BattGuard™
Installation Instructions
and
User's Guide

PRELIMINARY

Release X1

February 2002

WARNING: Battery systems have the potential to cause severe burns, shocks, and other serious injuries. Graviton, Inc. strongly advises that only persons specifically trained in the techniques and procedures necessary to ensure personal safety while working with high-energy batteries install or maintain the BattGuard battery monitoring system.

BattGuard™ Release X1

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Graviton, Inc.

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ACKNOWLEDGMENTS

NOTICE

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1 Introduction

Welcome

With the BattGuard™ Battery Monitoring System, you'll be able to continuously monitor the health of the individual batteries used in your battery back-up system. You will have assurance that they will function properly when you need them most – during a power outage.

BattGuard includes the following components:

- **BattGuard Telesensors** – specially designed transceivers that are connected to each battery cell in your backup system and monitor the health of your backup system. The Telesensors measure voltage, current and temperature and transmit the data every 15 minutes using a performance optimized 2.4GHz direct sequence spread spectrum (DSSS) radio.
- **End-of-String master** – special Telesensor that receives the battery data from the Telesensors and provides a radio to serial (PC) interface.
- **DCU** (Data Collection Unit) – laptop computer that collects the following data for each battery: battery current measurements, voltage, and temperature.
- **BattGuard software** – specialized computer program used to configure the Telesensors, graphically display battery data, and export the data for further analysis using other programs such as Microsoft Excel.

About This Document

This guide includes procedures to help you install and use the BattGuard Battery Monitoring System.

Audience

Information in this guide is directed to field engineers and technicians, customer engineers, technicians, and contracted installation personnel with background in the technical and safety aspects of battery and battery monitoring systems.

WARNING: Improper handling of batteries can cause serious injury. Refer to the battery manufacturer's installation and service instructions before installing BattGuard Telesensors.

Notes and Warnings

Note	Helpful Information – A note conveys additional information that may be helpful in completing a task.

WARNING – Personal Injury or Severe Equipment Damage – This special note warns you of a potentially hazardous situation in which there may be possibility of personal injury or severe equipment damage.

FCC Compliance Information

Radio Frequency Interference Requirements – USA

WARNING A minimum separation distance of 20 cm.(6 inches) must be maintained between the radiating element of the transmitter and nearby persons in order to ensure compliance with FCC rules for rf exposure. This transmitter must not be co-located with other transmitters or antenna

This device uses, generates, and radiates radio frequency energy. The radio frequency energy produced by this device is well below the maximum exposure allowed by the Federal Communications (FCC).

This device complies with the limits for a class B digital device pursuant to Part 15 subpart C of the FCC Rules and Regulations. Operation is subject to the following two conditions:

1. This device must not cause harmful interference.
2. This device must accept any interference received, including interference that may cause undesired operation.

The FCC limits are designed to provide reasonable protection against harmful interference when the equipment is installed and used in accordance with the instruction manual and operated in a commercial

environment. However, there is no guarantee that interference will not occur in a particular commercial installation, or if operated in a residential area.

If harmful interference with radio or television reception occurs when the device is turned on, the user must correct the situation at the user's own expense. The user is encouraged to try one or more of the following corrective measures:

- Re-orient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver
- Connect the equipment into an outlet on a circuit different from that on which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

CAUTION Do not modify this device. Any changes or modifications not expressly approved by the party responsible for compliance, could void the user's authority to operate the equipment.

Model Number 0920

Customer Support

For customer support in the U.S., call Furmanite, Inc. toll free at the following number:

(866) 217-3182

2 Installation

This chapter lists the required hardware and software needed to install BattGuard and provides step-by-step instructions.

Before You Begin

Before you install the BattGuard Battery Monitoring System, follow the guidelines in this section to help you prepare for installation.

Unpacking and Inventory

- Unpack the Telesensors and related components on a flat, clean surface at the installation site.
- Check the quantity of items received against the packing list and a copy of the purchase order to ensure that you have received your complete order.
- Inspect all components to determine that they are not damaged. If a component appears to be damaged or is missing, contact your shipper and Customer Service immediately.
- Save all packing materials.

Components

- BattGuard Installation CD
- Telesensors, shunts, and cables
- End-of-String Master module, serial interface cable, and power supply
- Personal computer

Tools and Additional Equipment

Ensure that the following protective equipment is available to personnel who perform BattGuard installations:

- Goggles and face shields
- Acid-resistant gloves
- Protective aprons

- Portable or stationary water facilities for rinsing eyes and skin in case of contact with acid electrolyte
- Bicarbonate of soda, mixed with a ratio of 0.l kg to 1 liter (1 lb to 1 gal) of water to neutralize acid spillage

Note	The removal and/or neutralization of an acid spill may result in the production of a hazardous waste. Be sure to comply with appropriate governmental regulations.

- Class C fire extinguisher

Note	Some battery manufacturers do not recommend the use of $C0_2$ Class C fire extinguishers due to potential of thermal shock on the battery cases. Check with the manufacturer's instructions before using.

- Adequately insulated tools

Important Safety Precautions

WARNING: Full voltage and current are always present at the battery terminals. Batteries can produce dangerous voltages, extremely high currents, and possible risk of electric shock. Batteries may cause severe injury if the terminals are shorted together or to ground (earth).

Observe the following protective procedures during installation:

- Wear protective clothing, eyewear, rubber gloves, and boots. Batteries contain corrosive acids or caustic alkalis and toxic materials and can rupture or leak.
- Remove all jewelry, and remove all metal objects from your pockets. Jewelry and objects could fall onto the batteries or inside the battery cabinet.
- Use only tools with insulated handles, so they will not short battery terminals. Do not place tools or other items on top of the batteries or anywhere they could fall onto the batteries or inside the battery cabinet.
- Prohibit smoking and open flames.
- Ensure that the load test leads are clean, in good condition, and connected with a sufficient length of cable to prevent accidental arcing in the vicinity of the battery.
- Ensure that all connections to load test equipment include short-circuit protection.
- Ensure that battery area ventilation is adequate.

- Ensure unobstructed egress from the battery area.
- Neutralize static buildup just before working on a battery by contacting the nearest effectively grounded surface.

Parts Substitution

Do not use substitute parts or perform any unauthorized modification of equipment. This will void your warranty and may create a hazardous condition.

Overview of Installation Steps

Installing BattGuard involves the following steps:

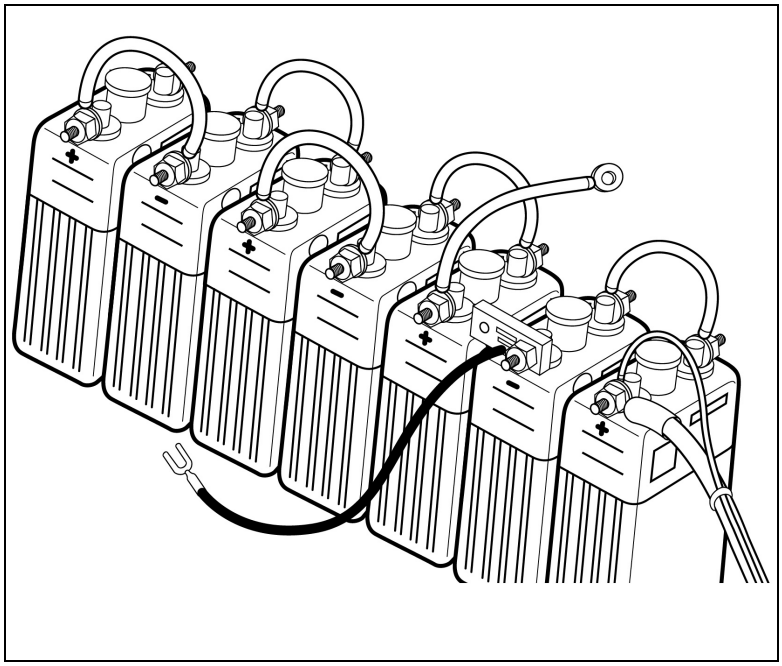
1. Install the Telesensor hardware on each battery cell.
   (See next section.)
2. Install the End-of-String module and connect to a PC.
   (See “End-of-String Master Installation Procedure” on page 2-7.)
3. Install the BattGuard software.
   (See “Software Installation Instructions” on page 2-7.)
4. Set up the battery strings so BattGuard can monitor them.
   (See “Setting Up Battery Strings” on page 4-1.)

