left on during storage, it may drain the battery.

Using the Expander Pak for the first time

CAUTION: Prior to operating the Expander Pak for the first time, be sure that it is fully charged. Recharge with connection to a Solar Stik™ System or with an external charging source (such as an AC battery charger) until battery reaches float voltage (Full-Green LED bars on SOC meter)

Precautions using Modified Sine Wave Inverter with rechargeable appliances

A Non-sinusoidal inverter produces a “modified sine wave”. Most rechargeable battery-operated equipment uses a separate charger or transformer that is plugged into an AC receptacle and produces a low voltage charging output. Some chargers for rechargeable batteries can be damaged if connected to a modified sine wave inverter. Take precautions when using any inverter and make sure that the recharging appliance is compatible with the inverter output. When rechargeable battery-operated devices such as radios or flashlights, it is recommended that direct DC connections be used.

Environmental & Handling Precautions

(See figures on next page)

All Solar Stik™ components are ruggedized, yet there are a few things the operator can do to prevent failures and prolong the operational life of the Expander Pak 1000.

This Expander Pak 1000 functions best in sheltered locations; however, it can be operated outdoors with minimal risk under certain conditions.

Water

- The Solar Stik™ Expander Pak 1000 and other Solar Stik™ components are designed for outdoor operation, even during periods of inclement weather.
- The lid must remain closed and latched, the case level and upright during operation in wet environments.
- If outdoor operation is necessary, all lids should be closed and only connections on the exterior of component cases should be used.

Impact

- All Solar Stik™ equipment is ruggedized for punishing conditions; however, equipment should not be dropped onto hard surfaces at a height greater than one foot when transporting or during operation.

Dust

- The Expander Pak 1000 is designed for operation in climates where high levels of dust or other particulates may exist.

Setup Precautions

- Do not operate Power Management Systems in or around standing water.
- Do not lay power distribution cords (extension cords) in standing water.

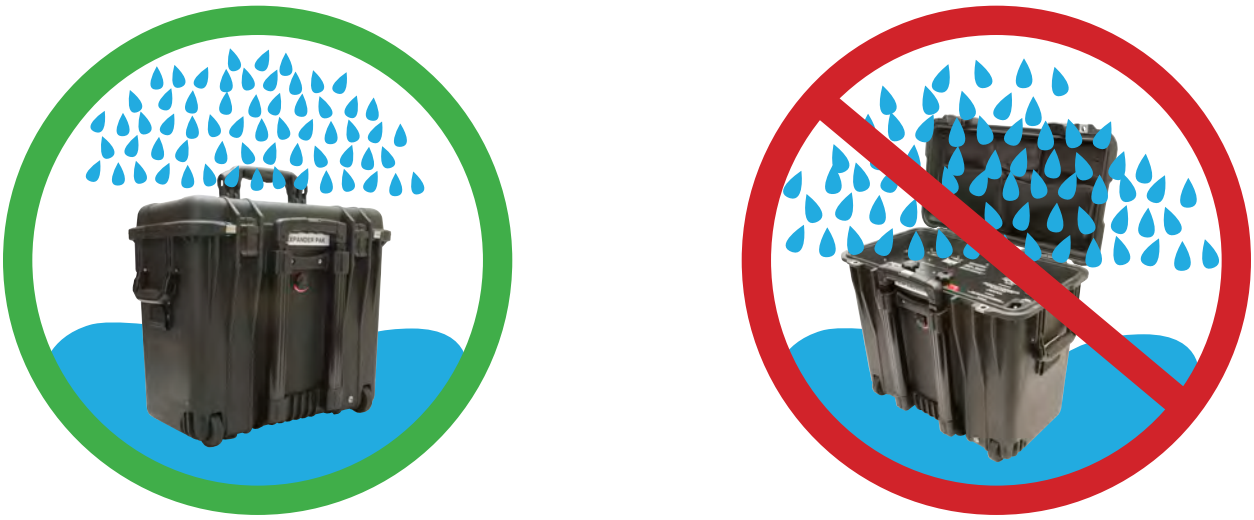

Figure 1 - Water

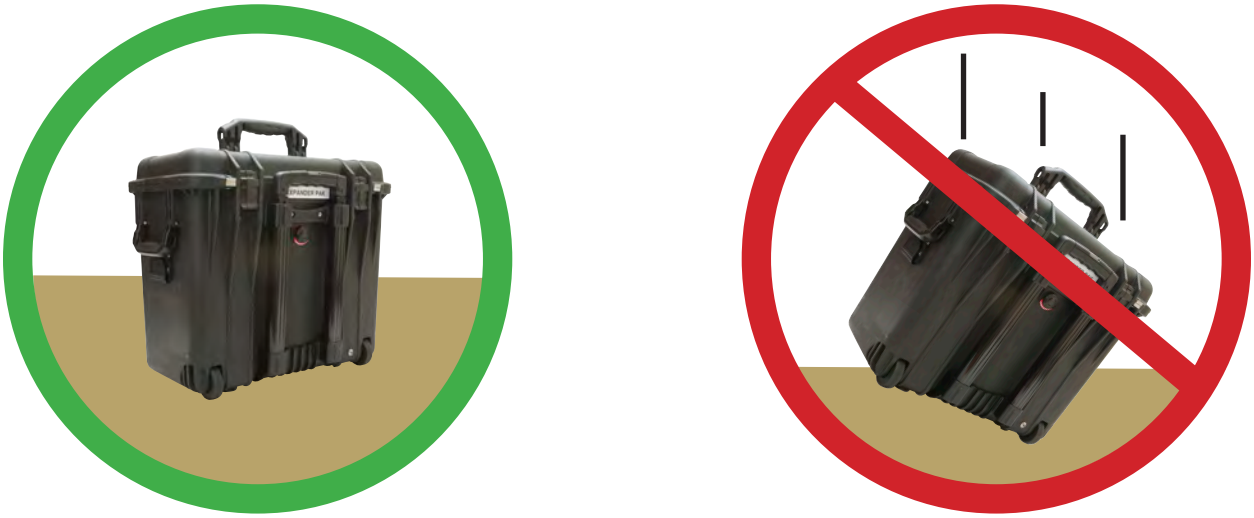

Figure 2 - Impact

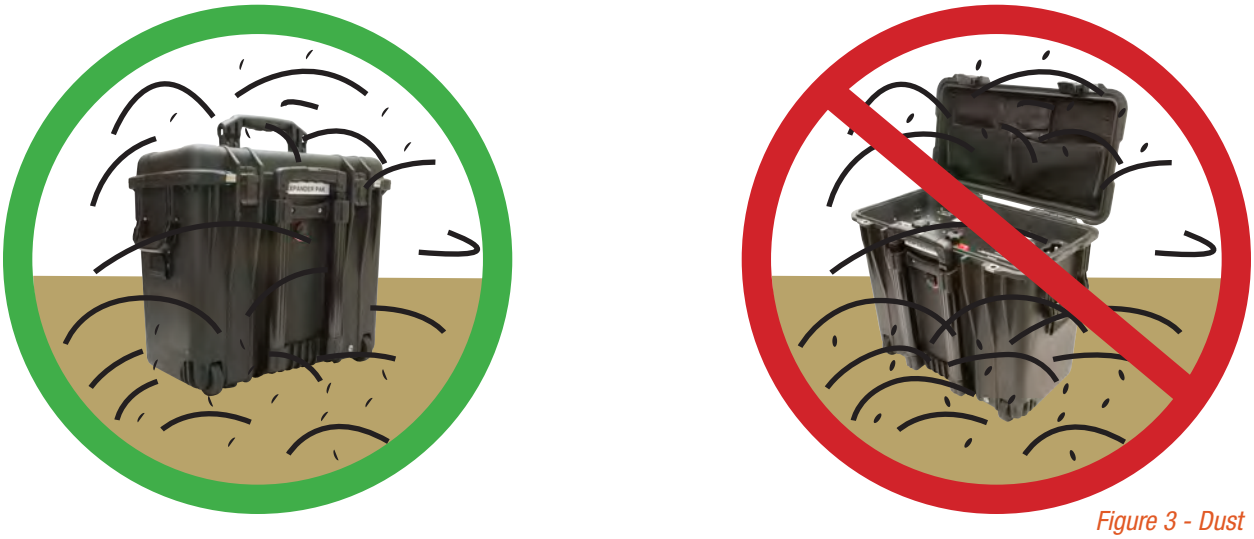

Figure 3 - Dust

Solar Stik™ Principles of Operation

Portable Power Generators, "Micro-Grids", and Efficiency

Portable Electrical Systems function along a spectrum of Efficiency, from very low to very high, depending on how they are configured.

