U.S. Department
of Transportation

**Pipeline and Hazardous
Materials Safety
Administration**

1200 New Jersey Avenue SE
Washington, DC 20590

SEP 15 2015

Mr. Ryan Lenaric
Quality Manager
Oxus America
2676 Paldan Drive
Auburn Hills, MI 48326

Ref. No. 15-0111

Dear Mr. Lenaric:

This responds to your June 8, 2015 email requesting clarification of the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) applicable to a portable oxygen concentrator (POC). Specifically, you inquire about obtaining approval from the Federal Aviation Administration (FAA) to allow a passenger to carry and operate the Model Number RS-00500 POC onboard an aircraft.

According to your letter, the POC noted above is for oxygen delivery to patients who require ambulatory supplemental oxygen therapy and is comprised of the same technology as your previously approved Model Number RS-00400 POC. The maximum operating pressure of the Model Number RS-00500 POC is 20.5 pounds per square inch (psig). The POC is capable of operation from AC or external DC power sources as well as a lithium ion battery pack. The battery pack has a Watt-hour (Wh) rating of 97 (2.2 ampere-hour (Ah) x 3.6 volts (V) x 12 cells). The lithium ion battery pack meets the appropriate testing requirements of the UN Manual of Tests and Criteria, and the battery pack is packaged in a manner to prevent short circuits when offered for transport or carried onboard an aircraft. You ask whether the Model Number RS-00500 POC is authorized under the HMR to be carried onboard an aircraft

Based on the information provided, the Oxus America Model Number RS-00500 POC is not subject to the HMR as a Division 2.2 non-flammable gas. Furthermore, the lithium ion battery pack conforms to § 175.10(a)(18), excluding lithium ion batteries with a Wh rating between 100 and 160 Wh that require operator approval; and the Oxus America Model Number RS-00500 POC contains no other hazardous materials. Therefore, the Oxus America Model Number RS-00500 POC is allowed to be transported by passengers in accordance with the HMR.

Please note that notwithstanding the passenger exception in § 175.10(a)(18) of the HMR, the provisions of Special Federal Aviation Regulation (SFAR) 106 apply and are under the purview of the FAA. This response satisfies only one requirement in the FAA approval process before a POC may be operated onboard an aircraft. You may contact Ms. DK Deaderick in FAA's Flight Standards Service at (202) 267-7480 for questions regarding FAA's approval process.

I trust this satisfies your inquiry. Please contact us if we can be of further assistance.

Sincerely,

Dirk Der Kinderen
Acting Chief, Standards Development Branch
Standards and Rulemaking Division

Boothe
175.10(a)(18)
Exceptions
15-0111

Goodall, Shante CTR (PHMSA)

From: Geller, Shelby CTR (PHMSA)
Sent: Monday, June 08, 2015 4:44 PM
To: Hazmat Interps
Subject: FW: Interpretation Request Letter (HMR; 49 CFR Parts 171-180)
Attachments: PHMSA Letter Request 060815.pdf; DM-01005317_ATTACHMENT.pdf

Hi Shante and Alice,

Forwarded is a request for a formal letter of interpretation.

Thanks,
Shelby

From: Ryan Lenarcic [mailto:rlenarcic@oxusamerica.com]
Sent: Monday, June 08, 2015 10:21 AM
To: PHMSA HM InfoCenter
Cc: Gary Abusamra
Subject: Interpretation Request Letter (HMR; 49 CFR Parts 171-180)

Dear PHMSA Office of Hazardous Materials and Standards:

Please find attached our interpretation request letter and supplemental documentation regarding the applicability of the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) specifically pertaining to Oxus Model Number RS-00500 POC and its battery pack. We look forward to your response, thank you.

Ryan Lenarcic

Oxus

Quality Manager
Oxus, Inc

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JUNE 8, 2015

PHMSA Office of Hazardous Materials Standards
Attn: PHH-10
East Building
1200 New Jersey Avenue, SE.
Washington, DC 20590-0001

Dear PHMSA Office of Hazardous Materials and Standards:

Oxus is preparing to enter the market with a new version of our Portable Oxygen Concentrator (POC) and is requesting an amendment to § 175.10(a)(18) of the HMR, Special Federal Aviation Regulation 106, *"Rules for Use of Portable Oxygen Concentrator Systems on Board Aircraft"* (SFAR 106). This amendment would include the Oxus Model Number RS-00500 POC in the list of approved POC's for use on board aircraft.

SFAR 106 permits passengers to carry on and use certain POC's on board aircraft if the aircraft operator ensures that the conditions specified in the SFAR for their use are met. Section 2 of SFAR 106 requires that PHMSA determine that the POC does not contain hazardous materials and that the requestor includes this determination in the SFAR application.

This letter is a request for interpretation and response by PHMSA regarding the applicability of the Hazardous Materials Regulations (HMR; 49 CFR Parts 171-180) specifically pertaining to Oxus Model Number RS-00500 POC and its battery pack.

Background:

Oxus is a technology company that designs and manufactures oxygen concentrator products for several markets. The Oxus Portable Oxygen Concentrator gives patients independence to live their life without worrying about bottle delivery, filling bottles at home, or running out of oxygen.

Device Description:

The Oxus Model Number RS-00500 POC is for oxygen delivery to patients that require ambulatory supplemental oxygen therapy and utilizes molecular sieve / Pressure Swing Absorption (PSA) technology. The POC is designed to be used in many environments including but not limited to the patient's home, car, train, and aircraft. The Oxus Model Number RS-00500 POC is self-sufficient, capable of operation from AC or external DC power sources as well as a replaceable battery. This model is comprised of the same technology as our previously approved Model Number RS-00400 POC.

Users:

The device is intended to deliver concentrated oxygen, on a prescription basis, for adult patients with chronic pulmonary diseases such as chronic bronchitis, emphysema, asthma, or lung cancer, those in the terminal stage of cancer, or any patient requiring supplemental oxygen.

Battery:

The battery consists of (12) Lithium Ion rechargeable cells of 18650 size, assembled in a 4 series / 3 parallel (4S 3P) configuration. Each cell has an average voltage of 3.6V and a typical capacity of 2.2Ah giving a battery pack of 14.4V and 6.6Ah typical.