Hardware Installation Instructions

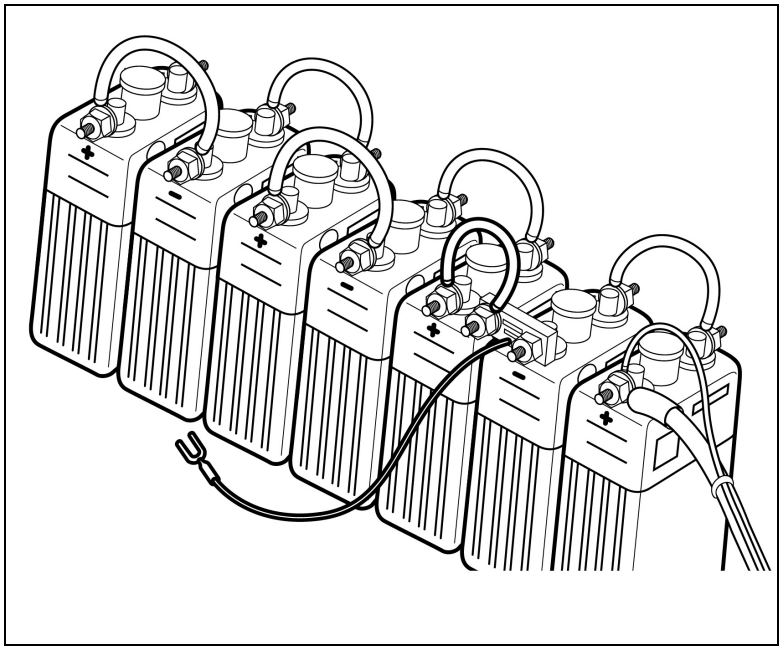
All safety precautions listed in this document should be followed during BattGuard installation. Work performed on batteries should be done only with proper and safe tools and with the protective equipment listed in “Tools and Additional Equipment” on page 2-1.

Telesensor Installation Procedure

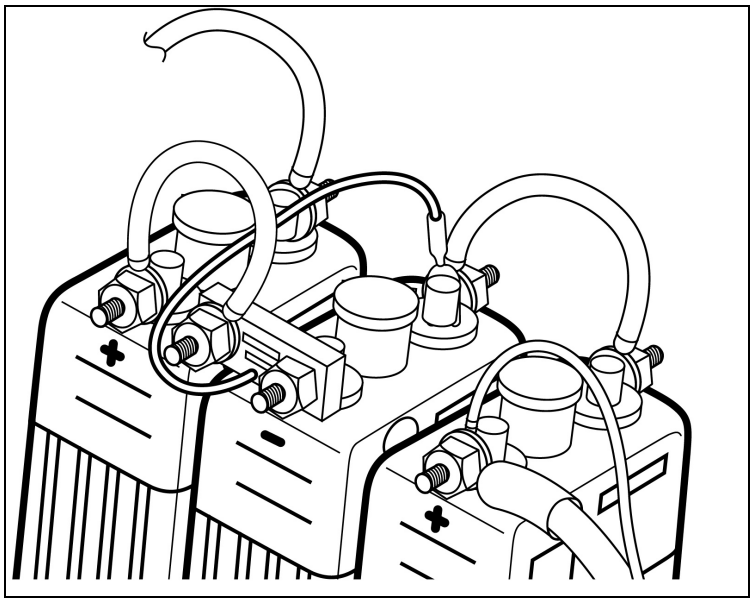
1. Disconnect the battery-to-battery lead from the negative terminal of the first battery to be monitored, and fasten the negative end of the BattGuard shunt to the negative terminal of the battery.



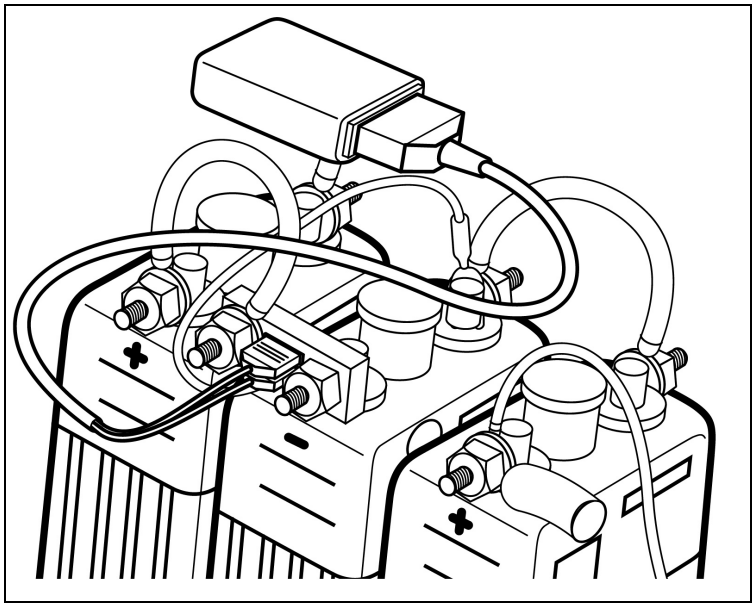
2. Fasten the loose end of the lead (from step 1) to the positive end of the BattGuard shunt.



3. Fasten the small, red wire on the BattGuard shunt to the positive terminal of the battery.



4. Connect the ribbon cables on the BattGuard Telesensor to the connectors on the BattGuard shunt.

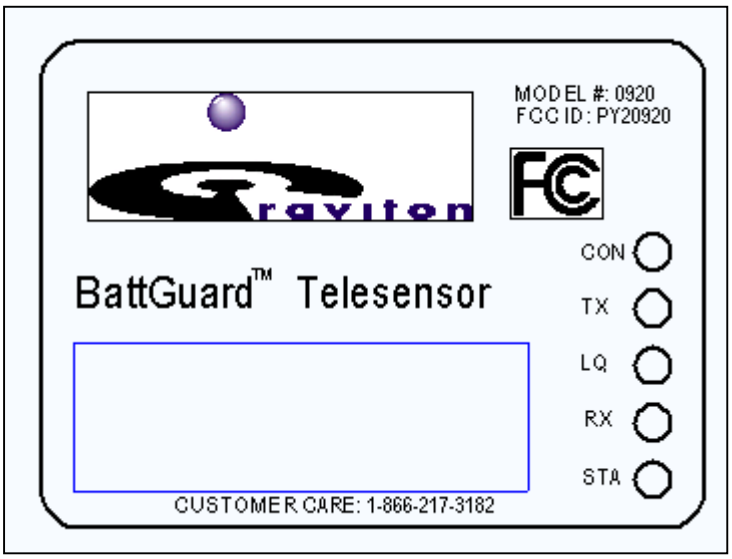


The BattGuard Telesensor begins its initialization process automatically. Once initialized, the "CON" indicator will be off, the "STA" indicator will be lit until the Telesensor is able to send its data to the End-of-String Master, and the "TX," "LQ," and "RX" will flash briefly during transactions with the Master (every 15 minutes).

5. Repeat steps 1 through 4 for all batteries to be monitored.

BattGuard Telesensor Front Panel

The front panel of the BattGuard Telesensors includes a bank of LEDs, as the figure below shows.

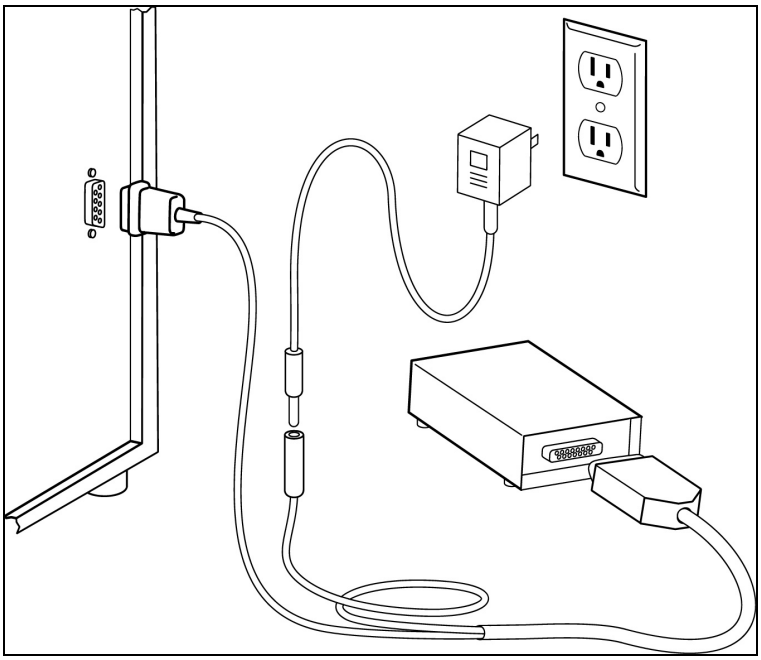


The table that follows lists each LED and its corresponding function and color.

Label	Function	Color
RES	Reset Switch	N/A
CON	Control Indicator	Green
TX	Transmit	Red
LQ	Link Quality	Amber
RX	Receive	Green
STA	Status	Red

End-of-String Master Installation Procedure

1. Connect the End-of-String master to the PC as shown below.



Software Installation Instructions

Hardware Requirements

The following requirements are the minimum needed to install BattGuard on your computer.

