Tech20030716-3-0

Alarm Functions

Operation and set-up of Alarm Functions

Battery powered UPS systems rely upon the integrity of the batteries to be able to support the UPS when utility power fails. Therefore control circuits in the UPS monitor the overall voltage on the battery and try to maintain this voltage at the defined 'float charge' voltage. With regular maintenance of the UPS, these systems can generally be relied upon to maintain the overall string or battery voltage within defined limits. Most UPSs have the facility to indicate locally and remotely, if the overall battery voltage cannot be maintained within the defined range.

Unfortunately, this level of control and indication cannot show if individual elements (blocs) of the battery are performing poorly but only string level information. To obtain this greater level of information requires a battery monitoring system.

Cellwatch™ provides the means to comprehensively monitor the condition of each bloc in a battery system by regularly monitoring the voltage and ohmic value of the blocs or jars. It not only presents the user with snapshot information on the status of each bloc, but also provides access to historical data for these blocs.

Because of the level of detail available from the system, and because battery faults have varying degrees of significance, Cellwatch™ is designed to be used in an interactive manner. The predominant output from Cellwatch™ is the visual display.

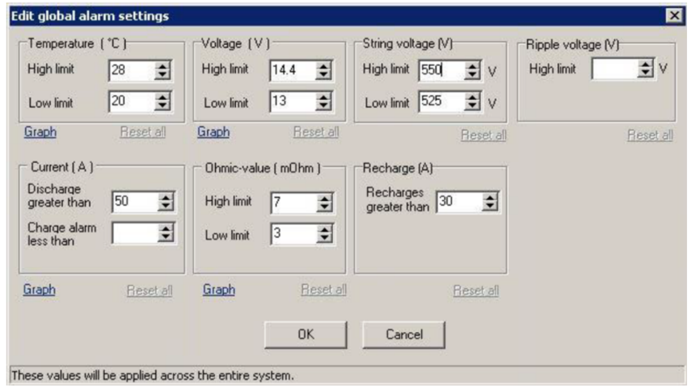
The graphical user interface presents a simple way of determining the status of the monitored blocs, and it also gives summary information at string and battery level.

Alarm Indication Philosophy and Implementation in Cellwatch™

The alarm notification philosophy adopted in Cellwatch™ compliments the monitoring philosophy, by comparing individual bloc parameters to their associated alarm level settings. Any excursions outside the defined limits are then highlighted graphically for the user.

The parameters that are monitored against defined alarm levels are:

- **Bloc (or jar) and String Voltage** – upper & lower voltage limits are specified
- **Bloc (or jar) Ohmic value** – upper & lower ohmic value limits are specified
- **Temperature** - upper & lower temperature limits are specified
- **String Current** - upper & lower string current limits can be specified
- **String Voltage** – upper and lower string voltage limits can be specified
- **String Ripple Voltage (Ext. Feature)** - upper string ripple voltage limits can be specified
- **String Recharge Current** – lower limit or minimum current required for detecting recharge current can be specified



These seven settings are shown in the 'Edit global alarm settings' dialogue box illustrated above:

If ANY of the monitored values drift outside the defined alarm levels, an alarm condition will be indicated.

For example, if the voltage or ohmic value on any **one** bloc should go higher than the High Limit OR Lower than the Low Limit, then this will be indicated by the bloc depiction turning from **GREEN** to **RED**. At the same time, the indicator on the tab for the String and Battery that contains this bloc, will change from **GREEN** to **RED**, and the dry contact associated with Voltage or ohmic value, will be activated.

The purpose of this philosophy is to alert the operator of the battery system, to a potential problem that requires further investigation. To gain more information about the cause of the alarm requires the operator to interrogate the Cellwatch™ system – either locally or remotely.

The benefit of this detail approach over the more global 'overall string' approach is that the operator is encouraged to ascertain the nature and severity of the problem, rather than (perhaps) dismissing it as inconsequential.

Setting the Alarm Levels

Temperature

This is the easiest alarm to set. The standard operating temperature for a lead acid battery is 25ºC (77ºF). For every 8ºC (15ºF) increase in temperature the battery can experience a 50% drop in life expectancy. Similarly the performance measured as a percentage of available capacity falls off rapidly as the temperature is reduced. At 10ºC (50ºF), battery performance is down to 85% to 90% compared to that available at 25ºC.