A typical portable power electric system can be characterized as a "closed circuit" or "micro-grid". It is a small power system that often includes self-contained power generation, transmission, distribution, sensors, energy storage, and power management devices. It may be integrated with other power systems but operates independently from them when necessary or desired.

Equipment consuming electricity in a closed circuit often does so in a dynamic fashion. "Dynamic" means that power is consumed at varying rates, depending on the operator's needs or the specific appliance's mode of operation. For example, a two-way radio consumes MORE power when it is transmitting than when it is receiving.

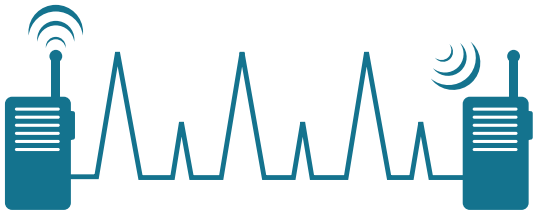

Figure 4 - Dynamic Load

Communication devices, medical equipment, lighting, and refrigerators are just a few examples of equipment that operate dynamically.

When a portable fuel-driven power generator (gas or diesel) is the primary source of power in a closed circuit, it must operate continuously to provide electricity to the appliances (loads), even if the requirements of connected loads are minimal or intermittent. This is a classic example of a "low efficiency" circuit (excess fuel energy is wasted in the production of power for consumption by an appliance).

Using a battery as the main source of power in a closed circuit results in "high efficiency", because power is transferred in and out of the batteries only as is necessary to keep the appliance loads operating. In a true micro-grid, multiple sources of power generation can be used simultaneously to support the battery and ensure uninterrupted power flow to the appliance loads. The battery becomes the HEART of the entire electrical circuit.

There are four categories of equipment represented in a true Micro-Grid Configuration:

Figure 5 - Categories of Equipment

In a properly balanced, "high-efficiency" micro-grid, ALL power generation devices should be focused on one role – supporting the battery!

Solar Stik™ Principles of Design

Portability

Every component in the Solar Stik™ System is designed to be man portable and set up using simple methods. All items are D.O.T. approved for land, sea, and air transport, and no trailers, cranes or forklifts are required.

Adaptability (Open Architecture)

The Solar Stik™ System incorporates modularity as a key feature. The ability to add Commercial Off The Shelf (COTS) components ranging from extension cords to appliances allows the operator to configure the system to a specific role or make changes when necessary.

Expandability

The System can be scaled up or down, in accordance with the power requirements. If additional Solar Power is desired, additional panels (such as solar shades, tents, or other rigid panel arrays) can be incorporated. If additional battery storage capacity is needed, additional Expander Paks can be plugged into the existing system.

Autonomy

The Solar Stik™ System will provide the operator with as much renewable solar power as is possible, considering the environmental conditions it is operating in, but with the safety-net of traditional power sources such as fuel-driven generators. Using a Solar Stik™ System prevents total reliance on any one power source and provides as much autonomous operation as is possible.

Quality Construction

All Solar Stik™ System Components are domestically produced the in U.S.A. They are designed and constructed to withstand harsh environments, hard impacts, and hard operation.

All Solar Stik™ equipment is designed for long life with minimal maintenance.

Expander Pak Applications

The Solar Stik™ System is a Battery-based system. The Solar Stik™ generates DC Power and stores it in Power Paks, which then delegate power to appliances only as they require it for operation.

The Paks can handle single or multiple loads simultaneously, and they provide “POWER ON DEMAND” to the connected appliance(s). They can be used in conjunction with additional external lead-acid battery banks, and can also be recharged independently of the Solar Stik™ System. The simplicity of the Pak allows the novice operator to use the system for simple tasks, and the versatility of the Pak provides the experienced operator with a multi-faceted solution for nearly any power need.

Figure 6 - Power Storage Icon

The Inter-Connection System

A key feature of the Solar Stik™ design is the “Inter-Connection System”. The System uses a unique set of polarized “Plug & Play” connections, called Inter-connector Plugs & Ports. These are used when connecting 24V DC components or batteries within the System’s architecture.

The Inter-connect Cable can be viewed as an “extension of the battery” through a DC circuit. In effect, it is a common “BUS”. It provides a convenient method to add or remove appliances, management devices, or even additional batteries in and out of a DC Network, or ”micro-grid”.

The Inter-connection System is protected from overloads and short circuits through a network of circuit breakers strategically placed throughout the circuit. It ensures that the potential for a “reverse polarity connection” within the circuit is minimized. Mitigating against simple mistakes in the field provides significant benefits.

If a problem occurs in a leg of the Inter-connection circuit, the affected leg will disconnect from the primary network, leaving the other circuits functioning. If a major failure occurs in the circuit, then the entire network will shut down.

Additionally, the Inter-connection System allows setup and configuration of the circuit to be performed by one person in just a few minutes.

Inter-connect cables are supplied with certain Solar Stik™ System components such as Expander Paks, Wind Stiks™, Power Hubs, PRO-Verters™, and PRO-Cells™.

The Inter-Connection System Serves Two Functions

1. Significant improvement of safety within the 24 Volt DC circuit.

2. Rapid assembly, modification, and scaling of the system architecture.

The Mil-Series Inter-Connector

- **100A Maximum Current**
- **24V DC connection only**
- **Plug mechanically “Locks” into place**
- **Rotate knob clockwise to lock, counter-clockwise to release**
- **Mechanical assembly - can be disassembled and modified in the field**