- Pentium or better
- 16 MB RAM minimum
- Color monitor
- Hard disk with at least 5 MB available
- Keyboard and mouse
- Printer (Optional, for hardcopy printouts)
- CD-ROM

Software Requirements

The following software must be installed on your system before BattGuard can be installed.

- Microsoft® Windows 95™ or higher, or Windows NT™ 4.0
- Spreadsheet software such as Microsoft Excel for Windows Version 97, 2000, or XP (optional for data export functionality)

Software Installation Procedure

Before installing BattGuard, close all other applications.

To install BattGuard:

1. Insert the Battery Monitor Program CD into the drive.

   The installation program automatically launches.
2. Click **Install**.
3. Follow the on-screen instructions until you've completed the installation procedure.
4. At the "Installation Complete" window:

   a. To finish the installation and exit, click **Finish**.

   b. Restart your computer.

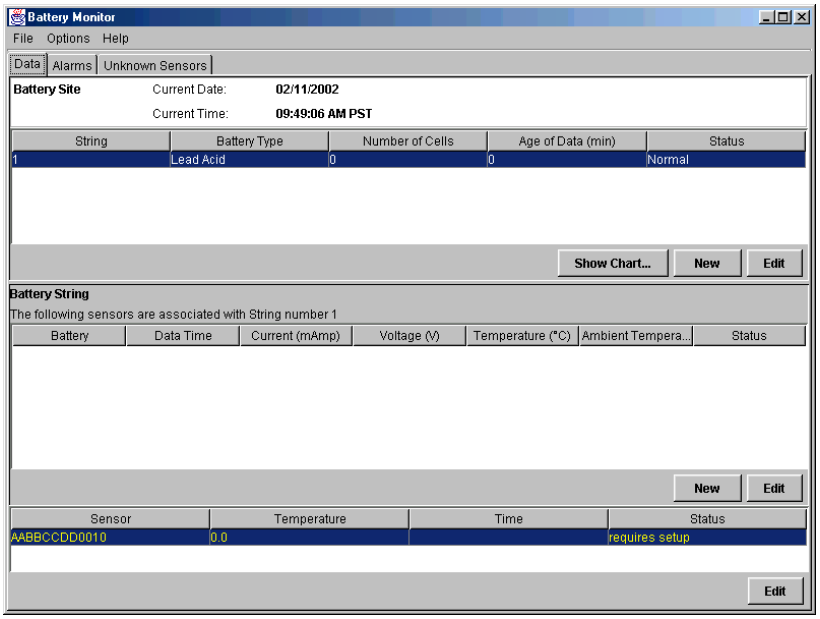
Verifying the BattGuard Software Installation

This section contains procedures for launching BattGuard to ensure that it has been installed properly.

To launch BattGuard:

1. From the Windows Start menu, select **Programs**, then **BattGuard 1.0**, then **BattGuard**.

BattGuard opens, with the Data tab displayed.



2. Now that the BattGuard system has been installed, go to “Setting Up Battery Strings on page 4-1.

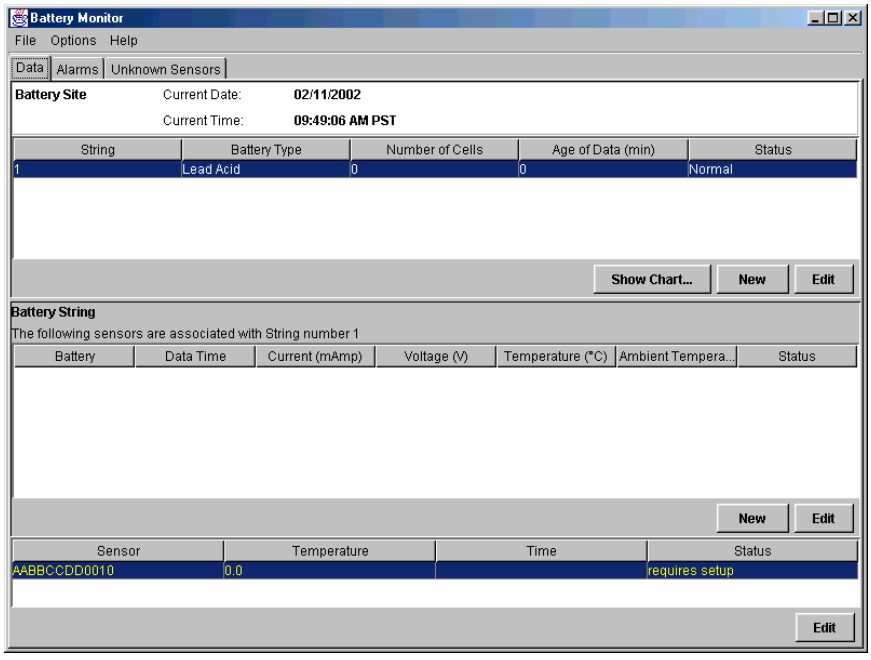
3 Using BattGuard

Understanding the BattGuard Screen

Information in BattGuard is presented on three different panels, which are accessed using tabs at the top of the BattGuard screen.

The Data Tab

The Data tab provides a tabular depiction of the battery configuration and the high-level status of each string and batteries in the selected string. “Warning” level alarms appear as blinking yellow text and “critical” level alarms appear as blinking red text.



Battery Site Area

The top part of the window shows strings and high-level status of each string. “Warning” level alarms appear as blinking yellow text and “critical” level alarms appear as blinking red text.

Battery String Area

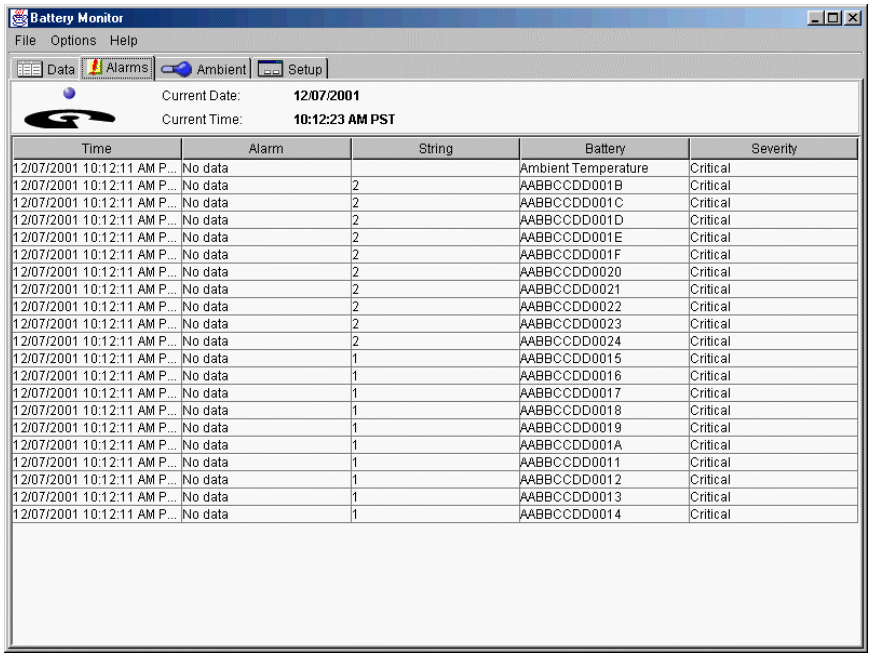
The middle part of the window shows status information for all batteries making up the selected string. New and Setup buttons let you add strings, change string settings, and set up battery alarms. Double-click a battery to view its configuration.

Ambient Temperature Area

The bottom part of the window lists ambient temperature Telesensors by display name and displays their temperature, the time taken, and the status of the Telesensor. Double-click a battery to view its configuration.

The Alarms Tab

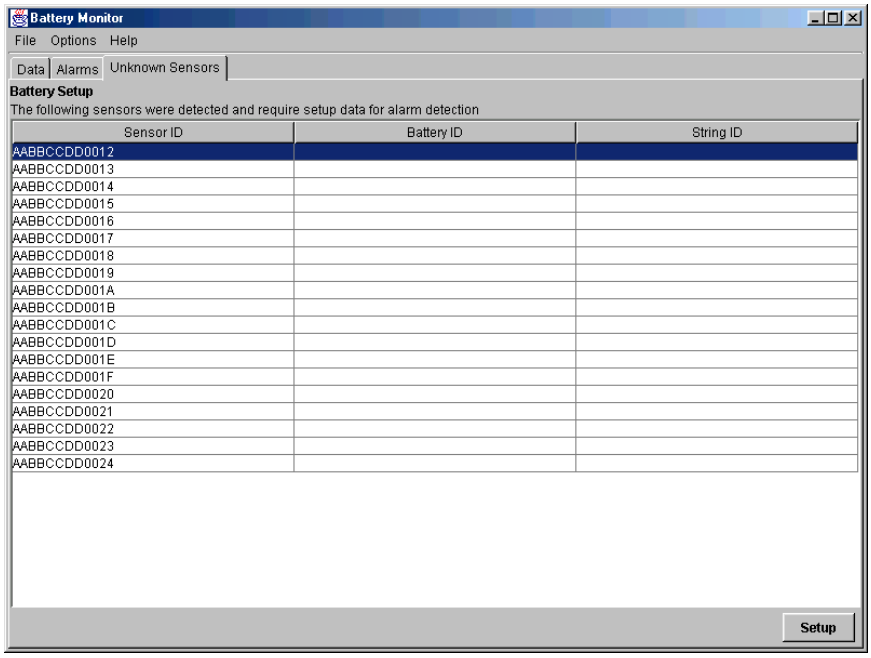
The Alarms tab presents a list of alarms that have been generated. See “Monitoring Alarms” on page 3-5 for a description of the alarms.