Therefore both upper and lower temperature alarm limits should be programmed in Cellwatch and both manufacturer's specifications as well as the planned capacity and capability of any temperature/environmental control systems should be taken into consideration. Cellwatch can operate either in Celsius or Fahrenheit depending on what the users has selected on the desktop. By default all temperature readings are recorded as Celsius and are converted to Fahrenheit when a user views a history file.

DCM Temperature (Requires DCM 5 T)

Cellwatch 4.2 provides the feature of temperature probe readings on the sense wires for each channel measured. The temperature sensors on the DCM 5 are connected to the negative post along with the sense wire for voltage and ohmic readings. Post temperatures are recorded for each cell/jar and therefore each cell/jar will respond independently to the temperature alarm settings. The temperature alarms will trigger according to the alarm value defined in the String/Battery/Global settings. This means the temperature alarm may be active for an individual or a subset of jars without the string or ambient alarm activating. This alarm value is vital for providing Thermal Runaway detection in an open rack environment where the temperature of each jar needs to be individually monitored.

Current

The standard Cellwatch current probe can measure up to 1000 amps DC. The current probe is capable of withstanding 1,500 amps before saturation. Attempting to measure low charge currents below 10 amps accurately is almost impossible with such a wide range device.

Discharge

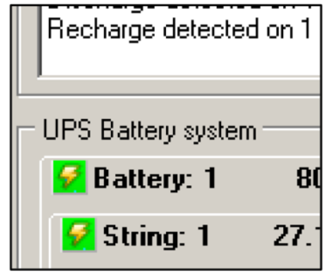
We recommend setting the ***"Discharge greater than"*** value to approximately ½ the actual load current of the string. This value is used to initiate the discharge scan routine. If the minimum maintained current conditions defined in the cellwatch.ini file (default value is 5 seconds) the discharge alarm will be initiated and the resulting discharge file will be saved. The value should be determined by looking at the actual and not theoretical or designed loading of the string and the UPS or perhaps by reviewing the capacity of the battery as a whole. If the value is set too low, load fluctuations, electrical noise and phase changes in the UPS may cause numerous 'nuisance alarms' to be triggered. These would be short meaningless data files that fill up the HDD of the system and trigger alarms, if connected.

Instead, set a value (most often above 50 amps) that represents 50% to 75% of the typical string current in a discharge. Take the load rating of the UPS, divide it by the number of strings being monitored, and then divide it by the string voltage to give the typical string current. This value can be configured as a system alarm or for individual batteries and/or strings.

Take a 300KVA UPS with 2 x 480V strings. 300KVA equals 150KVA per string. Divide each string rating by 480 volts and we get 312 amps. Use 50% of this (156 amps) as the discharge trigger value.

Remember, as the string voltage diminishes under load, the current will always increase (along with temperature) which ensures that the end of the discharge is always captured.