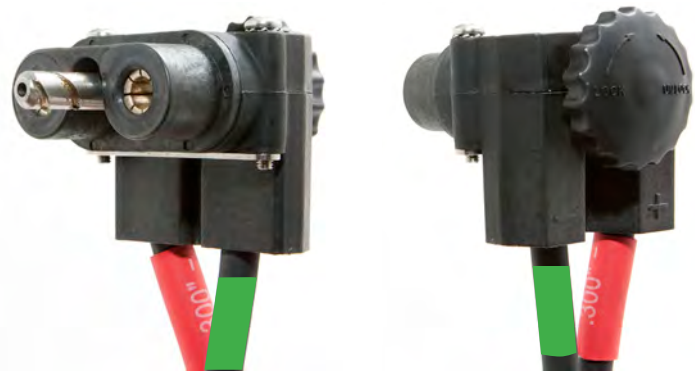

Figure 7 - Mil-Series Inter-connector Plug

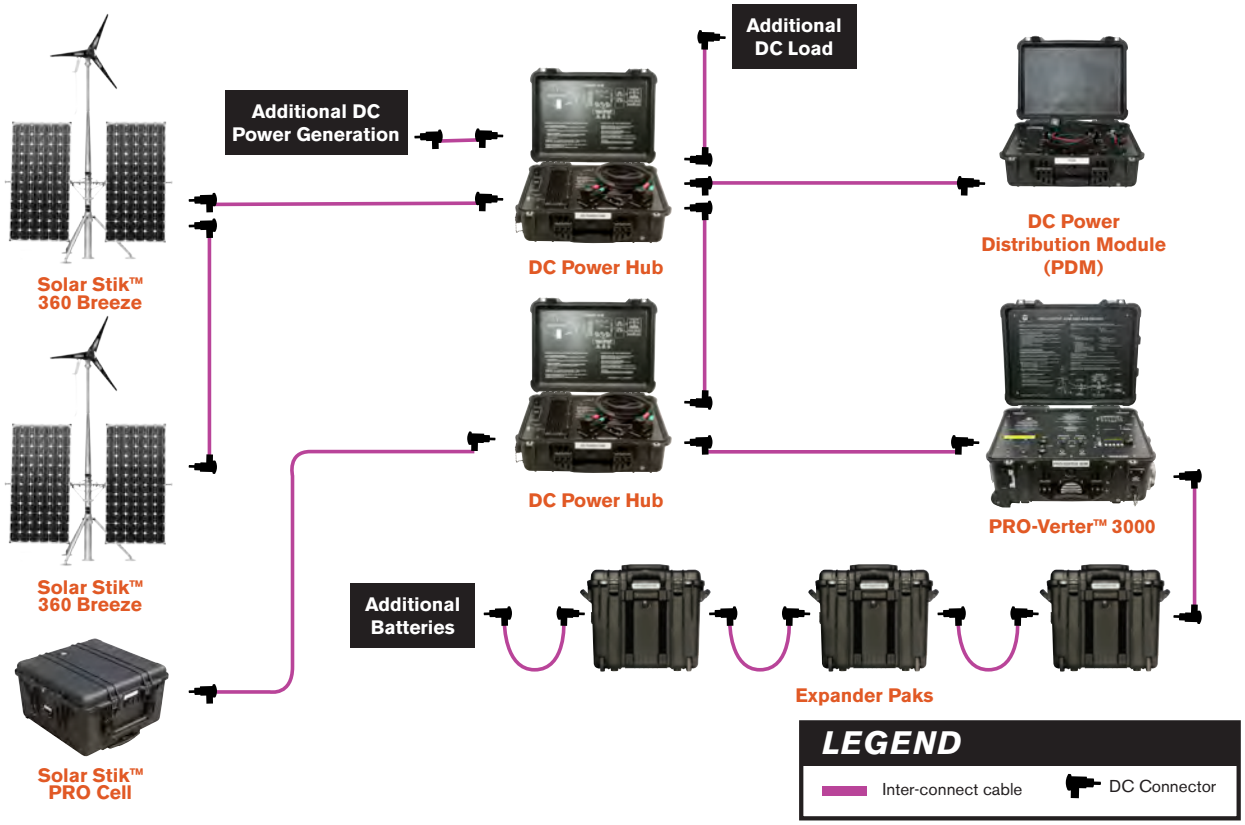

Figure 8 - Inter-connect System Example

Figure 9 - Plugging In Inter-connect Cable

MIL-Series Expander Pak 1000 Features

- Custom OEM PELICAN™ 1440 case
- 3’ DC Accessory Ring Terminal Cables
- 100 Amp Master Circuit Breaker Switch
- 24 Volt Post Terminals – internally mounted
- Solar Stik™ Exclusive Battery Cycle Count Display
- Multi-colored LED Battery State of Charge Display
- Twin 12 Volt 45Ah Valve Regulated Lead-Acid AGM batteries
- “24VDC” Inter-connector Ports – designated for connecting additional Expander Pak battery storage

Case Exterior - Views & Descriptions

Case Interior - Views & Descriptions

Expander Pak Function

The Mil Series 1000 Expander Pak provides additional power storage capacity to any Solar Stik™ System. It can also be used as an independent power supply when conditions warrant.

A Solar Stik™ System's battery reserve capacity can be increased by connecting Expander Paks together, to Power Paks, or to an otherwise suitably equipped Solar Stik™ Power Management System.

INFO: Proper sizing of the battery reserve capacity in a circuit provides the following benefits:
1. Reduced depth of discharge as power is taken in & out of the battery bank.
2. Additional operation time between recharges – Less "Cycling".

There is no limit to how many Expander Paks may be employed in a system.

The Expander Pak has a Battery "State of Charge" display that indicates the charge status of the battery when the "Display" button is pressed. An incorporated "Battery Cycle Count" display keeps an ongoing record of the discharge/recharge cycles experienced by the internal batteries.

A pair of three-foot ring terminal accessory cables is also included which can be used to connect accessories (such as an inverter), alternative charging sources, or additional batteries/Paks to the Expander Pak's Terminal Posts.

Figure 10 -Expander Paks connected using 5' Inter-connect cables

Power Reserve Capacity

The Expander Pak 1000 has a 45 Amp-hour (about 1 Kilowatt-hour) AGM battery bank. This large battery reserve capacity allows the Expander Pak to support longer operating times or heavier loads. Connecting additional Expander Paks, Power Paks, or other deep-cycle AGM batteries will increase battery capacity.

Storage and Transport Rule

Before storing or transporting an Expander Pak for any length of time greater than 48 hours, it is important to fully charge the Pak. If storing for an extended period, periodically check the Pak to make sure that it is maintaining its charge, or connect a battery charger/maintainer during storage.

WARNING: Extended storage with battery voltage less than 24.0 VDC will cause damage. DO not store a discharged battery. Turn off the Master / Breaker Switch. If the Master Breaker Switch is left on during storage, it will drain the battery.

Normal Operating Voltage

The Mil-Series Expander Pak 1000 operates at 24VDC power levels. Normal operating voltage ranges from 21.0 VDC to 29.0 VDC.

100 Amp “Master” Breaker / Switch

The 100 Amp Master Breaker Switch connects the internal 24VDC batteries to the Terminal Posts on the Expander Pak faceplate and the two “24VDC” Inter-connector Ports on each side of the Expander Pak.

The yellow LED on the faceplate illuminates when the Expander Pak’s Master Breaker Switch is activated (turned ON).

Figure 11 -100 Amp Master Breaker Switch

Although power can flow through the Expander Pak from one Inter-connector port to the other at any time, NO power can flow into or out of the Expander Pak’s internal batteries unless the Master / Breaker Switch is turned ON. As a result, the Master / Breaker Switch MUST BE ON in order for an individual Expander Pak’s batteries to be charged, or for power to be drawn out of the Pak’s batteries.

“Push-to-Display” Buttons

The Expander Pak comes equipped with exclusive “Battery Cycle Count” and “State of Charge” displays located on the faceplate. For the first few seconds after the Master/Breaker Switch is activated, the State of Charge and Battery Cycle Counter displays will rapidly flash as they perform an initialization test. After the displays go blank, initialization is complete. At any time following initialization, press the associated “Push-to-Display” pushbuttons to illuminate the associated State of Charge or Battery Cycle Count displays.

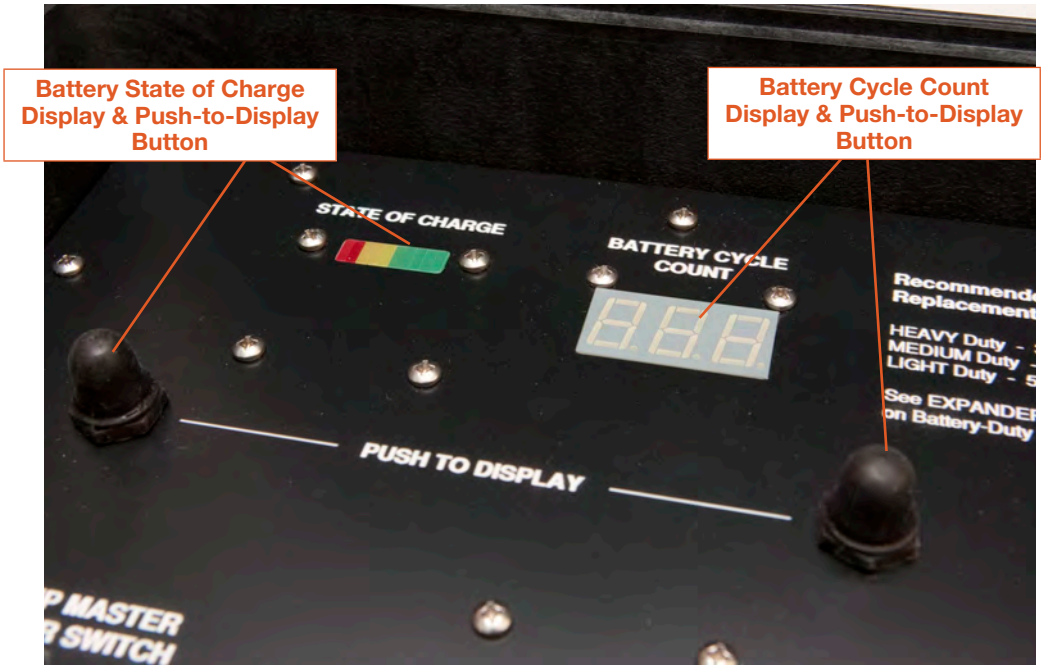

Figure 12 - Push-to-Display buttons

Battery Cycle Counter

Battery Cycle Count is one of the most critical factors influencing a battery system’s longevity. Battery replacement intervals are determined by the duty cycle, and are printed on the Expander Pak faceplate adjacent to the Cycle Counter.