Time	Alarm	String	Battery	Severity
12/07/2001 10:12:11 AM P...	No data		Ambient Temperature	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001B	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001C	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001D	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001E	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001F	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0020	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0021	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0022	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0023	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0024	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0015	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0016	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0017	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0018	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0019	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD001A	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0011	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0012	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0013	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0014	Critical

The Unknown Telesensors Tab

If unprogrammed Telesensors are installed and broadcasting, they are detected by BattGuard and displayed in the Unknown Telesensors panel.



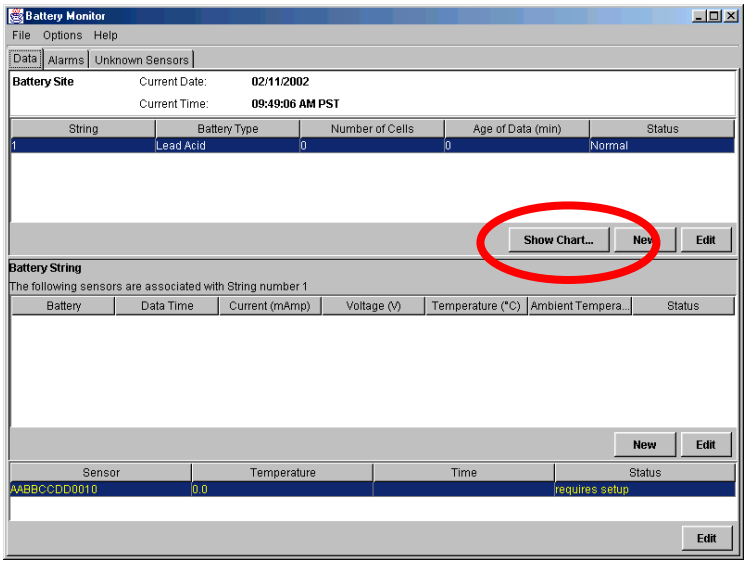
For instructions on how to program these Telesensors, go to “Telesensors Installed – On-Line Configuration” on page 4-1.

Charting Voltages and Temperature

A charting feature provides easy access to voltages and temperatures for all batteries in a given string.

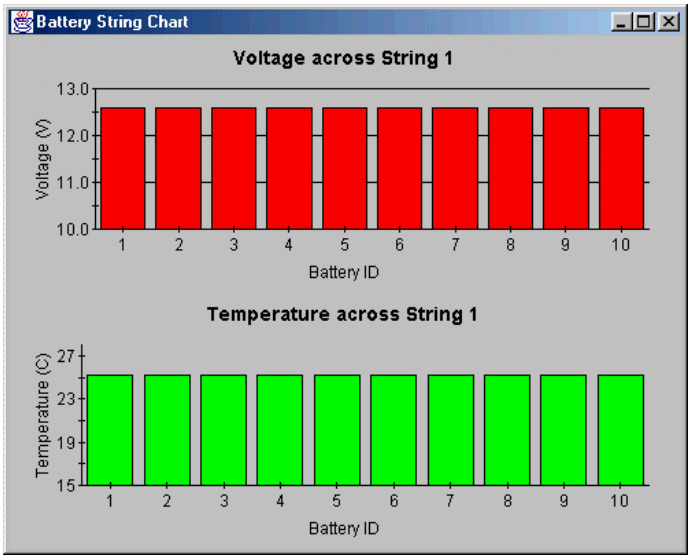
To view a chart:

1. From the Data tab, select a string.



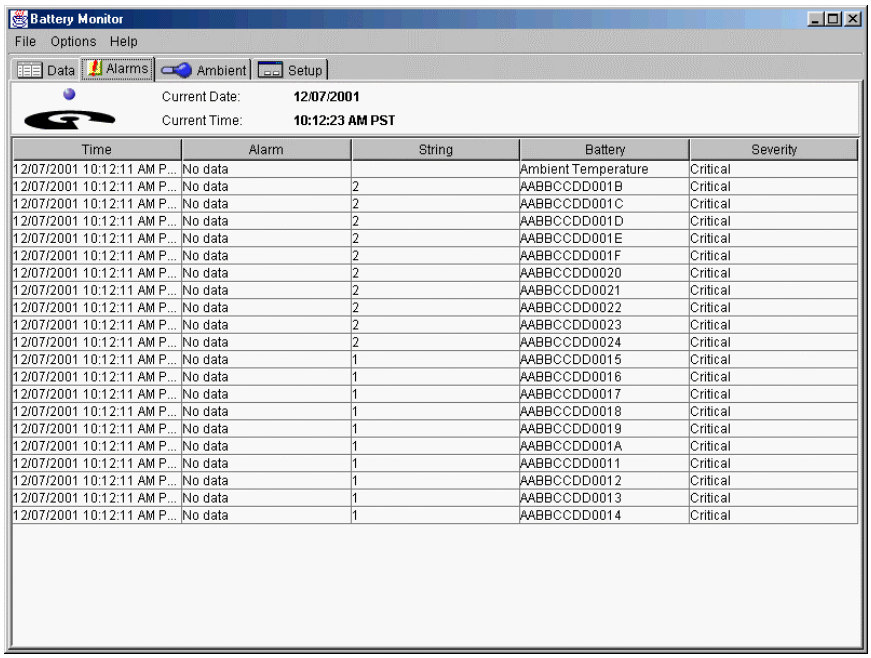
2. Click **Show Chart**.

   The Battery String Chart window appears.



Monitoring Alarms

When an alarm is generated, it appears on the Alarms list until the alarm conditions no longer exist.



Time	Alarm	String	Battery	Severity
12/07/2001 10:12:11 AM P...	No data		Ambient Temperature	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001B	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001C	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001D	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001E	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD001F	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0020	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0021	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0022	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0023	Critical
12/07/2001 10:12:11 AM P...	No data	2	AABBCCDD0024	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0015	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0016	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0017	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0018	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0019	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD001A	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0011	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0012	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0013	Critical
12/07/2001 10:12:11 AM P...	No data	1	AABBCCDD0014	Critical

The information appearing on this tab can be used to identify the cause of the alarm so the problem can be resolved. The Alarms tab shows the following information:

- **Time** – The date and time of the alarm occurrence
- **Alarm** – The type of alarm
- **String** – The affected string
- **Battery** – The battery affected by the alarm
- **Severity** – Either critical or warning

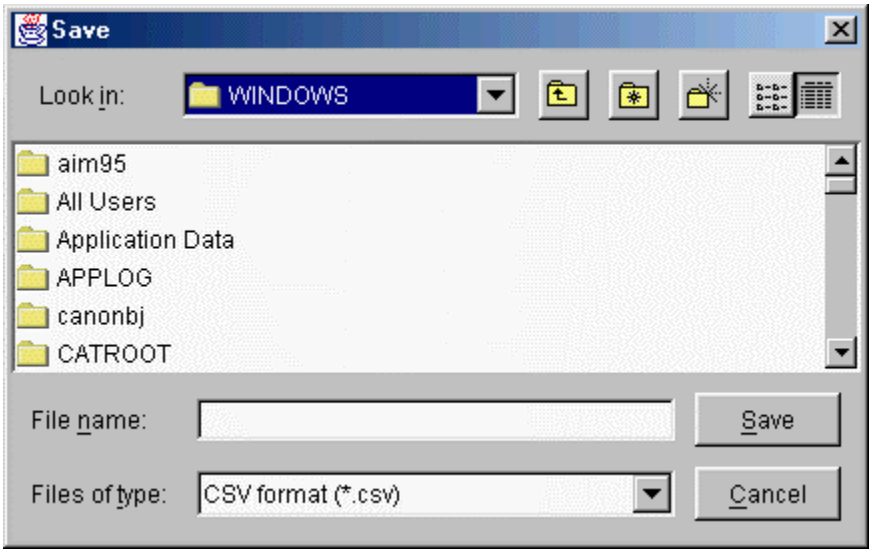
Exporting Data

You can use the Export feature to export current settings to a CSV-formatted file, which can be read by other programs such as Microsoft® Excel.