Recharge

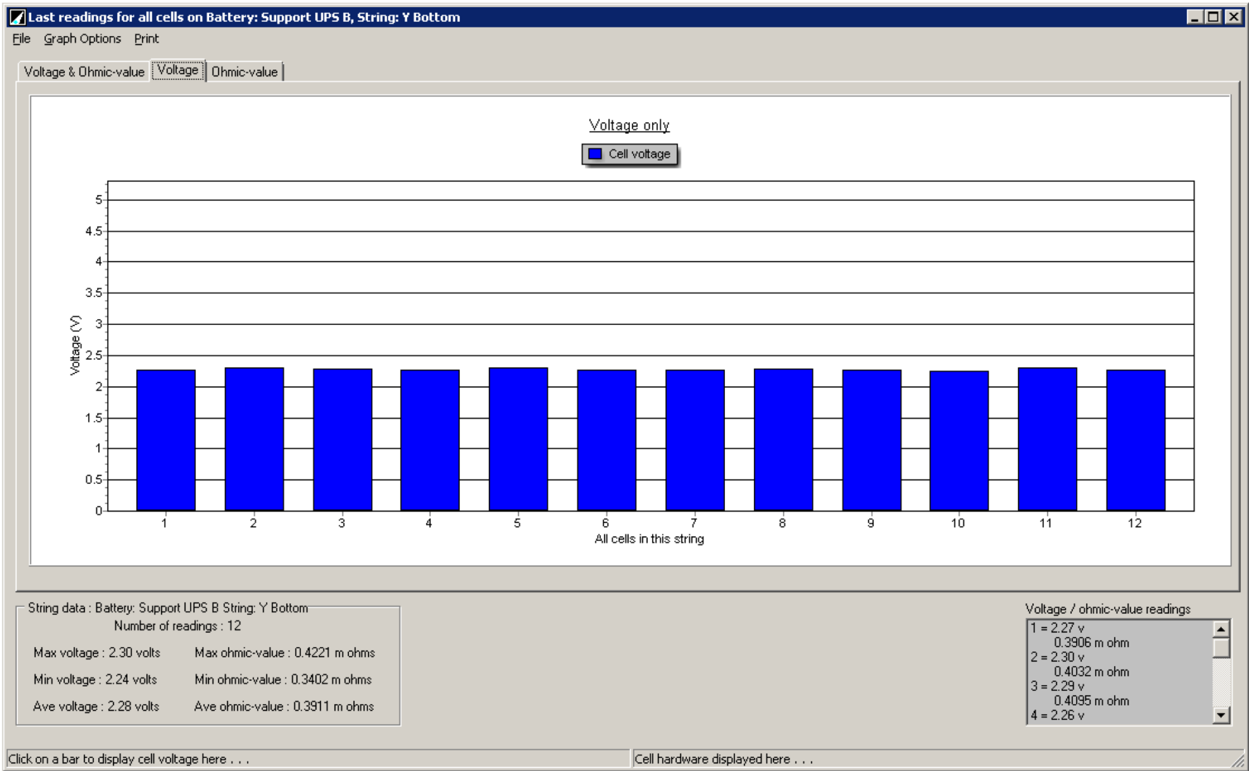


A jars performance while on load and its response time to a recharge current gives greater visibility into the health of a jar. It is possible for a jar or string to perform as expected during a discharge but respond poorly to a recharge current. Cellwatch 4.2 creates a separate recharge file to show a strings performance following a discharge event. When the positive current entering a string exceeds the preset charge alarm limit, Cellwatch will begin writing the recharge file. The voltage will be recorded for each jar, including temperature for each jar if using a DCM 5. String current and string temperature will also be recorded during the recharge period. The software will indicate the recharge event with a small recharge icon in the battery and string tab.

Voltage

Low voltage

The low voltage alarm is intended to indicate a bloc, cell or jar whose voltage is sinking while on float charge due to a short or partially short circuit cell. Low voltage alarms indicate improper charging of a cell which can indicate improper string voltages, imbalance in the string, or failing cells. While it can be temporarily used as a terminal voltage indicator for battery tests, the alarm is NOT intended to be configured as a low discharge voltage alarm setting indicating terminal voltage for cells in a discharge. A typical low voltage value for alarming can be determined from either looking at manufacturer’s specifications or reviewing a voltage scan for the string and selecting a value based on average bloc value and taking into account minimum voltages. For example, consider the following string graph:



This is a typical string voltage graph and shows an average voltage of 13.47 volts – a per cell value of 2.25 volts. Manufacturers such as C&D Technology recommend a low voltage limit of 2.16 volts per cell or 4% drop in voltage. Therefore selecting a voltage level of 4% below this average voltage (12.93V) would provide good voltage alarm sensitivity while not presently causing an alarm trigger (in the above example the present lowest voltage is shown as 13.11v).

High Voltage

VRLA jars or blocs can develop high float voltages prior to failure due to open circuit or partially open circuit cells, although this is seen less often these can be very damaging failure mechanisms. Manufacturers may recommend a figure as high as 9% over average as an indicator of problems. For charging purposes, we recommend a number based upon 105% of average value to pick up high float values while still avoiding false alarms.

Most manufacturers will recommend a maximum float voltage of 2.26 volts per cell. Follow manufacturer recommendations for setting a high float voltage. It is not recommended to set the alarm limit to the equalization voltage (typically 2.3 volts per cell) as equalization settings are typically temporary.

Ripple Voltage (Requires DCM 5 - Extended Feature)

High ripple voltages can indicate that the UPS has failing components. Large ripple levels can cause damage to a battery over time. Some batteries may respond different than others to high ripple voltages. Many manufacturers and some standards bodies recommend a maximum ripple voltage of 5% of the output voltage of the UPS. So for a 540 DC Float Voltage, the recommended AC ripple alarm would be 27 Volts. Little to no ripple voltage is always preferred for the DC battery.

As an extended feature, this feature requires both DCM 5 and an activation code.

String Voltage

A string's overall voltage can be an indicator of voltage imbalance in the string or improper settings on the UPS charger. String level high and low voltage alarms allow for warning based solely on the charge status of string. This can help prevent overcharge and undercharge situations. Small increases of voltage on individual jars may not trigger a per cell/jar alarm. However, the change in overall string voltage can be identified independently and corrective action taken before the battery is damaged.