Expander Pak batteries are date-stamped upon installation and rated by the manufacturer for: 500 Cycles minimum @ 80% Depth of Discharge (Average). The replacement cycle date should be based on the intended service of the battery.

Replacement cycles will be more frequent if repeatedly subjected to high discharge rates and depth of-discharge greater than 80% (in this case performance will degrade and replacement occurs between 400-500 Cycles). Replacement cycles will be less frequent if battery is repeatedly subjected to low discharge rates and depth-of-discharge less than 80% (batteries maintain rated performance for long duration - 600-700 Cycles).

The Expander Pak's built-in Battery Cycle Counter monitors the depth and duration of battery discharge / recharge cycles and keeps a record of the number of complete cycles the Expander Pak's batteries have experienced.

In the event batteries need replacement, the cycle count can be reset (Battery Replacement Procedures are included with the 1kW-h Battery Service Kit).

State of Charge (SOC) Display

The Expander Pak's enclosed 24-volt battery system State of Charge is indicated by a multi-colored, segmented LED display that illuminates red, yellow and green in accordance to battery voltage to provide an indication of low, moderate or highly charged batteries.

The most accurate state of charge readings are taken when the Expander Pak is standing alone and not connected to other Paks, appliances, or charging sources. If it is not convenient to disconnect an individual Expander Pak for state of charge measurement, then sources of power contribution (generators, chargers, etc.) and sources of power drain (e.g., lighting, appliances, etc.) should be turned off to the extent possible. Doing so will help improve the accuracy of the reading.

If the State of Charge display strobes and flashes when the push to display button is depressed, this is an indication that the internal batteries are heavily discharged. In this case, the Expander Pak should be fully recharged as soon as possible.

WARNING: Do not store a discharged battery as this will compromise its life.

SOC METER - LED DISPLAY			
Color	Battery Voltage		Display Behavior
	at least	less than	
Green	25.0	NA	Steady
Green	24.43	25.0	Steady
Green	23.86	24.43	Steady
Green	23.29	23.86	Steady
Green	22.71	23.29	Steady
Yellow	22.14	22.71	Steady
Yellow	21.57	22.14	Steady
Yellow	21.0	21.57	Steady
Red	20.43	21.0	Steady
Red	19.86	20.43	Flashing
Red	NA	19.86	Flashing Warning*

Table 1 - SOC Meter LED Display

* All LEDs will flash twice, then rapidly decrement down from all 10 illuminated to only 1 illuminated in Red, then repeat.

Alternative Methods of Recharging the Expander Pak

The Expander Pak was designed to operate in conjunction with the Solar Stik™ System; however, additional methods of recharging are possible.

All non-solar methods of recharging should be performed using only regulated 24VDC charging sources. Methods include “jumping” from a 24VDC vehicle system using traditional jumper-cables, NATO Omni-Cable, or AC to 24VDC battery charging device connected at the Terminal posts.

The Expander Pak may remain active while connections are made. Once the charging device is connected, make sure that the 100A Master Breaker Switch is turned “on” to recharge the Pak’s battery bank. You can see the status of the Pak’s battery by pressing the “Battery State of Charge” pushbutton on the Expander Pak faceplate. Once the Pak’s batteries are fully charged, the State of Charge display will indicate > 26 Volts DC, or full scale “green” depending on the output voltage of the charging device.

Explosion and Fire Hazard

WARNING: Only connect to the battery post terminals using correct polarity. Failure to do so may cause fire or explosion.

Recharging Voltage

WARNING: Do not connect an external charging source to the post terminals that exceeds 29.8 volts DC. This will damage the AGM battery bank and is not covered under any warranty.

Figure 13 -Recharging from a Vehicle’s 24V System

Service & Maintenance of the Expander Pak

There is a simple rule to remember about maintaining the Expander Pak AGM batteries:

Never store a discharged Expander Pak.

Other than keeping the battery fully charged during storage, an AGM, or Valve Regulated Lead Acid (VRLA), type of battery does not require any type of maintenance by the operator (such as checking fluid levels).

Please refer to page 39 for additional details about lead-acid batteries, their construction, and their operating characteristics.

For required maintenance review the specific manufacturer's literature for the respective components included in the Expander Pak.

It is advised that the User Interface (interior panel surface) be kept clean. Use a damp towel (no spray, or dripping wet cloths) to wipe the panel clean as necessary.

Environmental Impacts and the User Interface

If using the Expander Pak outdoors, try to keep the LED displays covered if using in direct sunlight.

The Mil-Series Expander Pak 1000 User Interface is NOT waterproof; however it can withstand exposure to moisture for short durations (dew, mist, light rain). The Expander Pak is designed to operate in dusty conditions, and it can handle high particle environments with ease. A Rain Guard accessory is available for environments where it may be exposed to excessive moisture.

Water Intrusion into the Pak - Draining the Pak

The Expander Pak is only weather resistant when the lid is closed. If the case is left open during periods of rain or snow, water will likely accumulate in the case. If this occurs, the water must be drained from the Pak BEFORE attempting to move it.

The electronics are mounted under the faceplate, and therefore, are at the highest internal location. If water has intruded, and splashes around inside the case during transport, damage to the sensitive electronics will occur.

To drain water from the case, locate the drain on the lower side of the front of the Pak. Remove the screw and water will evacuate the case. Once drained, the Pak will still need to be opened and dried out thoroughly. If no water has impacted the electronics, the unit can be returned to service. If water has impacted the electronics, do not return the unit to service and notify Tech Support at the first opportunity.

Figure 14 -Drain Plug Screw

Transporting the Expander Pak

All Expander Paks are U.S. D.O.T. approved for land, sea, and air transport. All Expander Paks have integrated handles and/or wheels that make transport easy.

Lifting the Expander Pak

The Mil-Series Expander Pak 1000 and Power Paks are designated as “Two-Man” Lifts. Do not attempt to lift the Expander Pak alone as injury may occur. Use the wheels and transport handles whenever possible.

Figure 15 - Two Man Lift Handles

Figure 16 - U.S. D.O.T. Approved

Figure 17 - Dolly Handle & Wheels on Expander Pak

U.S. D.O.T. Regulations for Transport of Expander Pak

CODE OF FEDERAL REGULATIONS

Title 49, Volume 2, Parts 100 to 185
Revised as of October 1, 1999

Cite: 49 CFR 173.159

Title 49: Transportation
PART 173—SHIPPERS—GENERAL REQUIREMENTS FOR SHIPMENTS AND PACKAGINGS
Subpart E—Non-bulk Packaging for Hazardous Materials Other Than Class 1 and Class 7

§ 173.159 Batteries, wet.

(a) Electric storage batteries, containing electrolyte acid or alkaline corrosive battery fluid (wet batteries), may not be packed with other materials except as provided in paragraphs (g) and (h) of this section and in §§173.220 and 173.222; and any battery or battery-powered device must be prepared and packaged for transport in a manner to prevent:

(1) A dangerous evolution of heat (i.e. , an amount of heat sufficient to be dangerous to packaging or personal safety to include charring of packaging, melting of packaging, scorching of packaging, or other evidence);

(2) Short circuits, including, but not limited to:

(i) Packaging each battery or each battery-powered device when practicable, in fully enclosed inner packagings made of non-conductive material;

(ii) Separating or packaging batteries and battery-powered devices in a manner to prevent contact with other batteries, devices or conductive materials (e.g. , metal) in the packagings; or

(iii) Ensuring exposed terminals are protected with non-conductive caps, non-conductive tape, or by other appropriate means; and

(3) Damage to terminals. If not impact resistant, the outer packaging must not be used as the sole means of protecting the battery terminals from damage or short circuiting. Batteries must be securely cushioned and packed to prevent shifting which could loosen terminal caps or reorient the terminals. Batteries contained in devices must be securely installed. Terminal protection methods include but are not limited to:

(i) Securely attaching covers of sufficient strength to protect the terminals;

(ii) Packaging the battery in a rigid plastic packaging; or

(iii) Constructing the battery with terminals that are recessed or otherwise protected so that the terminals will not be subjected to damage if the package is dropped.