The Lithium Ion Battery specifications for this unit are attached for your review; however a brief synopsis is as follows:

Chemistry	Lithium Ion 14.4 VDC (nominal)
Battery Options	Single Battery Double Battery (equals two single batteries)
Dimensions	6.59" x 4.23" x .84" (single battery) [16.7 cm x 10.7 cm x 2.1 cm] 6.59" x 4.23" x 1.68" (double battery) [16.7 cm x 10.7 cm x 4.2 cm]
Weight	1.426lbs. (0.647Kg).
Watt-Hour Rating per Single Battery	97 Wh
Battery Duration	4 Hours (Pulse setting of 18 bpm with single battery) 8 Hours (Pulse setting of 18 bpm with double battery)
Charge Time	Minimum of 3 Hours for single battery and 6 hours for double battery

The battery complies with the following:

- EMC Directive 2006/95/EC
- Low Voltage Directive 2004/108/EC
- Battery Recycling Directive 2006/66/EC as amended
- "RoHS" Directive 2002/95/EC

Device Standards Compliance:

The Oxus America Model Number RS-00500 POC is designed to conform to the following standards:

- IEC/EN 60601-1:2012, Medical Electrical Equipment – Part 1: General requirements for basic safety and essential performance
- IEC/EN 60601-1-2:2007, Part 1-2: General Requirements for Safety – Collateral Standard: Electromagnetic Compatibility – Requirements and Tests.
- IEC/EN 60601-1-6:2010+A1:2013 Medical electrical equipment – Part 1-6: General requirements for basic safety and essential performance – Collateral standard: Usability
- IEC/60601-1-8:2006 Medical electrical equipment – Part 1-8: General requirements for safety – Collateral standard: General requirements, tests and guidance for alarm systems in medical electrical equipment and medical electrical systems
- IEC/60601-1-11:2011 Medical Electrical Equipment - Part 1-11: General requirements for safety - collateral standard: Requirements for medical electrical equipment and medical electrical systems used in the home healthcare environment.
- CAN/CSA C22.2 No. 60601-1:14, Canadian Standard, Medical Electrical Equipment - Part 1: General requirements for basic safety and essential performance
- Medical Device Directive 93/42/EEC

Device Classification:

- IEC Class II Internally Powered Equipment
- Class IIa according to the MDD 93/42/EEC
- Type BF Applied Part
- IP22 with the carry bag Drip Proof Equipment
- Continuous Operation

Synopsis and Submission:

Specifically, the following characteristics relate to the Oxus America Model Number RS-00500 POC and its battery pack:

1. The maximum operating pressure is 20.5 psig. This maximum operating pressure limit is a shutdown condition controlled by a pressure sensor within the device

2. Each single lithium ion battery pack satisfies the requirements of § 173.185(c)(1)(i) which states that the Watt-Hour rating may not exceed 100 Wh for a lithium ion battery and be marked with the Watt-hour rating on the outside case.

3. The battery has been tested in accordance with the UN Manual of tests and Criteria part III subsection 38.3 (ST/SG/AC.10/11/Rev.3) - more commonly known as the UN T1-T8 Transportation tests; and has been found to comply with the stated criteria. [USDOT-E7052]

4. The lithium ion battery pack satisfies the requirements of § 173.21(c) which states that an electrical device is forbidden for transportation unless it is packaged in a manner to preclude it from creating sparks or generating a dangerous quantity of heat (for example, by the effective insulation of exposed terminals). The Oxus America battery pack has no exposed terminals which could be the

source of a short circuit. The safety profile of the battery pack includes safety circuit to protect against over current, over voltage, and over temperature conditions. In addition, there are also single fault tolerances for both over current and over temperature safety protection provided by a current limiting fuse and over temperature thermal fuse. All safety systems when activated shut down operation of the battery assembly.

Based upon the information provided above, we respectfully submit that the Oxus America Model Number RS-00500 POC is not currently subject to the HMR because it meets the following criteria:

1. The pressure of the oxygen in the device does not exceed 40.6 psia at 20°c;
2. The lithium ion battery used to operate the device is exempted from the HMR;
3. The battery pack is packaged in a manner to preclude it from creating sparks or generating a dangerous quantity of heat (for example, by the effective insulation of exposed terminals); and
4. The Oxus America Model Number RS-00500 POC contains no other materials subject to the HMR.

Thank you in advance for your time and consideration pertaining to this request. Please advise with any comments, questions, or concerns you may have by phone at 248-475-0925, by email at rlenarcic@oxusamerica.com, or by fax at 248-475-0938.

Sincerely,

Ryan Lenarcic
Quality Manager
OXUS AMERICA

INSPIRED ENERGY®
SOLUTIONS FOR PORTABLE POWER

Battery Specification

Document Number & Revision

DS274ED22

Description

Rechargeable Smart Lithium Ion Battery Pack

Inspired Energy Part Number For Battery

NL2024ED22

Statement Of Confidentiality

The information contained within this document is confidential and proprietary to Inspired Energy. This information should not, in whole or in part, be reproduced, disclosed or used except as expressly and duly authorized by Inspired Energy.

TABLE OF CONTENTS

1. REVISION HISTORY

Revision	Release Date	Revisions	Issued By	Approved By
0.1	10/30/08	Discussion.	RAH	DB, LJ
0.2	11/3/08	Clarical..	RAH	DB, LJ
1.0	2/19/09	Release.	RAH	DB, LJ

2. INTRODUCTION

2.1. Scope

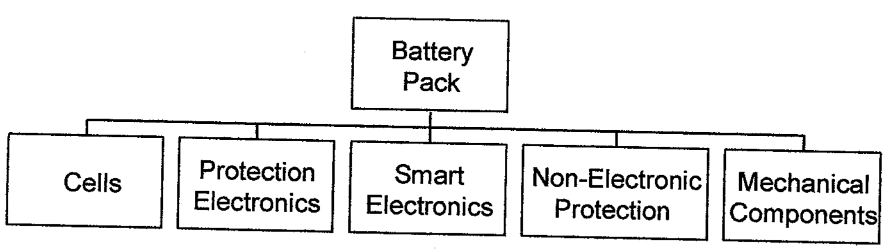
This specification describes the physical, functional and electrical characteristics of a rechargeable Lithium Ion battery pack supplied by Inspired Energy. This specification is the interface document between Inspired Energy and it's customers. It is understood that the customer may create their own internal specification. However, this specification is the master that defines the battery's operation. Battery packs produced will meet this specification.

2.2. Battery Pack Overview

This specification describes the physical, functional and electrical requirements for the NL2024ED Smart Battery including a rechargeable Lithium Ion battery and a Battery Management Module. The battery consists of (12) Lithium Ion rechargeable cells of 18650 size, assembled in a 4 series / 3 parallel (4S 3P) configuration. Each cell has an average voltage of 3.6V and a typical capacity of 2.2Ah giving a battery pack of 14.4V and 6.6Ah typical.

The battery is capable of communicating with host or the charger through the System Management Bus (SMBus). The battery is fully SMBus and SBDS Revision 1.1compliant. Protection is provided for over-charge, over-discharge and short circuit. For redundancy, passive safety devices have been integrated into the pack to protect against over-current and over-temperature, and secondary over-voltage has been implemented with a logic-fuse and controller.

The battery pack comprises the individual elements as shown below.



2.3. General Precautions

2.3.1. Handling

- Avoid shorting the battery
- Do not immerse in water.
- Do not disassemble or deform the battery
- Do not expose to, or dispose of the battery in fire.
- Avoid excessive physical shock or vibration.
- Keep out of the reach of children.
- Never use a battery that appears to have suffered abuse.

2.3.2. Charge & Discharge

- Battery must be charged in appropriate charger only.
- Never use a modified or damaged charger.
- Specified product use only.

2.3.3. Storage

- Store in a cool, dry and well-ventilated area.

2.3.4. Disposal

- Regulations vary for different countries. Dispose of in accordance with local regulations.

3. REQUIREMENTS

3.1. General Requirements

3.1.1. Nominal Voltage

The battery nominal operating voltage is 14.4V.

3.1.2. Rated Capacity

The initial capacity is ≥ 6270mAh (based on a CV charge of 16.8V ± 50mV with a current limit of 4A and a 1320mA discharge to 11.00V @ 25C, within 1 hour of charge).