Alarming in Constant Voltage Scanning mode

Because cells can quickly change in voltage by several millivolts, a new alarming algorithm has been introduced when in constant voltage scan mode.

A cell must remain above the alarm threshold for 5 scans (default setting) before an alarm is considered active. During this qualification period, the cell will remain green but the hover hint will indicate a delay alarm is about to occur.

Users can see the delayed alarm status (via the hover hint), but the log file, emails and relays will not be triggered until the 5 scan threshold has been passed.

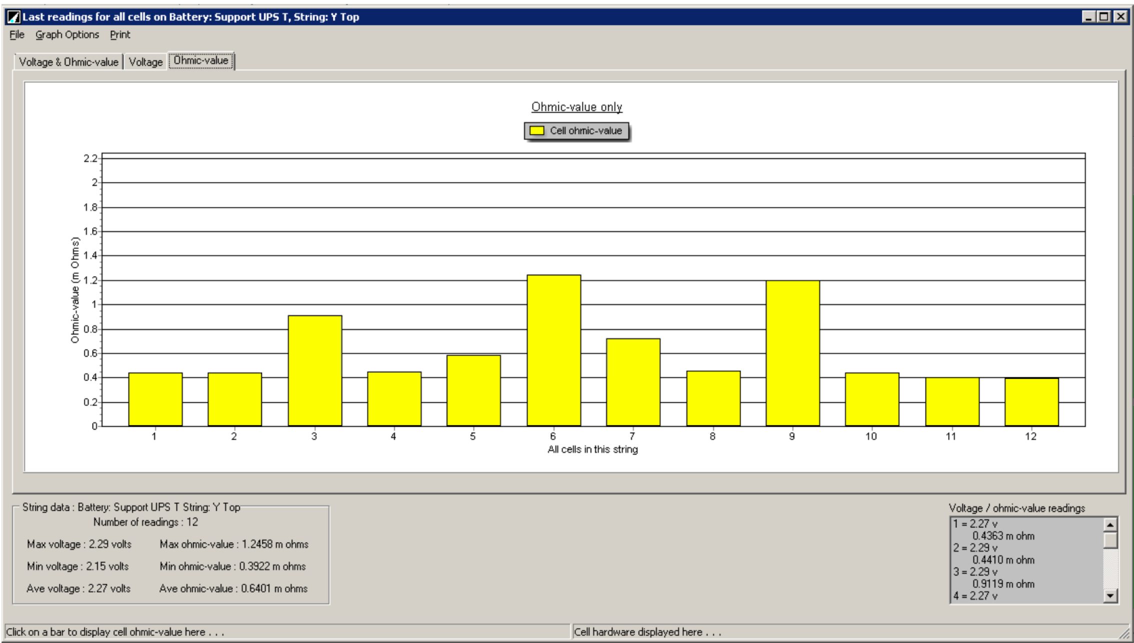
The same logic applies when an alarm clears and the cell transitions from the alarmed (red) back to the non-alarmed (green) state.

Ohmic Value

Ohmic value alarms indicate changes occurring within a cell. There are many issues that can cause changes within the ohmic value of a monitored point. If an ohmic value issue is identified, first check the link and verify the torque of the connection. If the ohmic value does not change after the torques are verified, then the cause is likely due to a change within the cell. Changes can be attributed to micro-fractures within the cell, corrosion of the grid, loss of electrolyte, a decreased reactive surface area, or a number of other issues.

High ohmic value

High ohmic value (or impedance or resistance) is the best and most important indicator of battery health. Generally the ohmic value will rise before the float voltage begins to deteriorate; the two changes often (but not always) go hand in hand.



In the example shown above all the ohmic values are between 0.29 milliohms (mOhms) and 1.25 mOhms. The average ohmic value is 0.39 mOhms. Anything immediately above 25% of the average of the string should be noted and evaluated. In the example above, this would indicate an average string alarm setting of 0.49 mOhms. In the example above cells 3, 6, and 9 all exhibit a higher than average ohmic value. Setting a string level high ohmic value alarm to 0.49 mOhms will cause cells 3, 6, and 9 to alarm.