(b) For transportation by aircraft:

(1) The packaging for wet batteries must incorporate an acid- or alkali-

proof liner, or include a supplementary packaging with sufficient strength and adequately sealed to prevent leakage of electrolyte fluid in the event of spillage; and

(2) Any battery-powered device, equipment or vehicle must be packaged for transport in a manner to prevent unintentional activation or must have an independent means of preventing unintentional activation (e.g. , packaging restricts access to activation switch, switch caps or locks, recessed switches, trigger locks, temperature sensitive circuit breakers, etc.).

(c) The following specification packagings are authorized for batteries packed without other materials provided all requirements of paragraph (a) of this section, and for transportation by aircraft, paragraph (b) of this section are met:

(1) Wooden box: 4C1, 4C2, 4D, or 4F.

(2) Fiberboard box: 4G.

(3) Plywood drum: 1D.

(4) Fiber drum: 1G.

(5) Plastic drum: 1H2.

(6) Plastic jerrican: 3H2.

(7) Plastic box: 4H2.

(d) The following non-specification packagings are authorized for batteries packed without other materials provided all requirements of paragraph (a) of this section, and for transportation by aircraft, paragraph (b) of this section are met:

(1) Electric storage batteries are firmly secured to skids or pallets capable of withstanding the shocks normally incident to transportation are authorized for transportation by rail, highway, or vessel. The height of the completed unit must not exceed 11/2times the width of the skid or pallet. The unit must be capable of withstanding, without damage, a superimposed weight equal to two times the weight of the unit or, if the weight of the unit exceeds 907 kg (2,000 pounds), a superimposed weight of 1814 kg (4,000 pounds). Battery terminals must not be relied upon to support any part of the superimposed weight and must not short out if a conductive material is placed in direct contact with them.

(2) Electric storage batteries weighing 225 kg (500 pounds) or more, consisting of carriers' equipment, may be shipped by rail when mounted on suitable skids. Such shipments may not be offered in interchange service.

(3) One to three batteries not over 11.3 kg (25 pounds) each, packed in strong outer boxes. The maximum authorized gross weight is 34 kg (75 pounds).

(4) Not more than four batteries not over 7 kg (15 pounds) each, packed in strong outer fiberboard or wooden boxes. The maximum authorized gross weight is 30 kg (65 pounds).

(5) Not more than five batteries not over 4.5 kg (10 pounds) each, packed in strong outer fiberboard or wooden boxes. The maximum authorized gross weight is 30 kg (65 pounds).

(6) Single batteries not exceeding 34 kg (75 pounds) each, packed in 5-sided

slip covers or in completely closed fiberboard boxes. Slip covers and boxes must be of solid or double-faced corrugated fiberboard of at least 91 kg (200 pounds) Mullen test strength. The slip cover or fiberboard box must fit snugly and provide inside top clearance of at least 1.3 cm (0.5 inch) above battery terminals and filler caps with reinforcement in place. Assembled for shipment, the bottom edges of the slipcover must come to within 2.5 cm (1 inch) of the bottom of the battery. The completed package (battery and box or slip cover) must be capable of withstanding a top-to-bottom compression test of at least 225 kg (500 pounds) without damage to battery terminal caps, cell covers or filler caps.

(7) Single batteries exceeding 34 kg (75 pounds) each may be packed in completely closed fiberboard boxes. Boxes must be of double-wall corrugated fiberboard of at least 181 kg (400 pounds) test, or solid fiberboard testing at least 181 kg (400 pounds); a box may have hand holes in its ends provided that the hand holes will not materially weaken the box. Sides and ends of the box must have cushioning between the battery and walls of the box; combined thickness of cushioning material and walls of the box must not be less than 1.3 cm (0.5 inch); and cushioning must be excelsior pads, corrugated fiberboard, or other suitable cushioning material. The bottom of the battery must be protected by a minimum of one excelsior pad or by a double-wall corrugated fiberboard pad. The top of the battery must be protected by a wood frame, corrugated trays or scored sheets of corrugated fiberboard having minimum test of 91 kg (200 pounds), or other equally effective cushioning material. Top protection must bear evenly on connectors and/or edges of the battery cover to facilitate stacking of batteries. No more than one battery may be placed in one box. The maximum authorized gross weight is 91 kg (200 pounds).

(e) When transported by highway or rail, electric storage batteries containing electrolyte or corrosive battery fluid are not subject to any other requirements of this subchapter, if all of the following are met:

(1) No other hazardous materials may be transported in the same vehicle;

(2) The batteries must be loaded or braced so as to prevent damage and short circuits in transit;

(3) Any other material loaded in the same vehicle must be blocked, braced, or otherwise secured to prevent contact with or damage to the batteries; and

(4) The transport vehicle may not carry material shipped by any person other than the shipper of the batteries.

(f) Batteries can be considered as non-spillable provided they are capable of withstanding the following two tests, without leakage of battery fluid from the battery:

(1) Vibration test . The battery must be rigidly clamped to the platform of a vibration machine, and a simple harmonic motion having an amplitude of 0.8 mm (0.03 inches) with a 1.6 mm (0.063 inches) maximum total excursion must be applied. The frequency must be varied at the rate of 1 Hz/min between the limits of 10 Hz to 55 Hz. The

entire range of frequencies and return must be traversed in 95 ± 5 minutes for each mounting position (direction of vibrator) of the battery. The battery must be tested in three mutually perpendicular positions (to include testing with fill openings and vents, if any, in an inverted position) for equal time periods.

(2) Pressure differential test . Following the vibration test, the battery must be stored for six hours at 24 °C ± 4 °C (75 °F ± 7 °F) while subjected to a pressure differential of at least 88 kPa (13 psig). The battery must be tested in three mutually perpendicular positions (to include testing with fill openings and vents, if any, in an inverted position) for at least six hours in each position.

(g) Electrolyte, acid or alkaline corrosive battery fluid, packed with batteries wet or dry, must be packed in one of the following specification packagings:

(1) In 4C1, 4C2, 4D, or 4F wooden boxes with inner receptacles of glass, not over 4.0 L (1 gallon) each with not over 8.0 L (2 gallons) total in each outside container. Inside containers must be well-cushioned and separated from batteries by a strong solid wooden partition. The completed package must conform to Packing Group III requirements.

(2) Electrolyte, acid, or alkaline corrosive battery fluid included with electric storage batteries and filling kits may be packed in strong rigid outer packagings when shipments are made by, for, or to the Departments of the Army, Navy, or Air Force of the United States. Packagings must conform to military specifications. The electrolyte, acid, or alkaline corrosive battery fluid must be packed in polyethylene bottles of not over 1.0 L (0.3 gallon) capacity each. Not more than 24 bottles, securely separated from electric storage batteries and kits, may be offered for transportation or transported in each package.

(3) In 4G fiberboard boxes with not more than 12 inside packagings of polyethylene or other material resistant to the lading, each not over 2.0 L (0.5 gallon) capacity each. Completed packages must conform to Packing Group III requirements. Inner packagings must be adequately separated from the storage battery. The maximum authorized gross weight is 29 kg (64 pounds). These packages are not authorized for transportation by aircraft.

(h) Dry batteries or battery charger devices may be packaged in 4G fiberboard boxes with inner receptacles containing battery fluid. Completed packagings must conform to Packing Group III requirements. Not more than 12 inner receptacles may be packed in one outer box. The maximum authorized gross weight is 34 kg (75 pounds).