To export data:

1. From the File menu, select **Export Data**.

   The Save dialog box appears.



2. Enter a file name and location for the file.
3. Click **Save**.

   Each battery is represented by a row of information in the file with the data arranged as follows:

   - Battery ID
   - String ID
   - Sensor ID
   - Cell temperature
   - Voltage
   - Current
   - Ambient temperature

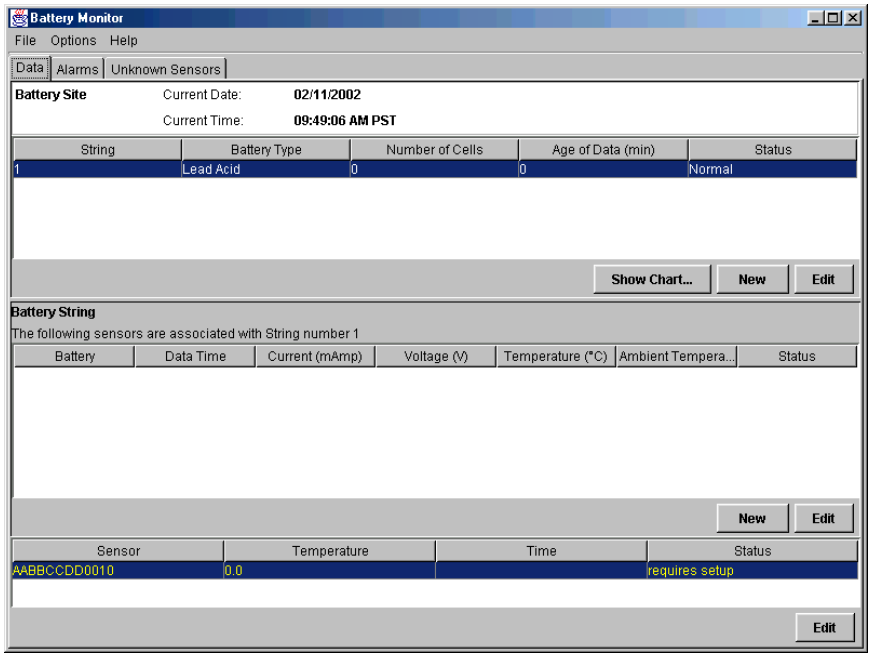
4 Setting Up Battery Strings

With the BattGuard system you can set up and configure battery strings before or after the Telesensors are actually installed. Depending on the status of your installation, use one of the following procedures:

- If Telesensors are already installed and operating (green "CON" LED flashing and red "STA" LED off, with an occasional blink), go to "Telesensors Installed – On-Line Configuration" on page 4-1.
- If Telesensors have not yet been installed, go to "Telesensors Not Installed – Off-Line Configuration" on page 4-4.
- To make changes to Telesensor data, go to "Modifying and Deleting String Settings" on page 4-7.

Telesensors Installed – On-Line Configuration

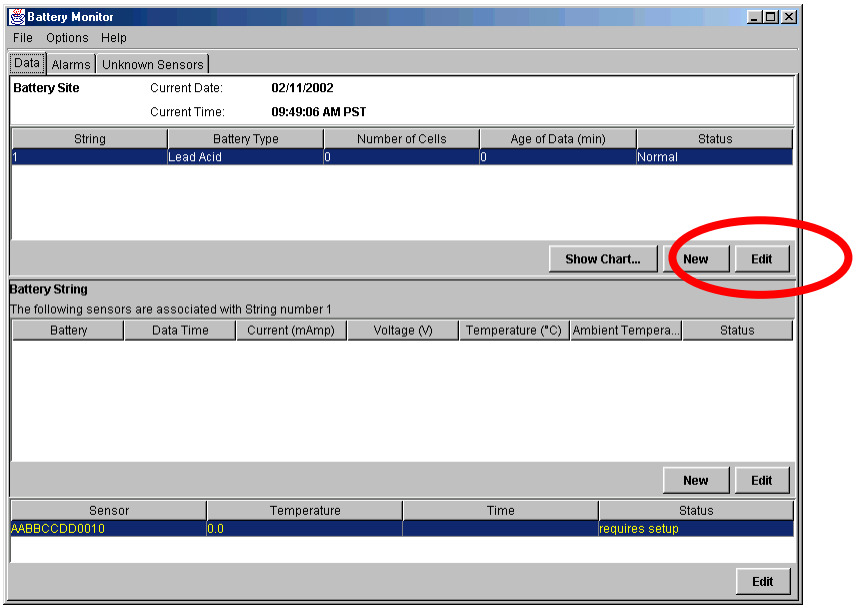
If Telesensors have been installed and programmed, data appears in the Data tab, where you can perform the required setup.



Setting Up the Strings

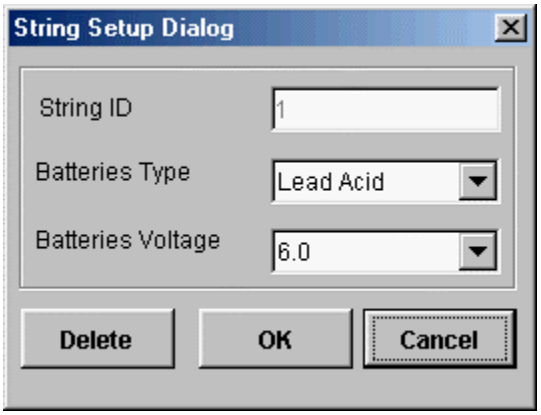
The first step is to set the battery type and voltage for each string.

1. From the Data tab, select the string from the list.



2. Click the **Edit** button as shown above.

   The String Setup Dialog box appears.

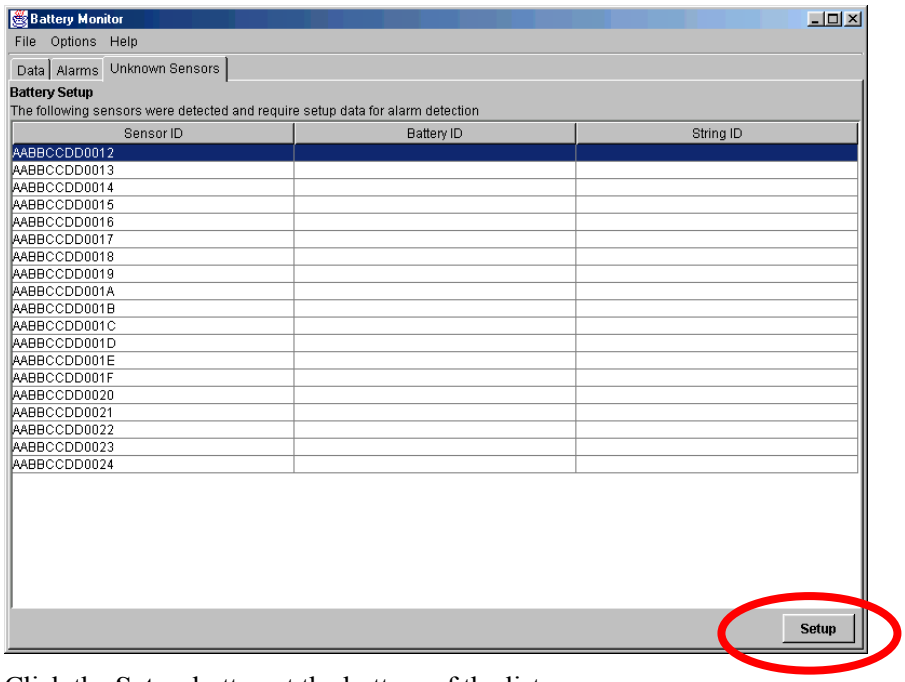


3. Enter the following information:
   - **Batteries Type** – Select the type of battery from the list.
   - **Batteries Voltage** – Select the voltage for batteries in the string from the list.
4. Click **OK**.