NDSL recommends a value between 20% and 25% of the average. Some manufactures recommend a value much higher than 25%. A 20% change in an inter-tier or inter-cell strap can be considered significant. As this is included in the ohmic value measurement for Cellwatch, we recommend first checking the torque of an alarmed cell to determine if the increase in ohmic value was related to the connection. If the ohmic value does not decrease back to normal then the jar has increased in ohmic value and should be monitored closely or considered for replacement. A higher than 25% value can be used but many factors should be considered when using alarms this high.

Factors to consider when setting higher alarms:

- **Consider the amount of acceptable risk.** A dropped load is a significant event. Cells that are higher in ohmic value pose a higher risk for being the points of failure during a discharge. Higher alarm settings could put the customer at higher risk.
- **Consider budget concerns.** Replacing individual cells or entire strings can be expensive. Alarms can be used to help plan ahead for which jars that will need to be replaced. Always monitor the rate of change of a cell to determine if it needs to be replaced immediately (i.e. this week) or later (i.e. a couple of months out).
- **Consider the time required for replacement of a defective cell.** Many users may have to wait days, weeks, or months to replace a failing cell. In these cases a conservative alarm is

suggested (20-25%) as this will help ensure the customer has enough time to react. Other users are able to replace a cell in a couple of hours then higher alarms (25+ %) may be suitable.

For best practice individual alarm settings should be configured for each monitoring point by adding this string average percentage to each channel. This ensures that all monitoring points must change the same amount to indicate an alarm. See Auto Set below for instructions on how to quickly configure this setting.

Low Ohmic value

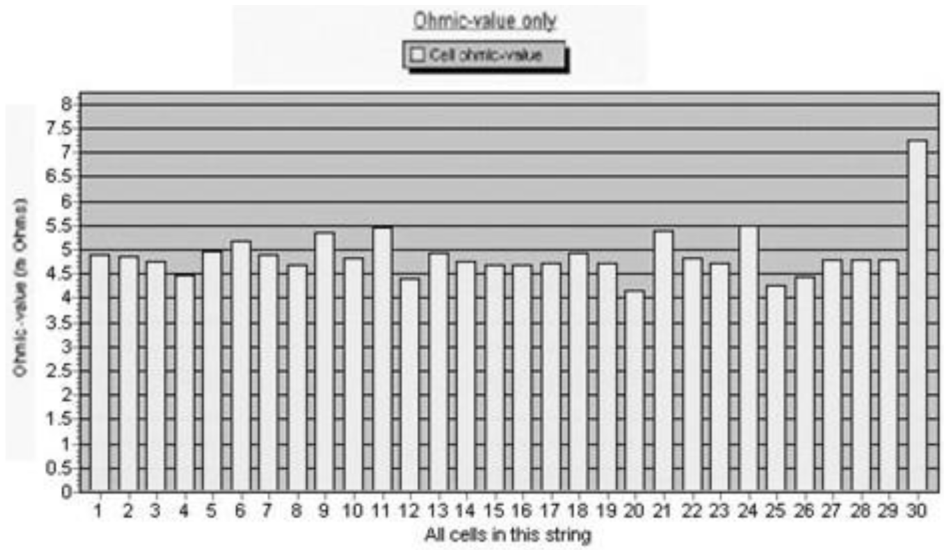
Cells will drop in ohmic value as sulfates dissolve off the plates and revert back to the electrolyte solution. Low ohmic value blocs are seen less often than high values and often go hand in hand with high voltages. We recommend a value of between -20% and -25% of average.

Auto Set Ohmic: Alarms Automatically set individual ohmic value alarms for each cell.

Without proper alarm setting, the Cellwatch system cannot ensure accurate detection of failing jars. The ‘Auto Set Ohmic Alarms’ feature uses actual ohmic value readings and sets alarms based on industry accepted algorithms. As shown in the illustration below, there will often be variances in the ohmic value of cells in a string. This can be due to differences in the jar ohmic value or variations in the cell interconnect straps due to length, corrosion, and even torque.

While setting baseline alarms for the string is still an acceptable way of monitoring overall string health, monitoring the individual ohmic values allows users to better see changes in the individual cells.

In prior versions of the Cellwatch software, the alarm levels for individual cells could be adjusted to accommodate large inter-cell links, but it required a skilled installer and a great deal of time. To reduce the amount of time required, and to minimize the risk of human error during the alarm setting process, Cellwatch 4.0 software will automatically determine the appropriate alarm levels and set the alarms based on an NDSL verified algorithm built into the software.



The *'Automatic Ohmic Alarm Setting'* feature sets individual jar alarm settings automatically. It can be run across the entire system, or may be utilized on a string-by-string basis.