(i) When approved by the Associate Administrator, electric storage batteries, containing electrolyte or corrosive battery fluid in a separate reservoir from which fluid is injected into the battery cells by a power device cartridge assembled with the battery, and which meet the criteria of paragraph (f) are not subject to any other requirements of this subchapter.

[74 FR 2257, Jan. 14, 2009]

Technical Specifications and Material Safety Data Sheets (MSDS)

See included MSDS sheets for detailed battery information.

Specifications

Storage	1.0 kW-h reserve capacity (45 amp-hour)
Normal Operating Voltage	21.0 to 29.0 volts DC
Batteries	(2) 12 volt Lead Acid AGM internal batteries (series circuit)
Post Terminals	24 volt post terminals (interior) with ergonomic twist knobs
Case	Custom Pelican™ 1440 case with lid organizer
Interconnect Ports	(2) Exterior 24VDC Inter-connector ports
Breakers	- 100 amp Master circuit breaker supports maximum load of 2400 watts - Full circuit protection with resettable breakers on User Interface
User Interface	- LED battery State-of-Charge (S.O.C.) meter - LED battery Cycle-Meter keeps track of the total cycles on the battery
Cycle Life	700 (80% Depth of Discharge)
Operating temperatures	-40 ºC to +65 ºC (-40 ºF to +149 ºF)
Weight	97 lb (44 kg)
Dimensions	19.70” x 12.00” x 18.00” (50 x 30.5 x 45.7 cm)
Cables	- 5’ (1.5 m) Mil-Series Inter-connect Cable - 3’ (1.5 m) 4AWG accessory cable (Red & Back/Green for 24VDC) with ring terminal ends
Warranty	3 year “materials and workmanship”

MATERIAL SAFETY DATA SHEET

LEAD ACID BATTERY

NORTHSTAR BATTERY COMPANY
Springfield, Missouri

I. PRODUCT IDENTIFICATION:

A. Chemical/Trade Name (per on label): Lead Acid Battery

B. Chemical Family/Classification: Electrical Storage Battery

C. Manufacturer's Name & Address:
NorthStar Battery Co. LLC
4000 Continental Way
Springfield, MO 65803

D. Contact:
U.S. - NSB Safety and Health Department
Phone: (417) 575-8219
Fax: (417) 575-8250

Aust. NorthStar Battery Pty Ltd
Phone: 02 9888 1998

E. Emergency Information:
Chemtrec (US, Canada & Mexico)
Phone: (800) 424-9300

Chemtrec (Outside US, Canada & Mexico)
Phone: +1 (703) 527-3887 (call collect)

F. Non-Hazardous Classification

Per US DOT, Northstar Battery Company products, submitted and tested by Wyle Labs, have been deemed to meet all requirements as specified in 49CFR§ 173.159 (d) for **exception** as hazardous material classification.

II. HAZARDOUS INGREDIENTS/IDENTITY INFORMATION:

NORTH AMERICAN INFORMATION:

			Air Exposure Limits (ug/m^3)		
Materials	**Approx % by Wt.***	**CAS Number**	**OSHA**	**AGGIH (TLV)**	**NIOSH**
Lead	50	7439-92-1	50	150	100
Lead Oxide	20	1309-60-0	50	150	100
Electrolyte (Sulfuric Acid) 1.400 sg	17	7664-93-9	1	1	1

*Please reference Appendix I (SES-544-16) for detailed product data.

AUSTRALIAN INFORMATION

Chemical or Material	**Australian Dangerous Goods Classification**	**Hazardous Substance Classification as per NOHSC Australia**	**Australian Poison Schedule Classification**
Non-Spillable Lead Acid Battery	Exempt under A67 (NATA Identification Guide) and Clause 238 of the Australian Dangerous Goods Code, Appendix 3	R34/R41	Schedule 6 Agricultural, Domestic and Industrial Substances

Note: Product contains toxic chemicals that are subject to the reporting requirements of Section 302 and 313 of the Emergency Planning and Community Right-to-Know Act of 1986.

MATERIAL SAFETY DATA SHEET *LEAD ACID BATTERY*	NORTHSTAR BATTERY COMPANY *Springfield, Missouri*

III. PHYSICAL DATA:

Material is solid at normal temperatures.

A. Electrolyte:

1.	Specific Gravity:	1.250 – 1.350 kg/dm^3
2.	Boiling Point:	110°C (230°F)
3.	% Volatiles By Weight:	Not Applicable
4.	Solubility in Water:	100%
5.	Melting Point Lead:	327°C (621°F)
6.	Vapor Density	Not Determined

B. Appearance and Odor

1. Electrolyte is a clear liquid with an acidic odor.

IV. HEALTH HAZARD INFORMATION:

Under normal operating conditions, because the battery is “non-spillable”, the internal material will not be hazardous to your health. Only internally exposed material during production or case breakage or extreme heat (fire) may be hazardous to your health.

A. Routes of Entry:

1. Inhalation: Acid mist from formation process may cause respiratory irritation.
2. Skin Contact: Acid may cause irritation, burns and/or ulceration.
3. Skin Absorption Not a significant route of entry.
4. Eye Contact: Acid may cause sever irritation, burns, cornea damage and/or blindness.
5. Ingestion: Acid may cause irritation of mouth, throat, esophagus and stomach.

B. Signs and Symptoms of Over Exposure:

1. Acute Effects: Over exposure to lead may lead to loss of appetite, constipation, sleeplessness and fatigue. Over exposure to acid may lead to skin irritation, corneal damage of the eyes and upper respiratory system.
2. Chronic Effects: Lead and its components may cause damage to kidneys and nervous system. Acid and its components may cause lung damage and pulmonary conditions.
3. Potential to Cause Cancer: The International Agency for Research on Cancer has classified "strong inorganic acid mist containing sulfuric acid" as a Category 1 carcinogen, a substance that is carcinogenic to humans. This classification does not apply to liquid forms of sulfuric acid or sulfuric acid solutions contained within a battery. Inorganic acid mist is not generated under normal use of this product. Misuse of the product, such as overcharging, may however result in the generation of sulfuric acid mist.

MATERIAL SAFETY DATA SHEET *LEAD ACID BATTERY*	NORTHSTAR BATTERY COMPANY *Springfield, Missouri*

C. Emergency and First Aid Procedures:

1. Inhalation: Remove from exposure, move to fresh air, and apply oxygen if breathing is difficult. Consult physician immediately.
2. Skin: Wash with plenty of soap and water for at least 15 minutes. Remove any contaminated clothing. Consult physician if skin irritation appears.
3. Eyes: Flush with plenty of water immediately for at least 15 minutes, lifting lower and upper eyelids occasionally. Consult a physician immediately.
4. Ingestion: Do not induce vomiting. Give large quantities of water. Never give anything by mouth to an unconscious person. Consult a physician immediately.

D. HANDLING AND STORAGE

1. Safe Storage: Store in a cool, dry place in closed containers. Keep away from ignition sources and high temperatures.
    1. Contact NorthStar Battery Company (417-575-8200) for shelf life information.
2. Handling: Avoid skin or eye contact. Avoid breathing vapors. Do not use near sources of ignition

V. CARCINOGENICITY: See section IV, Part B "Signs and Symptoms of Over Exposure"
MEDICAL CONDITIONS AGGRAVATED BY EXPOSURE: See section IV, Part B "Signs and Symptoms of Over Exposure"

VI. FIRE AND EXPLOSION HAZARD DATA:

A. Flash Point: Hydrogen = 259°C

B. Auto ignition Temperature: Hydrogen = 580°C

C. Extinguishing Media: Dry chemical, foam, CO_2

D. Unusual Fire and Explosion Hazards: Hydrogen and oxygen gases are produced in the cells during normal battery operation (hydrogen is flammable and oxygen supports combustion). These gases enter the air through the vent caps. To avoid the chance of a fire or explosion, keep sparks and other sources of ignition away from the battery.