Setting Up Batteries

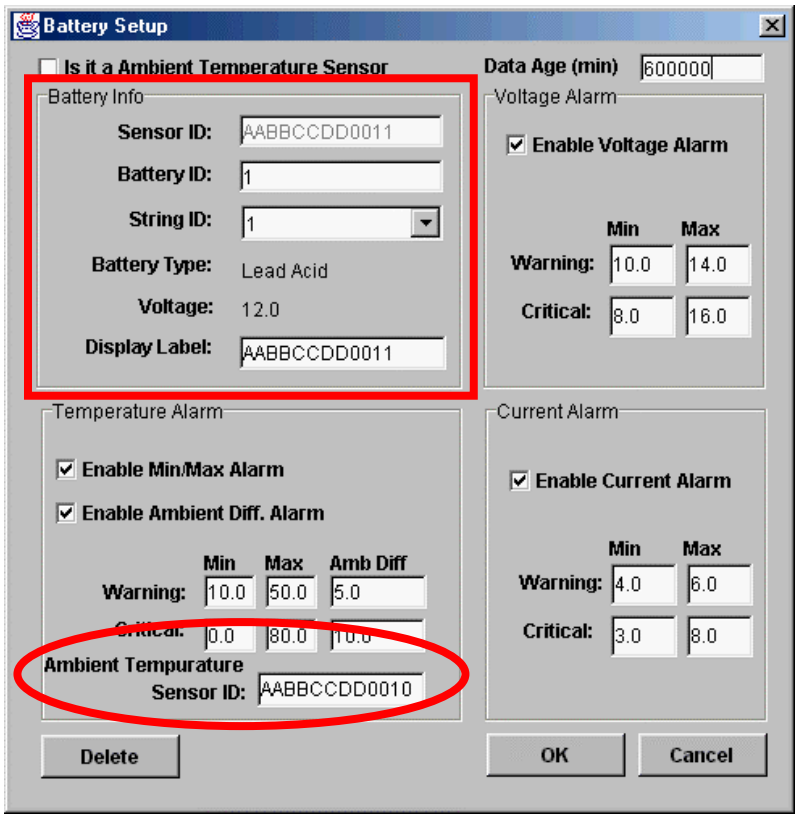
Once each string has been set up, you need to set up each battery in the string.

1. From the Unknown Telesensors tab, select the battery to be set up.



2. Click the **Setup** button at the bottom of the list.

   The Battery Setup dialog box appears.



3. Set the battery information (Battery Info) options and the Ambient Temperature Telesensor ID.
4. Click **OK**.

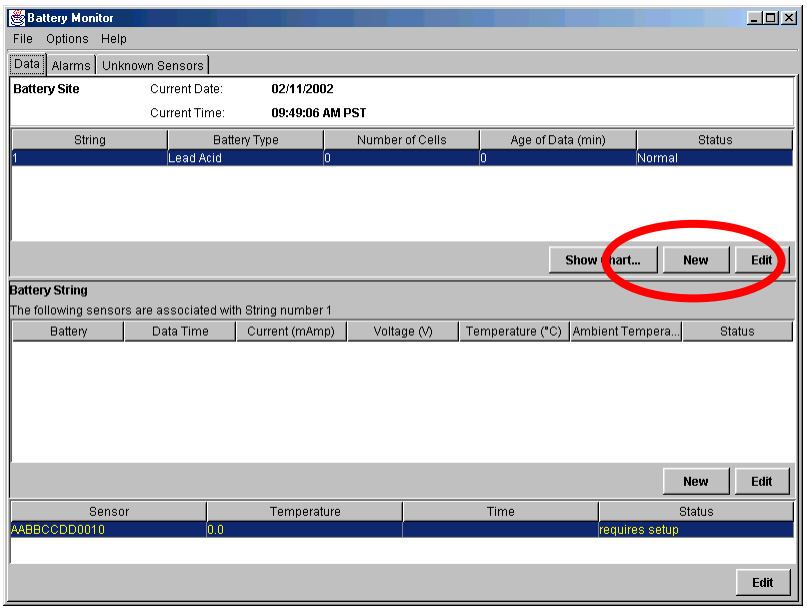
Telesensors Not Installed – Off-Line Configuration

You can set up string and battery information before physically installing the Telesensors.

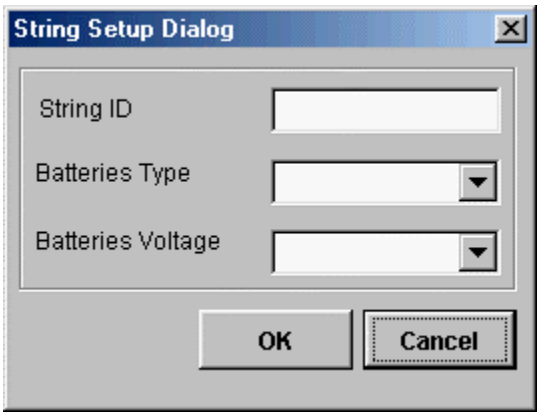
Setting Up New Strings

To set up new strings:

1. From the Data tab, click the **New** button at the top of the window.



2. The String Setup Dialog box appears.



3. Enter all the necessary information:
   - **String ID** – The string ID assigned to this string.

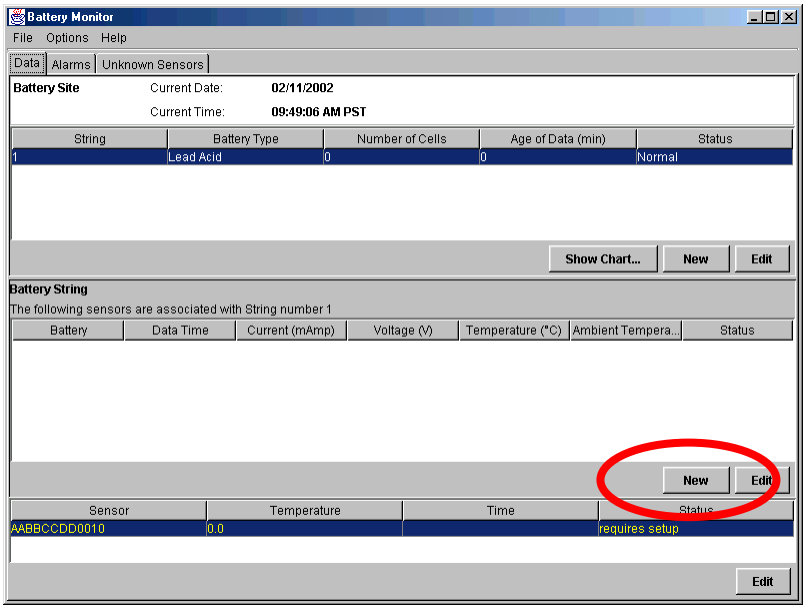
- **Batteries Type** – Select the type of battery from the list.
- **Batteries Voltage** – Select the voltage for batteries in the string from the list.

4. Click **OK**.

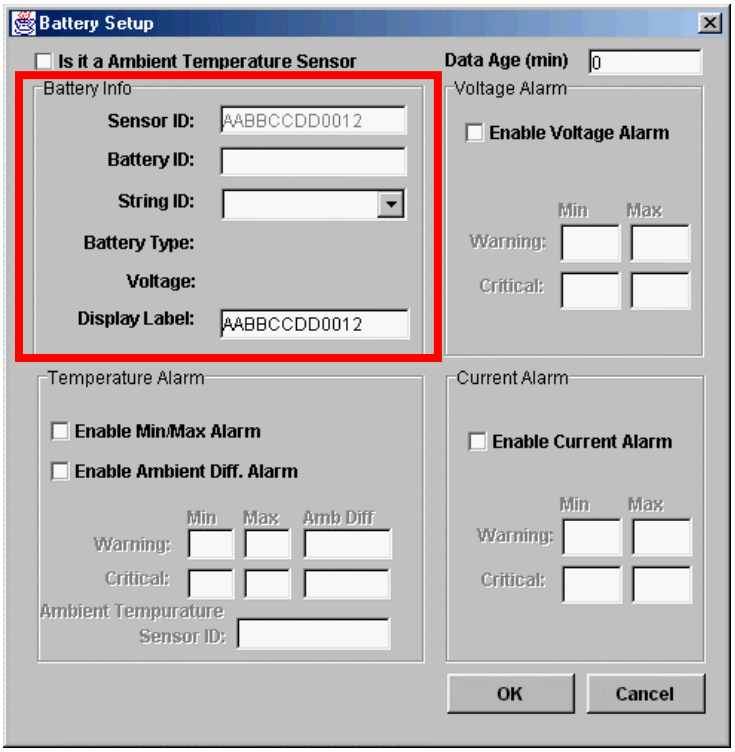
Setting Up Batteries

Once each string has been added, you must set up each battery in the string.

1. From the Data tab, click the **New** button at the bottom of the list of batteries.



The Battery Setup dialog box appears.