This feature is intended for new batteries and/or new strings added to a mixed battery (one having both new and old strings). It cannot be run system wide on a system with more than 35 days of data. In this situation, it must be run on a string by string basis.

NOTE: This feature should only be run by trained Cellwatch Installers.

Prerequisites for Automatic Ohmic Alarm Setting

Prerequisite conditions have been established to ensure alarms are not set improperly and are stated at the beginning of each of the two options below. Please read these conditions carefully to ensure you understand the features operation and restrictions before using this feature.

Scenario 1: New Installation (New Battery)

This option was designed for new installations that may contain multiple jar types (2v jars, 12v jars, and even 16v jars) on the same Cellwatch system. This option will automatically set the alarm level for each jar on each string on a Cellwatch system.

This option will automatically set the alarm level for each jar on each string on a Cellwatch system.

Prerequisites

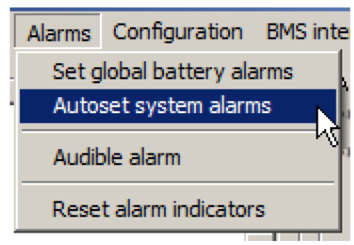
- **At least 1 ohmic value scan has occurred.** An initial ohmic value scan occurs after the Cellwatch is started and the ohmic data is required to run the Alarm Autoset feature.

It is good practice to verify the ohmic data of the initial reading for anomalies (for instance, jar straps may need re-torqueing). If anomalies are found, they should be fixed and a new ohmic scan performed.

- **The Cellwatch system has been running for less than 35 days.** This is a protection mechanism to ensure this feature can only be used for new batteries that do not have greater than 35 days of cumulative ohmic value history data. This ensures that users do not automatically reset alarm levels for mature batteries and/or create alarm levels that are beyond acceptable levels for the individual jars.
- **The feature has not been previously executed**. A system wide ohmic alarm Autoset operation should only be run once. Running this multiple times over the life of the battery will continually adjust the alarm limits beyond what is considered acceptable, potentially masking alarm conditions. Cellwatch has built in safe guards to prevent this from happening.

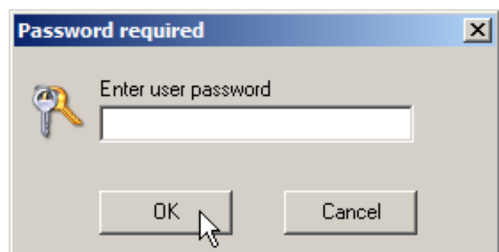
All existing ohmic value alarm settings must be set to the same level, within each string or not programmed.

To activate 'Automatic Ohmic Alarm Setting' click on the "Alarms" menu option located in the top menu bar and then select "Autoset system alarms" from the drop down menu.



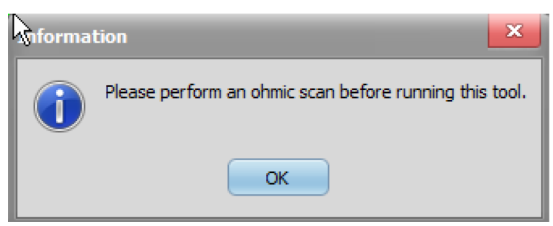
To ensure this is not run by an untrained or unauthorized user, a password must be entered to continue.

After entering the password select OK. If you do not have the password, the function will not execute. Select "Cancel" to return to the Cellwatch main screen. *NOTE: The default password is:* deafcat



Check for ohmic data

If no ohmic value information is present, or if the ohmic value scan has not yet completed, the following warning will appear. Simply click OK and allow the ohmic scan to complete (if it has already started) or manually perform an ohmic value scan using the Scan Settings drop down menu.



More than 35 days of data

If the Cellwatch system has more than 35 days of ohmic value reading data, you will be prevented from continuing (see right) You can still use the Per-String Autoset feature (see Scenario 2, below).