E. Firefighting PPE: Full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece

VII. REACTIVITY DATA:

A. Stability: Stable

B. Conditions to Avoid: Sparks and other sources of ignition.

C. Incompatibility: (materials to avoid)

1. Lead/lead compounds: Potassium, carbides, sulfides, peroxides, phosphorus, sulfur.

Date: 08-24-06	DCR: 999-S06	ISO Clause: 4.3.1	DCN: MSD-430-01-07	Page: 3 of 6

MATERIAL SAFETY DATA SHEET *LEAD ACID BATTERY*	NORTHSTAR BATTERY COMPANY *Springfield, Missouri*

2. Battery electrolyte (acid): Combustible materials, strong reducing agents, most metals, carbides, organic materials, chlorates, nitrates, picrates, and fulminates.

D. Hazardous Decomposition Products:

1. Lead/lead compounds: Oxides of lead and sulfur.

2. Battery electrolyte (acid): Hydrogen, sulfur dioxide, and sulfur trioxide.

E. Conditions to Avoid:

High temperature. Battery electrolyte (acid) will react with water to produce heat. Can react with oxidizing or reducing agents.

VIII. CONTROL MEASURES:

A. Engineering Controls:

Store lead/acid batteries with adequate ventilation. Room ventilation is required for batteries utilized for standby power generation. Never recharge batteries in an unventilated, enclosed space.

B. Work Practices:

Do not remove vent covers. Follow shipping and handling instructions which are applicable to the battery type. To avoid damage to terminals and seals, do not double-stack industrial batteries.

C. Personal Protective Equipment:

1. Respiratory Protection: None required under normal handling conditions. During battery formation (high-rate charge condition), acid mist can be generated which may cause respiratory irritation. Also, if acid spillage occurs in a confined space, exposure may occur. If irritation occurs, wear a respirator suitable for protection against acid mist.

2. Eyes and Face: Chemical splash goggles are preferred. Also acceptable are "visor-gogs" or a chemical face shield worn over safety glasses.

3. Hands, Arms, Body: Vinyl coated, VC, gauntlet type gloves with rough finish are preferred.

4. Other Special Clothing and Equipment: Safety shoes are recommended when handling batteries. All footwear must meet requirements of ANSI Z41.1 -Rev. 1972.

IX. ACCIDENTAL RELEASE MEASURES:

A. Not applicable under normal conditions.

B. In case of damage resulting in breakage of the battery container, see VIII, Sec. C Personal Protective Equipment.

MATERIAL SAFETY DATA SHEET *LEAD ACID BATTERY*	NORTHSTAR BATTERY COMPANY *Springfield, Missouri*

X. PRECAUTIONS FOR SAFE HANDLING AND USE:

A. Hygiene Practices: Following contact with internal battery components, wash hands thoroughly before eating, drinking, or smoking.

B. Respiratory Protection: Wear safety glasses. Do not permit flames or sparks in the vicinity of battery(s). If battery electrolyte (acid) comes in contact with clothing, discard clothing.

C. Protective Measures:

1. Remove combustible materials and all sources of ignition. Cover spills with soda ash (sodium carbonate) or quicklime (calcium oxide). Mix well. Make certain mixture is neutral, then collect residue and place in a drum or other suitable container. Dispose of as hazardous waste.

2. Wear acid-resistant boots, chemical face shield, chemical splash goggles, and acid-resistant gloves. Do not release unneutralized acid.

D. Waste Disposal Method (*):

1. Battery electrolyte (acid): Neutralize as above for a spill, collect residue, and place in a drum or suitable container. Dispose of as hazardous waste.

2. Do not flush lead contaminated acid to sewer.

3. In case of accidental spill, utilize personal protective equipment, i.e., face shield, rubber apron, rubber safety shoes.

4. Batteries: Send to lead smelter for reclamation following applicable Federal, State and local regulations. Product can be recycled along with automotive (SLI) lead acid batteries.

5. Battery may be returned, shipping pre-paid, to the manufacturer or any distributor for recycling. See 1.C for manufacturer's address or visit our web site @ www.northstarbattery.com.

*In accordance to Local, State and Federal regulations and laws.

E. Other Handling and Storage Precautions: None Required.

XI. ECOLOGICAL INFORMATION:

Lead and its compounds can pose a threat if released to the environment.
See Waste Disposal Method in Section X, Part D.

MATERIAL SAFETY DATA SHEET *LEAD ACID BATTERY*	NORTHSTAR BATTERY COMPANY *Springfield, Missouri*

XII. NFPA HAZARD RATING: SULFURIC ACID:

Flammability (Red)	=	0
Health (Blue)	=	3
Reactivity (Yellow)	=	1

XIII. DEPARTMENT OF TRANSPORTATION AND INTERNATIONAL SHIPPING REGULATIONS:

Proper Shipping Name	UN2800 - Battery, wet, non-spillable (electric storage)
IATA	Batteries must be packed to protect against short circuits and firmly secured to skids or pallets. Packaging instruction 806 Not restricted per special provision A67.
US DOT	Northstar Battery Company products, submitted and tested by Wyle Labs, have been deemed to meet all requirements as specified in 49CFR§ 173.159 (d) for exception as hazardous material classification.
IMDG	Northstar Battery Company products, submitted and tested by Wyle Labs, have been deemed to meet all requirements as specified in special provision 238 for determination of “Non-Spillable” and are not subject to the provision of this Code.

XIV. SPECIAL REQUIREMENTS:

TLV

- Sulfuric Acid - Occupation Exposure Limit - AUSTRALIA TWA 1mg/m3,JAN1993
- Lead - Occupation Exposure Limit - AUSTRALIA TWA 0.15 mg/m3, 2002

Date: 08-24-06	DCR: 999-S06	ISO Clause: 4.3.1	DCN: MSD-430-01-07	Page: 6 of 6

Warranty & Service

Solar Stik™, Inc. warrants the complete Expander Pak against “workmanship and assembly” defects for a period of THREE (3) years. Each component manufacturer represented in assembly of the Expander Pak maintains their own warranty; However, the Solar Stik™ Expander Pak warranty Supersedes all warranties less than 3 years.

In order to simplify and expedite your repair, warranty service may be arranged through Solar Stik™, Inc. Simply notify us, and at our discretion, we will repair the Expander Pak at our facility, or send out a warranty technician to your location. Location of repair is made at the sole discretion of Solar Stik™ Inc.

Depending on the environment in which the Expander Pak is employed, normal wear and tear to a certain degree will occur. Solar Stik™, Inc. will not cover normal wear and tear of the product or costs related to the removal, installation, or troubleshooting of the customer’s electrical systems. There is no warranty against the following:

1. The Expander Pak if it has been misused, neglected, improperly installed, physically altered or damaged, either internally or externally, or damaged from improper use or use in an unsuitable environment.

2. The product if it has been subjected to fire, water, generalized corrosion, biological infestations, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the manufacturer’s individual product specification, including over-voltage input from generators and lightning strikes.

3. Modifications or repairs have been performed by any entity other than Solar Stik™, Inc.

If Solar Stik™ repairs or replaces a product, its warranty continues for the remaining portion of the original warranty period or 90 days from the date of the return shipment to the original purchaser, whichever is greater. All replaced products and parts removed from repaired products become the property of Solar Stik™.

In no event will Solar Stik™, Inc. be liable for any special, indirect, incidental, or consequential damages, losses, costs or expenses however arising whether in contract or tort including and without restriction any economic losses of any kind, any loss or damage to property, any personal injury, any damage or injury arising from or as a result of misuse or abuse, or the incorrect installation, integration, or operation of any PRO-Verter™.

Case Warranty

Pelican™ Warranty applies to repairs/replacement of the Pelican Case only – The Expander Pak is constructed into a Pelican™ Case. Most case replacement of broken parts or repairs can be performed in the field; however, if entire case requires replacement, labor costs may be incurred.

PELICAN™
You break it, we replace it... forever.™

APPENDIX # 1: Understanding the Expander Pak Lead-acid Battery

Introduction

A Battery is the “heart” of any DC-based electrical system. While the Solar Stik™ System is engineered to work with nearly any 24 Volt battery technologies, it is usually best operated with lead-acid batteries. Currently, all Solar Stik™ Expander Paks utilize lead-acid battery technology.