3.1.3. Initial Impedance

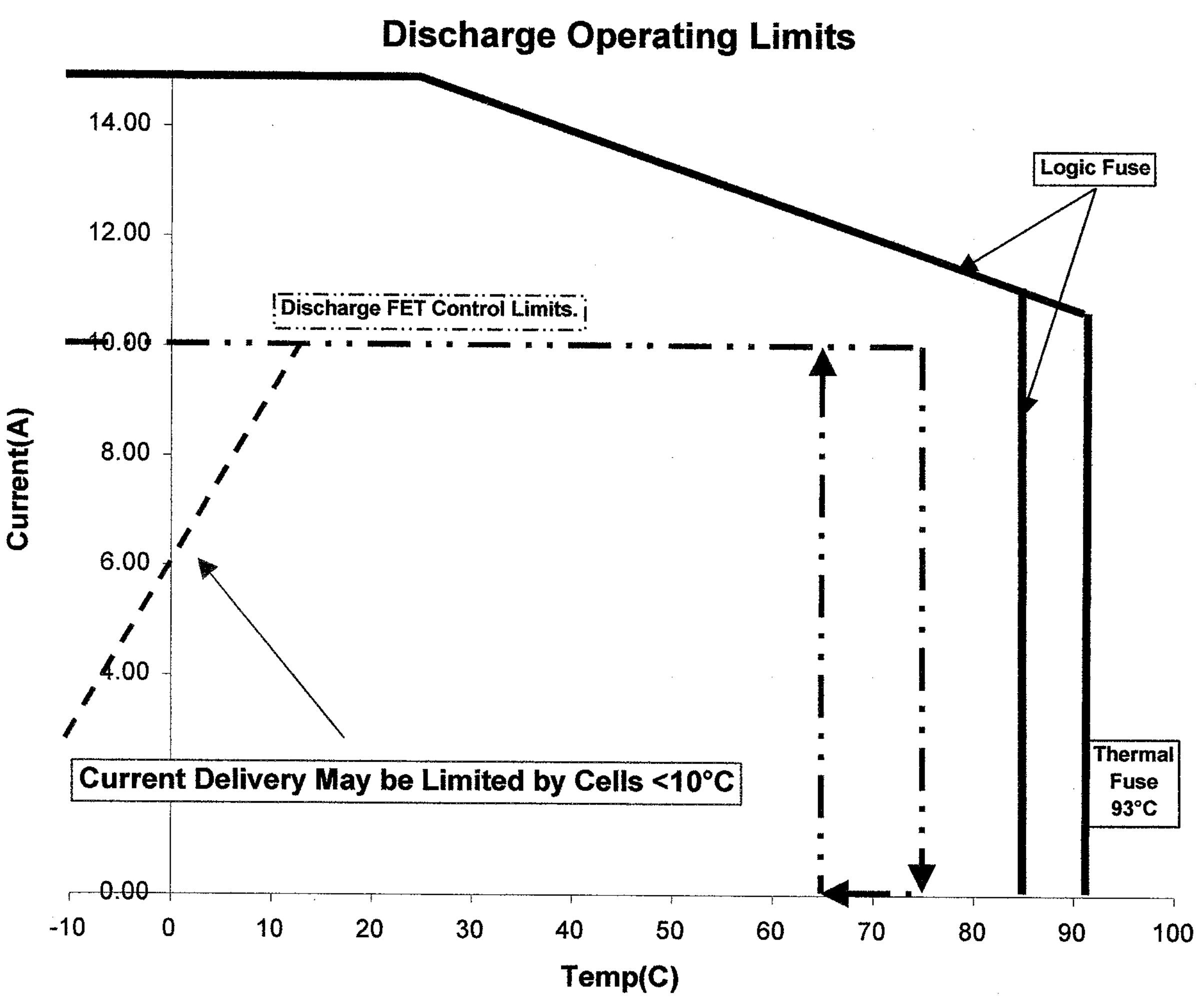
The internal impedance of a fully charged battery shall be < 165mΩ when measured across the positive and negative battery terminals at 1kHz at 20°C.

3.1.4. Discharge

Discharge Temperature Limits: As shown below, ≤ 80%RH

The battery shall be capable of continuous discharge within the Operating Boundary as shown in the graph below.

Host devices should be designed for a controlled shutdown following battery notification of termination by the battery sending TERMINATE_DISCHARGE alarm, prior to protection circuit cut-off.

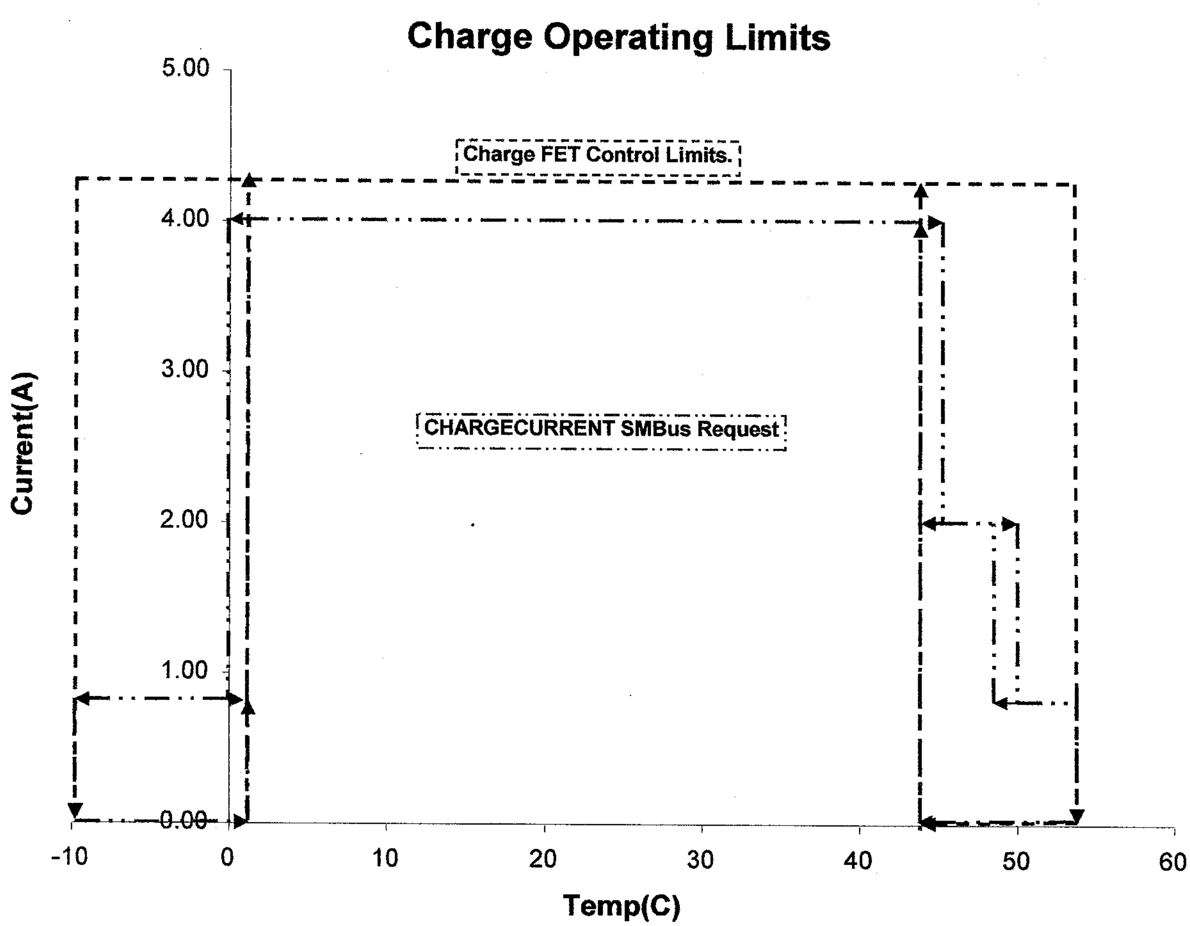


3.1.5. Charge

Charge Temperature Limits: As Shown below, ≤ 80%RH

The battery shall be capable of continuous charge at 16.8V, as shown in the graph below. A dedicated level II or level III smart battery charger is required to charge the battery. Using this type of charger, the battery will request appropriate charging Voltage and Current from the smart battery charger.