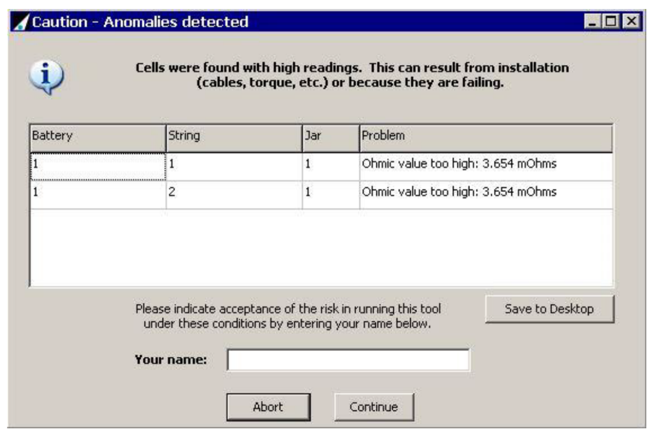
Alarms must be the same on each string

If individual jars have already had manual alarm settings configured within a string, the function will not execute. All alarm settings within a string must be the same value.

Check for anomalies

Finally, the system will check for any jar readings that deviate from the string average.

This verifies that anomalous conditions (a poorly torqued tab or a failing jar) are not about to be masked by the alarm Autoset functionality.



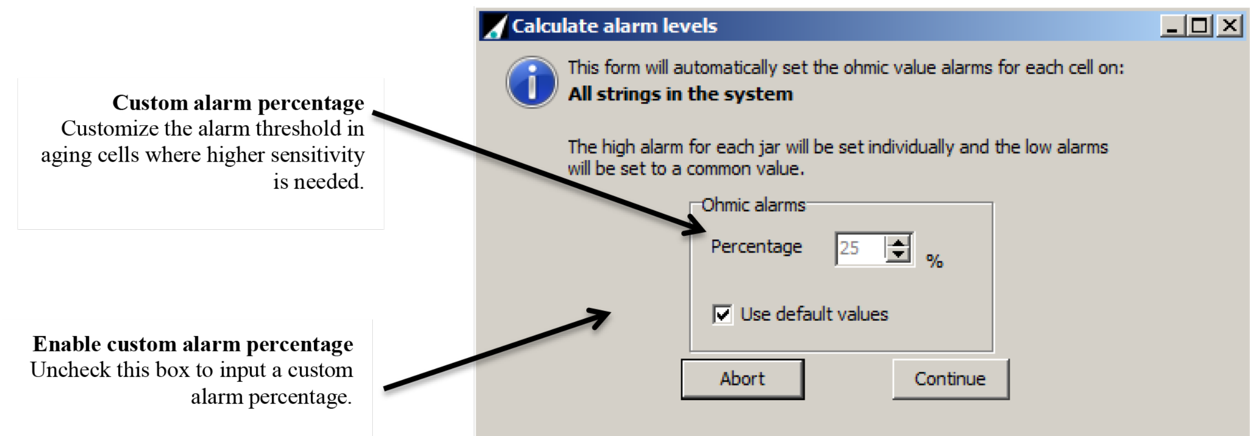
HINT: *Use the Save to Desktop button to export a checklist of the anomalous jars for investigation and resolution prior to continuing with this feature.*

If all of the prerequisite conditions have been met the following prompt will appear. The default setting is 25% above the string latest ohmic value recorded by the Cellwatch system. This setting can be changed by unchecking the ‘Use default values’ box.

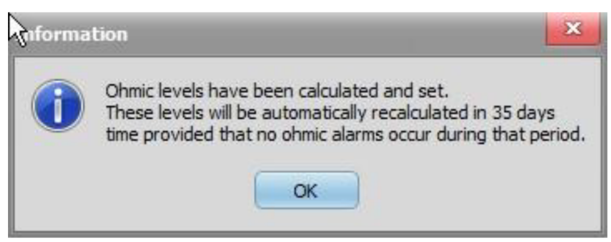
For new strings, Cellwatch recommends an alarm setting of 20% to 25% of the original ohmic value of the cell.

> ***NOTE:*** *When using Cellwatch on older strings, it is recommended to use a lower percentage for calculating alarm levels. A more acceptable value would be 10% or lower depending on the age of the string.*

Press ***'Continue'*** to set the alarms for all battery strings currently configured on the Cellwatch system.



All alarms for all battery strings will be programmed at the calculated level, using the selected percentage above the current measured ohmic reading. Once the alarms have been set a dialog will appear informing the user that the alarm levels will be automatically recalculated in 35 days' time (right).



Recalculation after 35 days

The Cellwatch system will count 35 days and then the alarms will automatically be recalculated without user intervention. During the first 30 days of a battery installation it is not uncommon for cell ohmic values to drop slightly due to the charge process and settling of the cells. This new baseline ohmic value is taken into effect and recalculated automatically without user intervention.

After 35 days, the Cellwatch system will automatically recalculate the ohmic alarm settings for all jars on all strings based on the new measurements.