The battery for any Solar Stik™ System requires proper use and care, so it is important for the operator to fully understand lead-acid batteries. The following section is an easy-to-understand introduction to the most commonly-used battery technology...The Lead-acid Battery. Lead-acid is the oldest rechargeable battery technology in existence. Invented by the French physicist Gaston Planté in 1859, lead-acid was the first rechargeable battery to be used in commercial applications. 150 years later, we still have no real cost-effective alternatives for cars, boats, RVs, wheelchairs, scooters, golf carts and UPS systems. The lead-acid battery is still the most widely used power storage device today.

A lead-acid battery is an electrical storage device that uses a chemical reaction to store and release energy. It uses a combination of lead plates and an electrolyte to convert “electrical energy” into “potential chemical energy” and back again.

There are many newer battery technologies available in the market-place, however, lead-acid technologies are the most-understood, and widely accepted as the “standard” by which all other batteries are measured. Newer technologies often have operational constraints like maximum & minimum operating temperatures and special charging requirements that make them less versatile and usable for the average consumer in everyday applications.

The lead-acid batteries in the Expander Pak are DEEP CYCLE, AGM (Absorbed Glass Matt) type.

“Deep-cycle” Battery

The deep-cycle battery is designed for maximum energy storage capacity and high cycle count (long life). This is achieved by installing thick “lead plates” with limited surface area. Typical applications are boats, golf carts, wheelchairs, solar applications, RVs, and Uninterruptable Power Supplies (UPS).

Absorbed Glass Mat Batteries (AGM)

The AGM is a newer type sealed lead-acid that uses absorbed glass mats between the plates. It is sealed, maintenance-free and the plates are rigidly mounted to withstand extensive shock and vibration. AGM batteries feature a thin fiberglass felt that holds the electrolyte in place like a sponge. AGM batteries cost much more than the “flooded” version of the same capacity, and are usually found in applications where high performance is demanded.

Lead-acid Battery Plates

The secret of any battery’s “runtime” lies in the battery plate’s “capacity”. The service life of a lead-acid battery can, in part, be measured by the thickness of the positive plates. The thicker the plates, the longer the life will be and the more energy storage one can expect. During charging and discharging, the lead on the plates gets gradually eaten away and the sediment falls to the bottom. The weight of a battery is a good indication of the lead content and the life expectancy.

As a rule of thumb, the heavier the battery, the more lead it contains and the longer it will last. Battery capacity and deep-cycling are less important for automotive uses because the battery is being recharged while driving. If continuously cycled, the thin lead plates of the starter battery would wear down rather quickly.

How The Chemical Reaction in a Battery Works

When the positive and negative lead plates are submersed in the electrolyte, a chemical reaction occurs. This reaction produces electrons that flow between the lead plates. The amount of “push” or “force” of the electrons moving between the plates is known as the “Voltage”.

The process can be summarized as a “hand-off” of sulfate in the battery cell between the electrolyte and the lead plates during charging and discharging. As the battery is discharged, sulfate in the electrolyte combines with the lead plates of the battery to form lead sulfate. As the plates accumulate the sulfate, the electrolyte becomes more like water and less like sulfuric acid.

The reverse occurs as the battery is charged. As charging current flows through the battery, the battery plates revert back to their original condition and the electrolyte reverts back to its original sulfuric acid content.

The AGM lead-acid battery remains under constant pressure of 1-4 psi. (This pressure helps the recombination process during charging under which 99+% of the Hydrogen and Oxygen generated during charging are turned back into water.) Nearly all AGM batteries are recombinant, meaning they can recombine 99% of the oxygen and hydrogen, and there is almost zero water loss. The charging Voltages are the same as for other lead-acid batteries. Even under severe overcharge conditions, hydrogen emission is below the 4% specified for aircraft and enclosed spaces. The low self-discharge of 1-3% per month allows long storage before recharging.

Battery Voltage

The “Voltage” of a battery is a direct indication of its state of charge. It indicates the amount of electro-motive force (or the amount of “push”) that moves electrons from the positive field to the negative field.

Voltage is a function of the specific gravity of the electrolyte at the place in the battery where the chemical reaction occurs. This chemical reaction takes place inside the pores of the active material on the lead plates.

If the battery has just been charged, the electrolyte in the pores of the battery’s lead plates is very rich in sulfuric acid, and as a result, the battery’s Voltage will be high, perhaps 27 to 28 Volts. As the battery rests following charge, Voltage slowly drops and stabilizes as the electrolyte stabilizes its mixture between the plates.

A similar change in battery Voltage occurs during discharge. While a fully charged battery may read 26.8 Volts, the Voltage will drop and then stabilize at a somewhat lower value as a load is applied to the battery. The change in Voltage occurs even though the state of charge of the battery has not significantly changed. This is due to the local electrolyte in the pores of the plates becoming less rich in sulfuric acid as the battery supplies current. As the battery discharges, electrolyte more like sulfuric acid enters the pores while electrolyte more like water exits the pores. As discharge continues, the electrolyte in the pores eventually stabilizes at a specific gravity somewhat lower than the average value in the battery, producing the slightly lower battery Voltage.

Battery Capacity

Capacity is the amount of energy a battery can store. The definition of Capacity is usually given in Amp-hours (Ah), and it specifies the amount of current (amps) it can provide over a period of one hour, rendering the battery “discharged”.

Sulfation (also spelled “Sulphation”)

Sulfation is a constant threat to batteries that are not fully charged. A layer of lead sulfate can form in lead-acid cells and inhibit the electro-chemical reaction that allows you to charge/discharge batteries. Sulfation of lead-acid batteries starts when the battery Voltage measures less than 24.4 (in a 24 Volt battery). Sulfation is a salt-like substance that forms on the battery plate surface, and it can harden on the battery plates if left long enough, reducing and eventually blocking chemical reaction between the lead plate and the electrolyte. It disables the ability of the battery to generate its rated Voltage and Amperage. Sulfation is the main reason lead-acid batteries don’t reach their intended life span. The best practice is preventing sulfate formation by proper battery care, immediately recharging after a discharge cycle, and NOT STORING A DISCHARGED EXPANDER PAK.

Gassing

Batteries start to gas when you attempt to charge them faster than they can absorb the energy. The excess energy is turned into heat, which causes the electrolyte to boil and evaporate.

Since AGM batteries are always sealed, it is very important to guarantee they are not overcharged. The only way to ensure this is to use a temperature-compensated charging system. If a charger has temperature compensation, it will detect and adjust battery charging rates accordingly.

Life Expectancy

Battery manufacturers define the “end-of-life” of a battery when it can no longer hold a proper charge (for example, a cell has shorted out) or when the available battery capacity is 70% or less than what the battery was rated for. The life of Lead-acid batteries is usually limited by:

Cycle Life

This is a measure of how many charge and discharge cycles a battery can take before its lead-plate grids/plates are expected to collapse and short out. The greater the average depth-of-discharge, the shorter the cycle life. The AGM Lead Acid batteries used in the current Expander Pak products are designed to have a minimum 500 cycle life.

Age

Age affects batteries as the chemistry inside them attacks the lead plates. The healthier the “living conditions” of the batteries, the longer they will serve you. Lead-acid batteries like to be kept at a full charge in a cool place. The longer the battery sits in a hot environment with no recharging, the less life it will have. Since lead-acid batteries will not freeze if fully charged, you can store them in the cold during winter to maximize their life.

Recommended Accessories

Mil-Series Omni Cable Pak
Item # 240014

Mil-Series Power Hub
Solar Stik™ Item # 240037

Mil-Series PRO-Verter™ 2300
Item # 240017

NATO Slave Omni Cable
Item # 240046

Please Consult the Solar Stik™ Website for additional education on 12 or 24 volt DC and 120 volt AC systems. Available for download are:

- Watts, Volts, & Amps… Basic Electricity
- Solar School
- Battery School
- Inverter School

…and more!

TECHNICAL SUPPORT LINE:
800-793-4364 Ext. 102
(24 hours a day, 365 days a year)

ADDRESS:
Solar Stik™ Inc. R&D Facility
226 1/2 West King Street
Saint Augustine, Florida 32084

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