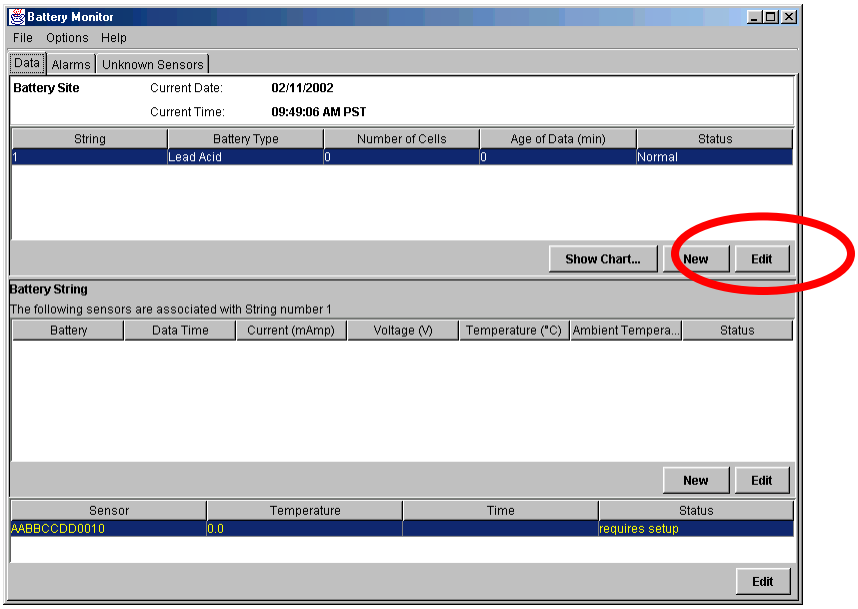


2. Set the battery information (Battery Info) options and the Ambient Temperature Telesensor ID.
3. Click **OK**.

Modifying and Deleting String Settings

To modify string settings:

1. From the Data tab, select the string for which you want to modify settings.



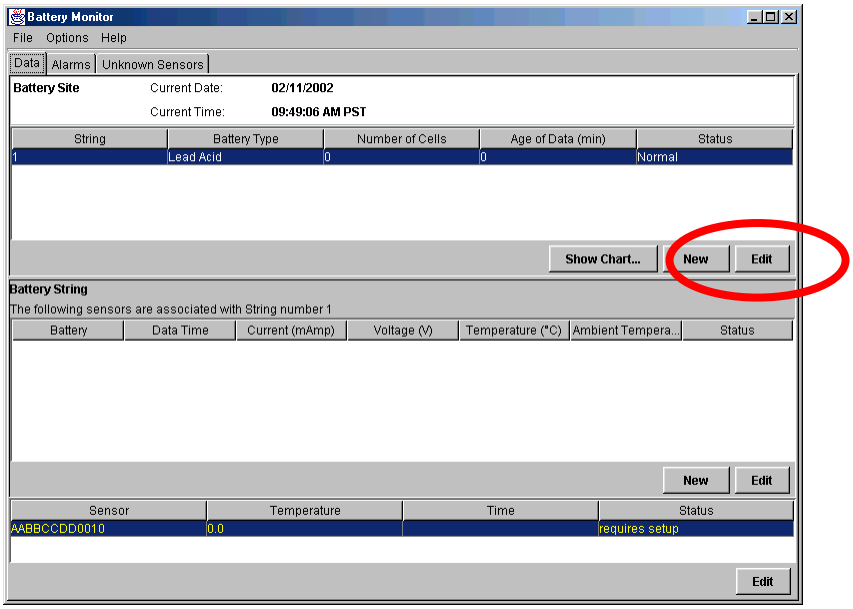
2. Click the **Edit** button at the top of the list of strings.

   The String Setup Dialog box appears.

3. Change the following information as desired:
   - **Batteries Type** – Select the type of battery from the list.
   - **Batteries Voltage** – Select the voltage for batteries in the string from the list.
4. Click **OK**.

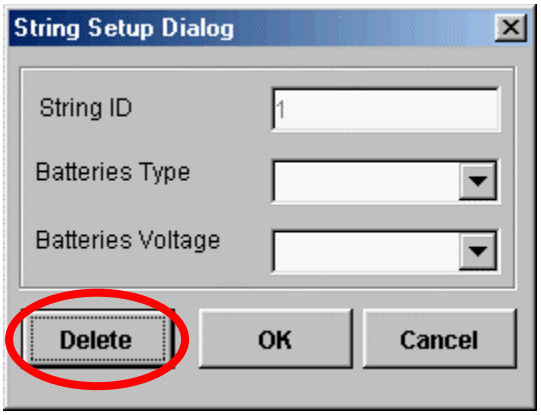
To delete a string:

1. From the Data tab, select the string you want to delete.



2. Click the **Edit** button at the top half of the window.

   The String Setup Dialog box appears.



3. Click **Delete**.

   The selected string is deleted.

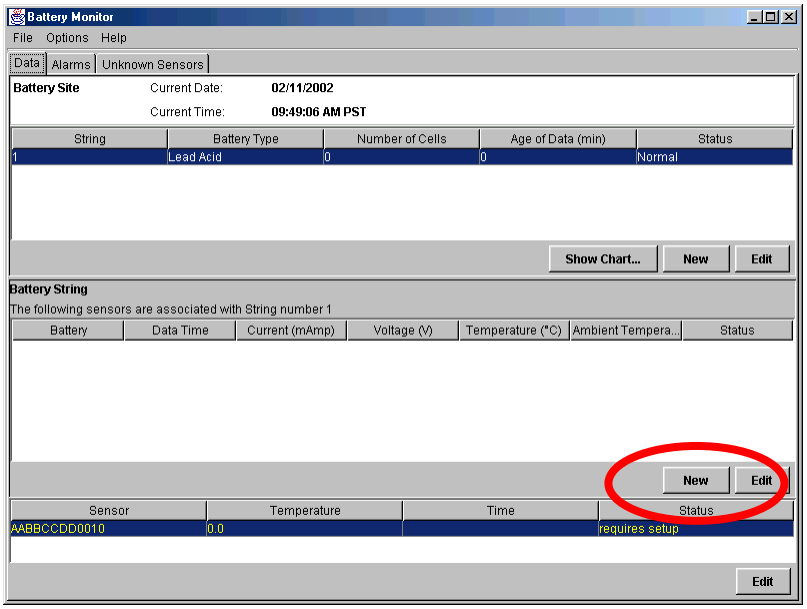
5 Setting Up Alarms

Alarm conditions exist when BattGuard receives Telesensor readings that exceed the previously defined alarm limits for a specific battery. Each battery may be assigned “warning” and “critical” thresholds for its voltage, current, and temperature values.

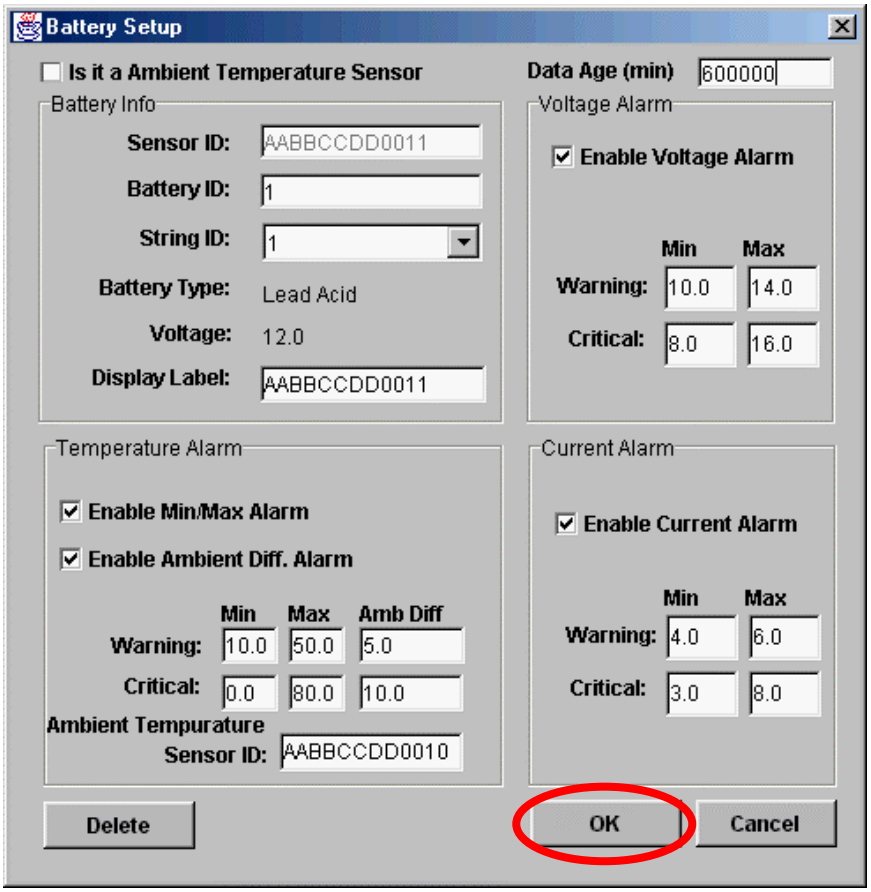
This section explains how to set up battery information and alarm settings.

To set up batteries and alarms for a battery:

1. From the Data tab, click the **New** button at the bottom of the list of batteries.



The Battery Setup dialog box appears.