The FULLY_CHARGED bit in the BatteryStatus() will be set when the charging current tapers down under 220mA while charging at 16.8V.



3.1.6. Storage

Storage Temperature Limits: -20°C to 60°C, ≤ 80%RH

The battery packs should be stored in an environment with low humidity, free from corrosive gas at a recommended temperature range <21°C. Extended exposure to temperatures above 45°C could degrade battery performance and life.

3.1.7. Terminal Specifications

See Mechanical Drawing for orientation of contacts J1-1,5

Terminal	Legend	Description
1	(+)	Positive side of battery
2	(C)	SMBus Clock. Internally a 1MΩ resistor is connected between (C) and (-).
3	(D)	SMBus Data. Internally a 1MΩ resistor is connected between (D) and (-).
4	(T)	300Ω ±5% resistor connected between (T) and (-).
5	(-)	Negative Side Of Battery

- A key slot is also present on each pack for mechanical alignment adjacent to the positive terminal.
- The SMBus Clock and data lines require separate pull-ups to system logic voltage, NOT the battery voltage. Typically a 15KΩ pull-up resistor is used, but please refer to the SMBus Specification for additional information.

3.2. Fuel-Gauge Electronics

3.2.1. Overview Of Operation

The battery is capable of communicating with host or the charger through the System Management Bus (SMBus). The battery is fully SMBus and SBDS Revision 1.1 compliant. An 8-bit Reduced Instruction Set CPU (RISC) is used to process the core algorithms and perform operations required for battery monitoring. Charge and discharge current, cell and pack voltages, and pack temperature are all measured using an integrated analog to digital converter at 14-bit to 16-bit effective resolution.

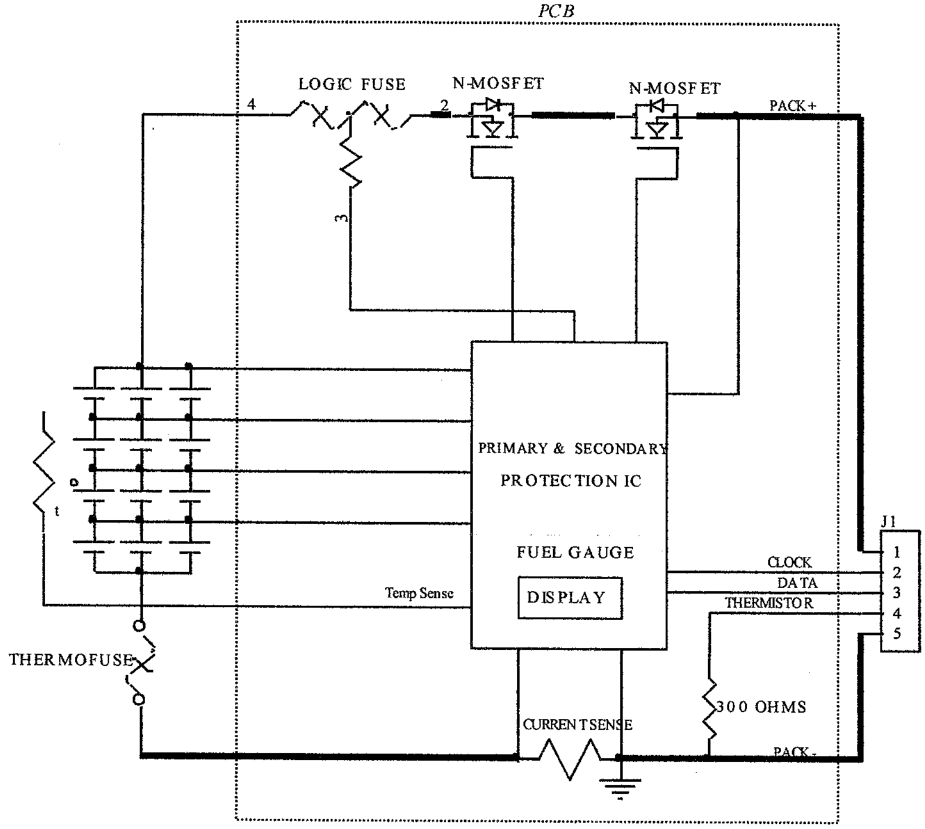
The battery pack uses a system level approach to optimize the performance of the battery. It's primary functions are to provide fuel gauging and software based charge control, and to ensure safe operation throughout the life cycle of the battery.

The fuel gauge determines the State-Of-Charge (SOC) by integrating the input and output current and using impedance tracking to accurately track the available capacity of the attached battery. To achieve the desired fuel-gauging accuracy, high-performance analog peripherals are used to monitor capacity change, battery impedance, open-circuit voltage and temperature. These factors are continually applied to account for battery non-linearity and environmental conditions. This approach provides the user a meaningful and repeatable capacity measure with minimal risk of overstating run time. Visually, the SOC can be obtained from the four on-pack LED's with push-button activation.

Charge control is used to provide optimal and safe charging requests to an SMBus level II or level III charger.

The system has three modes of operation; normal, sleep and shutdown. In normal mode, measurements, calculations, protection decisions and data updates are made on 1 sec intervals. Between these intervals, the electronics enters a reduced power mode. Sleep mode is entered when the system senses no host or charger present. While in this mode, battery parameters continue to be monitored at regular intervals. The system will continue in this mode until it senses host activity (communications or current flow). Shutdown mode occurs when the battery voltage falls below 2.3V/parallel cell group. In this mode, parasitic current is reduced to a minimum by shutting down the micro-controller and all associated circuitry. If this should happen, the battery will require an initial low current charge to bring the battery voltage back up before normal operation will resume.

The battery pack block diagram is shown below.



3.2.2. DC Specifications

Parameter	Limits	Remarks
Active mode current consumption	<650uA	When a host is detected (charging, discharging or communications).
Standby mode current consumption	<140uA	When no host activity is detected.
Shut-down mode current consumption	<1uA	Any cell voltage falls below 2300mV.

3.2.3. Measurement Accuracy

3.2.3.1. Voltage

The voltage measurements have a resolution of 1mV. The absolute accuracy of the reading is ±0.7% over the operating range. Note that measurements are made at the cell stack (not the pack connector). Therefore internal resistance drops due to the shunt, safety components, and contact resistance are not taken into consideration.

3.2.3.2. Temperature

The internal pack temperature is measured by a NTC thermistor attached to the cell stack. Temperature readings have a resolution of 0.1°K. The absolute accuracy is ±3°K over an operating range of -20°C to +80°C.

3.2.3.3. Current

The current measurements have a resolution of 1mA. The absolute accuracy of the reading is ±0.7% or ±3mA whichever is greater over the operating range. A guard band has been imposed around zero current (-3mA to +3mA).

3.2.4. LED Indication

The battery can directly display the capacity information. The battery capacity is displayed as the relative SOC. Each LED segment represents 25 percent of the full charge capacity. The LED pattern definition is given in the table below. The LED's illuminate for 4 seconds following switch activation. If the battery voltage is to low, there will be no LED indication.

Capacity	**LED Indicators #**				**Note**
	1	**2**	**3**	**4**	
At or below 10%					Blinks
10% - 25%					**Lit for 4 seconds.**
26% - 50%					**Lit for 4 seconds.**
51% - 75%					**Lit for 4 seconds.**
76% - 100%					**Lit for 4 seconds.**

3.3. SMBus and SBD Parameters

3.3.1. Overview Of Operations

The battery is fitted with a microprocessor and associated circuitry for communication with an external host device and/or smart battery charger. Reference should be made to the following specifications when reading this section:

- System Management Bus Specification (Rev 1.1, Dec 11, 1998)
- Smart Battery Data Specification (Rev 1.1, Dec 15, 1998)
- Smart battery Charger Specification (Rev 1.0, June 27, 1996)

3.3.2. SMBus Logic Levels

Symbol	Parameter	Limits		Units
		Min	Max	
V_{il}	Data/Clock input low voltage	-0.3	0.8	V
V_{ih}	Data/Clock input high voltage	2.1	5.5	V
V_{ol}	Data/Clock output low voltage		0.4	V

3.3.3. SMBus Data Protocols

SMBus Interface complies with SBS Specification Version 1.1. The battery pack includes a simple bi-directional serial data interface. A host processor uses the interface to access various battery pack registers.
The interface uses a command-based protocol, where the host processor sends the battery address command byte to the battery pack. The command directs the battery pack to either store the next data received to a register specified command byte or output the data specified by the command byte.

3.3.4. SMBus Host-to-Battery Message Protocol

The Bus Host communicates with the battery pack using one of three protocols:

- Write Word
- Read Word
- Read Block

3.3.4.1. Write Word

The first byte of a Write Word access is the command code. The next two Bytes are the data to be written. In this example the master asserts the slave device address followed by the write bit. The device acknowledges and the master delivers the command code. The slave again acknowledges before the master sends the data word (low byte first). The slave acknowledges each byte according to the I²C specification, and the entire transaction is finished with a stop condition.

1	7	1	1	8	1	8	1	8	1	1
S	Battery Address	Wr	A	Command Code	A	Data byte low	A	Data byte high	A	P

Write Word Protocol

1	7	1	1	8	1	8	1	8	1	8	1	1
S	Battery Address	Wr	A	Command Code	A	Data byte low	A	Data byte high	A	PEC	A	P

Write Word Protocol w/ PEC

□ SMBus Host (master) ▒ Smart Battery (slave)

3.3.4.2. Read Word

Reading data is slightly more complex than writing data. First the host must write a command to the slave device. Then it must follow that command with a repeated start condition to denote a read from that device's address. The slave then returns two bytes of data.

Note that there is not a stop condition before the repeated start condition, and that a "Not Acknowledge" signifies the end of the read transfer.

1	7	1	1	8	1	1	7	1	1	8	1	8	1	1
S	Battery Address	Wr	A	Command Code	A	S	Battery Address	Rd	A	Data byte low	A	Data byte high	!A	P

Read Word Protocol

1	7	1	1	8	1	1	7	1	1	8	1	8	1	8	1	1
S	Battery Address	Wr	A	Command Code	A	S	Battery Address	Rd	A	Data byte low	A	Data byte high	A	PEC	!A	P

Read Word Protocol w/ PEC

☐ SMBus Host (master) ▨ Smart Battery (slave)

3.3.4.3. Block Read

The Block Read begins with a slave address and a write condition. Then it must follow that command with a repeated start condition to denote a read from that device's address. After the repeated start the slave issues a byte count that describes how many data bytes will follow in the message. If a slave had 20 bytes to send, the first byte would be the number 20 (14h), followed by the 20 bytes of data. The byte count may not be 0. A Block Read can transfer a maximum of 32 bytes.

1	7	1	1	8	1	1	7	1	1	
S	Battery Address	Wr	A	Command Code	A	S	Battery Address	Rd	A	...

8	1	8	1	8	1		8	1	1
Byte count=N	A	Data byte 1	A	Data Byte 2	A	≈	Data byte N	!A	P

Block Read

1	7	1	1	8	1	1	7	1	1
S	Battery Address	Wr	A	Command Code	A	S	Battery Address	Rd	A

8	1	8	1	8	1		8	1	8	1	1
Byte count=N	A	Data byte 1	A	Data Byte 2	A	≈	Data byte N	A	PEC	!A	P

Block Read w/ PEC

☐ SMBus Host (master) ▨ Smart Battery (slave)

3.3.5. SMBus Battery-to-Charger Message Protocol

The Smart Battery, acting as an SMBus master will dynamically alter the charger characteristics of the Smart Charger, behaving as an SMBus slave using the SMBus Write Word protocol. Communication begins with the Smart Charge's address, followed by a Command Code and a two byte value. The Smart Charger adjust its output to correspond with the request.

1	7	1	1	8	1	8	1	8	1	1
S	Charger Address	Wr	A	Command Code	A	Data byte low	A	Data byte high	A	P

Battery Broadcast Message for the Charger

1	7	1	1	8	1	8	1	8	1	8	1	1
S	Charger Address	Wr	A	Command Code	A	Data byte low	A	Data byte high	A	PEC	A	P

Battery Broadcast Message for the Charger w/ PEC

☐ Smart Battery (master) ▒ Smart Charger (slave)

3.3.6. SMBus Battery Critical Message Protocol

A Smart Battery to SMBus Host or Smart Charger message is sent using the SMBus Write Word protocol. Communication begins with the SMBus Host's or Smart Battery Charger's address, followed by the Smart Battery's address which replaces the Command Code. The SMBus Host or Smart Charger can now determine that the Smart Battery was the originator of the message and that the following 16 bits are its status.

1	7	1	1	8	1	8	1	8	1	1
S	Target Address	Wr	A	Battery Address	A	Data byte low	A	Data byte high	A	P

Battery Critical Message

1	7	1	1	8	1	8	1	8	1	8	1	1
S	Target Address	Wr	A	Battery Address	A	Data byte low	A	Data byte high	A	PEC	A	P

Battery Critical Message w/ PEC

☐ Smart Battery (master) ▒ Smart Host or Smart Charger (slave)

3.3.7. Host To Battery Messages (Slave Mode)

The Host acting in the role of bus master uses the read word, write word, and read block protocols to communicate with the battery, operating in slave mode.