2. Set the following options, and click **OK**:

   - **Is it an Ambient Temperature Telesensor** – Select if this Telesensor is an ambient temperature Telesensor. The ambient temperature is the temperature measurement from a location other than the currently selected battery.
   - **Data Age –** The age (in minutes) beyond which data is considered out-of-date. Out-of-date data generates an alarm.

   Temperature Alarm

   - **Enable Min/Max Alarm** – Select this option to enable the temperature alarm. The temperature is monitored and an alarm is generated when the temperature is out of the specified range.
   - **Enable Ambient Diff. Alarm** – Select this option to enable the ambient temperature alarm. The ambient temperature is monitored and an alarm is generated when the difference between the temperature measured at the battery and the temperature measured at the designated "ambient temperature sensor" is out of the specified range.

- **Warning** – Set the minimum and maximum temperatures for a warning alarm. Temperatures falling below the minimum and above the maximum will trigger a “warning” level alarm.
- **Critical** – Set the minimum and maximum temperatures for a critical alarm. Temperatures falling below the minimum and above the maximum will trigger a “critical” level alarm.
- **Amb Diff** – Set the ambient temperature difference to trigger warning and critical alarms. An alarm is generated when the difference between the battery temperature and the ambient temperature is out of the specified range.
- **Ambient Temperature Telesensor ID** – The ID for the ambient temperature Telesensor. The temperature is measured at every battery shunt and at every Telesensor. Because of temperature gradients due to such factors as sunlight, ventilation patterns and doorways, one or more Telesensors may be designated as locations which best represent ambient conditions. Cell temperatures measured at each shunt may then be compared to one of these representative ambient sensors to accurately detect cell heating problems.

Voltage Alarm

- **Enable Voltage Alarm** – Select this option to enable the voltage alarm. The voltage is monitored and an alarm is generated when the voltage is out of the specified range.
- **Warning** – Set the minimum and maximum voltages for a warning alarm. Voltages falling below the minimum and above the maximum will trigger a “warning” level alarm.
- **Critical** – Set the minimum and maximum voltages for a critical alarm. Voltages falling below the minimum and above the maximum will trigger a “critical” level alarm.

Current Alarm

- **Enable Current Alarm** – Select this option to enable the Current alarm. The current is monitored and an alarm is generated when the current is out of the specified range.
- **Warning** – Set the minimum and maximum currents for a warning alarm. Current falling below the minimum and above the maximum will trigger a “warning” level alarm.
- **Critical** – Set the minimum and maximum currents for a critical alarm. Current falling below the minimum and above the maximum will trigger a “critical” level alarm.

6 Appendices

Appendix A presents a list of symptoms, likely causes, potential impacts, and recommended actions. It also identifies how BattGuard can help prevent each issue.

Appendix B lists IEEE recommendations for battery maintenance.

Appendix A – Battery Diagnostics

Battery Type	Symptom	Problem	Possible Cause	Impact	Recommended Action	How BattGuard Helps
Flooded, VRLA	Resistance readings >20% above installation value or value set by manufacturer.	Excessive resistance compared to installation value or average for string.	Loose connection. Corrosion.	Degradation in performance.	Retorque and retest. If terminal corrosion, clean and check resistance of connection.	Calculated impedance for battery will be >20% greater than average for string.
Flooded, VRLA	Water below low-level line. Specific gravity increases. Electrolyte is normally 1.215, and water is 1.0.	Low electrolyte level.	Normal electrolysis in flooded batteries. Leaks.	Reduced battery capacity.	Add water per manufacturer recommendations. Give equalizing charge to help mix water with electrolyte. Water has lower specific gravity and will sit on top. May take 6-8 weeks for complete mixing to occur in some cells.	Low electrolyte will result in an increased calculated impedance reading.
Flooded, VRLA	Cell temperatures deviate more than 3°C (5°F).	Differing response to charge on same string.	Inadequate airflow in room or enclosure. Proximity of some batteries to heat or cold source.	Some batteries overcharge, some undercharge leading to reduced capacity.	Adjust temperature environment of batteries or contact battery manufacturer to determine how best to compensate.	Differences in ambient temperature for each battery on the string will be apparent.
Flooded, VRLA	Excessive temperature. Thermal runaway.	High float voltage - overcharging	Incorrect charger settings. Defective charger / UPS.	Loss of water in flooded cells and dryout in VRLA cells. Accelerated corrosion and shedding of active material from positive plates	Check charger/UPS settings. Service charger/UPS.	Battery ambient and shunt temperatures will be significantly higher than average for string. Steady state float voltage and current will be higher than normal.
Flooded, VRLA	Loss of active material from negative plates. Sulfate crystals hardening on plate surfaces.	Loss of active material from negative plates. Sulfate crystals hardening on plate surfaces.	Incorrect charger settings. Defective charger / UPS.	Permanent loss of battery capacity	Check charger/UPS settings. Service charger/UPS.	Steady state float voltage and current will be lower than normal
Flooded, VRLA	Higher float voltage needed to maintain charge. If charger is not adjusted to provide higher float voltage, cells may be undercharged leading to problems described under low float voltage.	Loss of active material from negative plates. Sulfate crystals hardening on plate surfaces.	Poor or non-existent ambient temperature control.	Loss of capacity.	Install battery enclosure with regulated heat source. If temperature cannot be increased, consult battery manufacturer for appropriate charge level at the ambient temperature.	Ambient temperature reading will be <77°F.
Flooded, VRLA	High temperature causes increased float current. Increased corrosion. Gassing.	High temperature at batteries.	Poor or non-existent ambient temperature control.	Loss of battery life. Gassing, which means loss of water in flooded cells and dryout and thermal runaway in VRLA cells. Tests demonstrate that battery life is approximately 50% for each 10°F increase in ambient temperature above 77°F.	Install battery enclosure with regulated cooling source. If temperature cannot be reduced, consult battery manufacturer for appropriate charge level at the ambient temperature.	Ambient temperature reading will be <77°F.
Flooded	Temperature increase.	Thermal runaway.	Excessive temperature at batteries. Excessive float voltage.	Melting of jar. Possible fire or explosion in extreme cases.	Take steps to ensure that batteries are maintained at 77°F. Consult battery manufacturer to determine appropriate charge voltage for battery at its ambient temperature.	Ambient and shunt temperature readings will be significantly higher than normal or than string average.

Appendix B – IEEE Recommended Battery Maintenance Programs

Vented Lead-Acid Batteries for Stationary Applications (Flooded Batteries) (IEEE STD 450-1995)

Monthly Inspection – Check and Record:

a. Float voltage measured at battery terminals

b. General appearance and cleanliness of the battery, the battery rack and/or battery cabinet, and the battery area

c. Charger output current and voltage

d. Electrolyte levels

e. Cracks in cells or leakage of electrolyte

f. Any evidence of corrosion at terminals, connectors, racks or cabinets

g. Ambient temperature and ventilation

h. Voltage, specific gravity, and electrolyte temperature of pilot cell (if used)

i. Unintentional battery grounds

Quarterly Augmentation of Monthly Inspections – Check and Record:

a. Specific gravity of 10% of the battery cells

b. Voltage of each cell and total battery terminal voltage

c. Temperature of electrolyte of 10% of the battery cells (suggestion: take the temperature of the cells used in the specific gravity test in item a, above)

Annual Augmentation of Quarterly Inspections – Check and Record:

a. Specific gravity of each cell

b. Cell condition (detailed visual inspection of each cell in contrast to the general monthly inspection)

c. Cell-to-cell and terminal connection detail resistance

d. Structural integrity of the battery rack and/or cabinet

Valve-Regulated Lead-Acid (VRLA) Batteries for Stationary Applications (IEEE STD 1188-1996)

Monthly Inspection – Check and Record:

a. Overall float voltage measured at the battery terminals

b. Charger output current and voltage

c. Ambient temperature and the condition of ventilation and monitoring equipment

d. Visual individual cell/unit condition to include:

    1. Cell/unit integrity for evidence of corrosion at terminals, connections, racks or cabinet

    2. General appearance and cleanliness of the battery, the battery rack or cabinet and battery area, including accessibility

    3. Cover integrity and check for cracks in cell/unit or leakage at electrolyte

    4. Excessive jar/cover distortion

Quarterly Augmentation of Monthly Inspections – Check and Record:

a. Cell/unit internal ohmic values

b. Temperature of the negative terminal of each cell/unit of the battery

c. For applications with a discharge rate of 1 hour or less, a representative sample of the intercell connection detail resistances (minimum 10% or six connections). If an upward trend is detected from the initial readings, measure all connection resistances, determine the cause, and take corrective action as needed. Test different connections each quarter.

Semiannual Augmentation of Monthly Inspections – Check and Record:

a. Voltage of each cell/unit

Yearly Augmentation of Monthly Inspections – Check and Record:

a. Cell-to-cell and terminal connection detail resistance of entire battery

b. AC ripple current and/or voltage imposed on the battery

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