Host-to-Battery Messages

Function	Command Code	Description	Unit	Access	Default (POR)
ManufacturerAccess()	0x00			r/w	
RemainingCapacityAlarm()	0x01	Remaining Capacity Alarm Threshold .	mAh	r/w	660
RemainingTimeAlarm()	0x02	Remaining Time Alarm Threshold.	minutes	r/w	10
BatteryMode()	0x03	Battery Operational Modes.	Bit flags	r/w	0x0080
AtRate()	0x04	This function is the first half of a two-function call-set used to set the AtRate value used in calculations made by the AtRateTimeToFull(), AtRateTimeToEmpty(), and AtRateOK() functions.	mA	r/w	0
AtRateTimeToFull()	0x05	Returns the predicted remaining time to fully charge the battery at the AtRate() value.	minutes	r	65535
AtRateTimeToEmpty()	0x06	Returns the predicted remaining operating time if the battery is discharged at the AtRate() value.	minutes	r	65535
AtRateOK()	0x07	Returns a Boolean value that indicates whether or not the battery can deliver the AtRate value of additional energy for 10 seconds. If the AtRate() value is zero or positive, the AtRateOK() function will ALWAYS return TRUE.	boolean	r	1
Temperature()	0x08	Returns the pack's internal temperature.	0.1 °K	r	
Voltage()	0x09	Returns the battery's voltage (measured at the cell stack)	mV	r	
Current()	0x0a	Returns the current being supplied (or accepted) through the battery's terminals.	mA	r	0
AverageCurrent()	0x0b	Returns a rolling average based upon the last 64 samples of current.	mA	r	0
MaxError()	0x0c	Returns the expected margin of error.	percent	r	100
RelativeStateOfCharge()	0x0d	Returns the predicted remaining battery capacity expressed as a percentage of FullChargeCapacity().	percent	r	0
AbsoluteStateOfCharge()	0x0e	Returns the predicted remaining battery capacity expressed as a percentage of DesignCapacity().	percent	r	0
RemainingCapacity()	0x0f	Returns the predicted remaining battery capacity.	mAh	r	0
FullChargeCapacity()	0x10	Returns the predicted battery capacity when fully charged.	mAh	r	
RunTimeToEmpty()	0x11	Returns the predicted remaining battery life at the present rate of discharge.	minutes	r	65535
AverageTimeToEmpty()	0x12	Returns the rolling average of the predicted remaining battery life.	minutes	r	65535
AverageTimeToFull()	0x13	Returns the rolling average of the predicted remaining time until the battery reaches full charge.	minutes	r	65535
ChargingCurrent()	0x14	Returns the battery's desired charging rate.	mA	r	4000
ChargingVoltage()	0x15	Returns the battery's desired charging voltage.	mV	r	16800
BatteryStatus()	0x16	Returns the battery's status word.	Bit flags	r	0x2C0
CycleCount()	0x17	Returns the number of charge/discharge cycles the battery has experienced. A charge/discharge cycle is defined as: an amount of discharge approximately equal to the value of DesignCapacity.	cycles	r	0
DesignCapacity()	0x18	Returns the theoretical capacity of the new battery.	mAh	r	6600
DesignVoltage()	0x19	Returns the theoretical voltage of a new battery.	mV	r	14400
SpecificationInfo()	0x1a	Returns the version number of the SBDS the battery pack supports, as well as voltage and current scaling information.	Formatted word	r	0x0031
ManufacturerDate()	0x1b	Returns the date the electronics were manufactured.	Formatted word	r	
SerialNumber()	0x1c	Returns the electronics serial number.	number	r	
Reserved	0x1d - 0x1f			r	
ManufacturerName()	0x20	Returns a character array containing the manufacture's name.	string	r	INSPIREDE
DeviceName()	0x21	Returns a character array that contains the battery's name.	string	r	NL2024E
DeviceChemistry()	0x22	Returns a character array that contains the battery's chemistry.	string	r	LION
ManufacturerData()	0x23	Returns data specific to the manufacture.		r	

3.3.8. Battery To Charger Messages (Master Mode)

The battery, acting in the role of a bus master, uses the write word protocol to communicate with the charger, operating in slave mode. If the CHARGER_MODE bit in BatteryMode() is clear, the Battery will broadcast Charger request information every 10 to 60 second.

Battery-to-Charger Messages

Function	Command Code	Description	Unit	Access
ChargingCurrent()	0x14	Sends the desired charging rate to the battery charger	mA	W
ChargingVoltage()	0x15	Sends the desired charging voltage to the battery charger	mV	W

3.3.9. Critical Messages (Master Mode)

Whenever the Battery detects a critical condition, it takes the role of a bus master and sends AlarmWarning() message to the Host and/ or Charger. The Battery broadcasts the AlarmWarning() message at 10 second intervals until the critical condition(s) has been corrected.

Battery Critical Messages

Function	Command Code	Description	Unit	Access
AlarmWarning()	0x16	This message is to the host and/or charger to notify them that one or more alarm conditions exist.	Formatted word	W

Alarm Bit Definitions

Bit	Battery Status	Set When:	Action When Set:	Cleared When:
15	OVER_CHARGD_ALARM	RemainingCapacity() exceeds *FullChargeCapacity()* + ***300mAh.***	Stop charging.	A continuous discharge of >= 300mAh.
14	TERMINATE_CHARGE_ALARM	Primary Charge Termination, Cell or Pack Over-Voltage (COV or POV), Over-Current Charge (OCC), Over-Temp Charge (OTC) conditions. COV = 4300mV POV = 17500mV OCC = 4250mA OTC = 58°C	Stop charging.	RelativeStateOfCharge() <= 95%, COV, POV, OCC or OTC recovery threshold. COV recovery <= 4150mV POV recovery <= 16600mV OCC recovery <= 200mA for 70sec OTC recovery <= 56°C
13	Reserved			
12	OVER_TEMP_ALARM	Over-Temp Charge (OTC) or Over-Temp discharge (OTD) condition. OTC=58°C OTD=75°C	Appropriate FET will be disabled to prevent further action.	OTC or OTD recovery threshold. OTC recovery = 56°C OTD recovery = 65°C
11	TERMINATE_DISCHARGE_ALARM	RelativeStateOfCharge() <= 0%, Cell or Pack Under-Voltage (CUV or PUV), Over-Current Discharge (OCD), Over-Temp Discharge (OTD) conditions. CUV = 2500mV PUV = 10000mV OCD = -10000mA OTD = 75°C	Stop discharging.	RelativeStateOfCharge() >= 1%, CUV, PUV, OCD or OTD recovery threshold. CUV recovery >= 3000mV PUV recovery >= 12000mV OCD recovery >= -200mA for 70sec OTD recovery <= 65°C
10	Reserved			
9	REMAINING_CAPACITY_ALARM (User settable)	RemainingCapacity() < RemainingCapacityAlarm().	User defined.	RemainingCapacityAlarm() = 0 or is <= RemainingCapcity().
8	REMAINING_TIME_ALARM (User settable)	AverageTimeToEmpty() < RemainingTimeAlarm().	User defined.	RemainingTimeAlarm() = 0 or <= AverageTimeToEmpty().

Status Bit Definitions

Bit	Battery Status	Set When:	Action When Set:	Cleared When:
7	INITIALIZED		None.	
6	DISCHARGING	Battery is not in charge mode.	None.	Battery is in charging mode.
5	FULLY CHARGED	When the battery detects a primary charge termination.	Stop charging.	RelativeStateOfCharge() <= 95%.
4	FULLY DISCHARED	RelativeStateOfCharge() <= 0%.	Stop discharging.	RelativeStateOfCharge() >= 20%.

3.3.10.Pack Calibration Cycle

The NL2024ED uses the Impedance Track Technology to measure and calculate the available charge in battery cells. The achievable accuracy is better than 1% error over the lifetime of the battery. Max Error increases by 1% in 20 cycles, e.g., only occasionally is a full charge/discharge learning cycle required to maintain high accuracy.

3.4. Protection Electronics

3.4.1. Overview Of Operation

Electronic circuitry is permanently connected within the battery pack to prevent damage if either the charger or host device fails to function correctly. The circuitry also protects the battery if an illegal current source is placed across the battery terminals, or an illegal load is connected. Redundant levels of protection have been implemented (the primary protection levels are auto-resettable and the secondary are non-resettable).

3.4.2. Charge Protection

Over-Voltage:

The primary protection circuit will prevent the battery from charging if any cell voltage >= 4300mV. Then, once all cell voltages are <= 4150mV, it will allow charging again.

The secondary protection circuit will prevent the battery from charging if any cell voltage >= 4.45V +/-0.05V by blowing a power path logic fuse. The fuse is non-re-settable rendering the battery pack non-functional.

Over-temp:

The primary protection circuit also provides over-temperature protection and will prevent the battery from charging at temperatures =>54°C(see paragraph 3.1.5 for ChargeCurrent() request). Then, once the battery temperature has cooled to <=45°C, it will again allow charging.

Over-Current:

The primary protection circuit also provides continuous over-current protection and will prevent the battery from charging at Current() =>4.25A. Then, once the AverageCurrent() <= 200mA for 70sec, the battery will re-test the over-current condition, and again allow charging.

3.4.3. Discharge Protection

Under-Voltage:

The primary protection circuit will prevent the battery from being further discharged once any cell voltage reaches <=2500mV. Then, once all cell voltages are >= 3000mV, it will allow discharge again.

Over-temp:

The primary protection circuit also provides over-temperature protection and will prevent the battery from discharging at temperatures =>75°C. Then, once the battery temperature has cooled to <=65°C, it will again allow discharging.

If the battery reaches 85°C for any reason the secondary protection circuit will blow the in-line power path logic fuse. The fuse is non-re-settable rendering the battery pack non-functional.

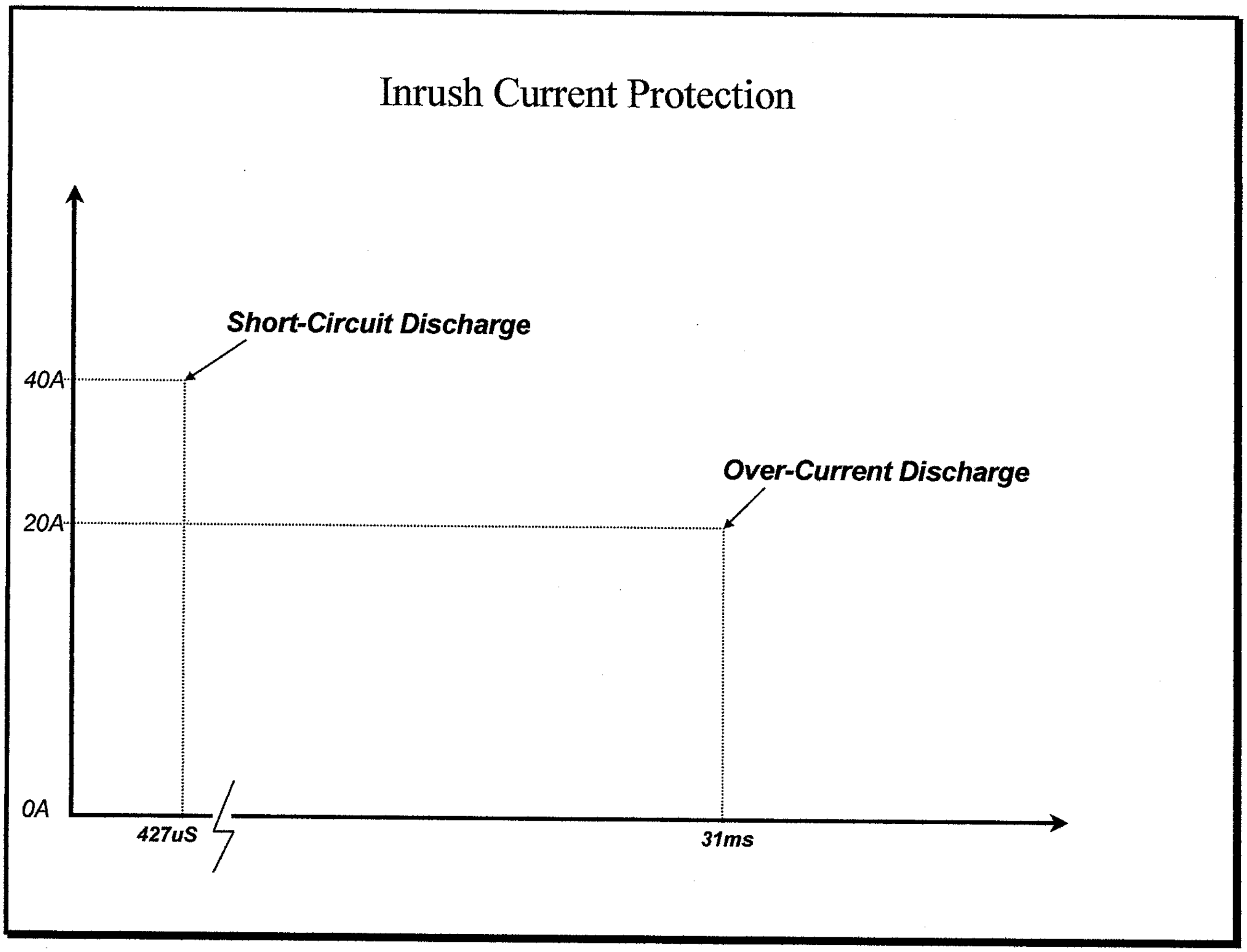
Over-Current:

The primary protection circuit also provides continuous over-current protection and will prevent the battery from discharging at Current() <= -10.00A. Then, Once the AverageCurrent() >= -200mA for 70sec, the battery will re-test the over-current condition, and again allow discharging.

3.4.4. Short-Current Protection

The primary protection circuit will prohibit the discharge of the battery if a short-circuit is placed across the battery + / - terminals. Then, once the AverageCurrent() >= -1mA for 70sec, the battery will re-test the short-circuit condition, and again allow discharging.

The pack is design to withstand reasonable in-rush currents without resetting the electronics and without interrupting the discharge cycle. The following graph illustrates the short-circuit/in-rush set points as implemented:



3.5. Passive Safety Protection

3.5.1. Overview Of Operation

The battery pack is fitted with additional components to protect it against abusive charge and discharge conditions. These are in addition to the electronic protection.

3.5.2. Thermal Fuse

A Thermal Fuse is fitted in series with the charge/ discharge path to protect the battery from over temperature. This device goes open circuit if the cell case temperature reaches the fuse's temperature rating of 93°C (+0°C, -5°C). The fuse is non-re-settable rendering the battery pack non-functional.

3.5.3. Slow-Blow Current Fuse (Logic Fuse)

A current slow-blow fuse is assembled in series with the battery pack to protect the battery pack against abusive over current over-load. The hold current is rated at 15A for 4 hours (minimum@25C). The fuse is non-re-settable rendering the battery pack non-functional.

3.6. Mechanical Specifications

3.6.1. Weight

Approximately 1.426lbs. (0.647Kg).

3.6.2. Mating Connector

The recommended interconnection mating male connector is AMP P/N 5787422-1 or 5787446-1.

3.6.3. Date Code/Serial Number

IE YYWWRR

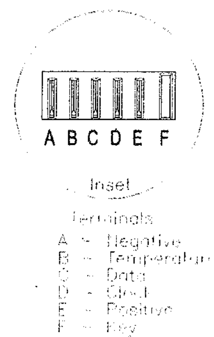
SN SSSSS XZZWh

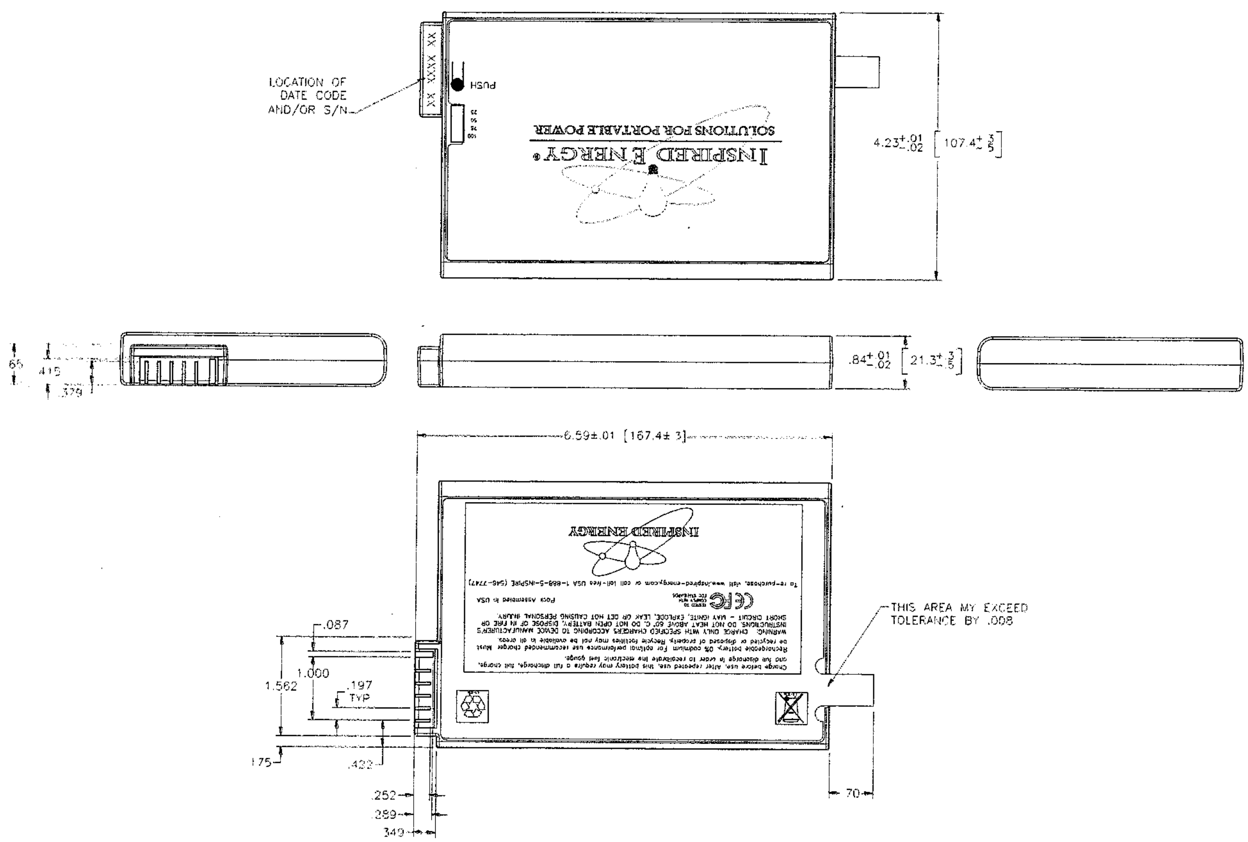
IE = Inspired Energy Newberry facility
YY = Calendar Year
WW = Calendar Week
RR = Battery revision
SSSSSS = Serial Number
X = the cell supplier
ZZWh = the stored energy of the battery in Watt hours

3.6.4. Packaging

The batteries are packaged in bulk, with 12 batteries per carton.

3.6.5. Mechanical Drawing




LOCATION OF DATE CODE AND/OR S/N
XX XXXX XX
PUSH
INSPIRED ENERGY
SOLUTIONS FOR PORTABLE POWER
4.23+.01/-.02 [107.4+.3/-.5]
.84+.01/-.02 [21.3+.3/-.5]
6.59±.01 [167.4±.3]
.087
1.000
1.562
.197 TYP
.175
.422
.252
.289
.349
.70
THIS AREA MY EXCEED TOLERANCE BY .008

3.7. Environmental/Safety Specifications

3.7.1. EMC And Safety

The battery complies with the following:

- EMC Directive 2006/95/EC
- Low Voltage Directive 2004/108/EC
- Battery Recycling Directive 2006/66/EC as amended
- "RoHS" Directive 2002/95/EC

The battery has been tested in accordance with the UN Manual of tests and Criteria part III subsection 38.3 (ST/SG/AC.10/11/Rev.3) - more commonly known as the UN T1-T8 Transportation tests; and has been found to comply with the stated criteria. [USDOT-E7052]

The battery has the following approvals and the pack will be labeled according:

- CE [EN55022:2006 (ITE Class B) & EN55024:1998 (ITE)]
- FCC Part 15 Class B

3.8. Reliability

3.8.1. Life Expectancy

Given normal storage & usage, user can expect the battery to deliver 80% or more of it's initial capacity after 300 charge/discharge cycles where the charge phase is CC/CV 4000mA, 16.8±0.05V and the discharge is 4000mA down to 2.9V/Cell at 25°C.

3.8.2. Warranty

Inspired Energy maintains a high quality standard. All products are warranted against defects in workmanship, material and construction. The warranty period is one (1) year from the date of shipment from Inspired Energy.

3.8.3. Shelf Life

The batteries are shipped from Inspired Energy with between 30% and 50% rated capacity and this provides a minimum of 6 months shelf life, when stored at 25°C. If the storage temperature exceeds 25°C over the 6-month period then the shelf life will be reduced and provisions should be made to recharge the battery periodically.

In order to prevent parasitic drain on the battery, the electronics will go into a shutdown mode if any cell voltage <= 2300mV. If this should happen, the battery pack will require an initial low charge to activate the electronics prior to the implementation of the normal charge. Any SMBus version 1.0, or higher, compatible charger is capable of providing this initial pre-charge.