IMPORTANT: *Enable custom alarm percentage Uncheck this box to input a custom alarm percentage. Custom alarm percentage Customize the alarm threshold in aging cells where higher sensitivity is needed. Page 12 of 21 Tech20030716-3-0 Alarm Functions This feature will not run on any strings on which there was an ohmic alarm during this 35 day time period (or if there are active ohmic alarms). The Cellwatch system will inform the user if any alarms are present and will record this information to the Cellwatch log file.*

Scenario 2: New Strings on an Existing Cellwatch System

Prerequisites

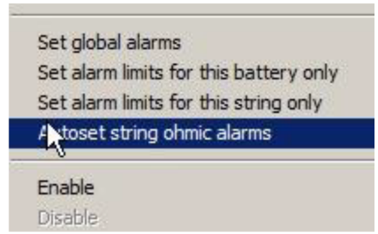
- **At least 1 ohmic value reading has been taken.** The initial ohmic value scan occurs anytime Cellwatch is started. Cellwatch must have this ohmic value data to run this operation. All existing ohmic value alarms on the string must be set to the same level.
- **There must be no ohmic alarms on this string**
  Unlike the system wide Autoset, when running on a per string basis, there must be no ohmic alarms on the target string. To clear active alarms either:

  a) Adjust the alarm levels for this string and manually perform a new ohmic scan or
  b) Click the Alarms menu, then click Reset alarm indicators (Note: this will clear all alarms on the system until the next scan)

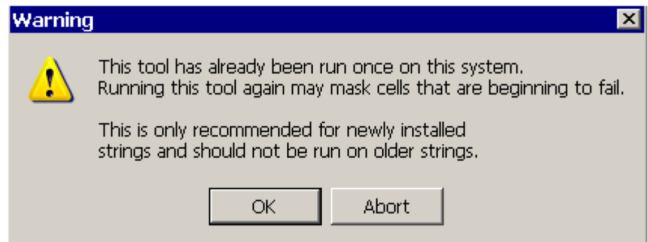
Regardless of the length of operation or the volume of history data available, there is an option for running an automatic ohmic alarm setting for individual strings. This feature is intended for new strings added to an existing battery or Cellwatch System and can be used at any time to set the ohmic value alarms.

NOTE: *This feature will only run for the individual string and not the entire Cellwatch System.*

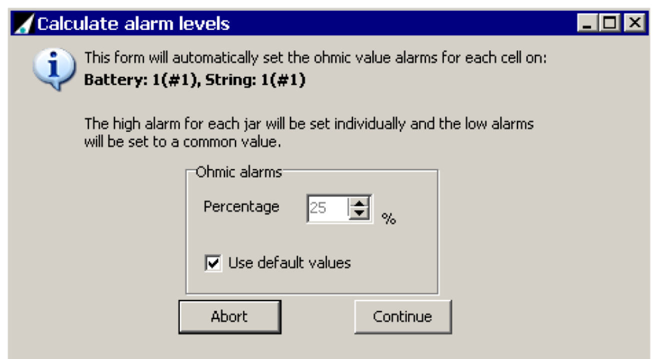
To access the feature, right click on the string tab for the appropriate string and click on ***"Autoset string ohmic alarms".***



If the Autoset function has already been executed the warning shown to the right will appear.



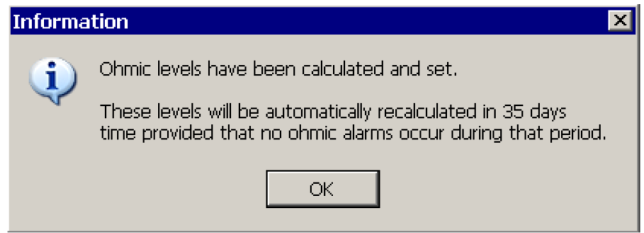
Regardless of the amount of Cellwatch ohmic data available for the string, this feature will execute.



This does not prevent the user from running the feature. It is to prompt the Cellwatch installer or user to evaluate the age of the strings being monitored and ensure this string is a new string being configured and not an aging string. Running this feature on aging strings will adjust alarm levels and can mask failing cells. By selecting "Ok" the feature will continue.

Note the controls are mostly the same for the string level activation and the controls for new battery settings. The only difference is that the string being set is identified and the feature will only run on a single string at a time. The user can proceed using the default settings or can select an alternative percentage by deselecting the default option and adjusting the percentage before continuing.

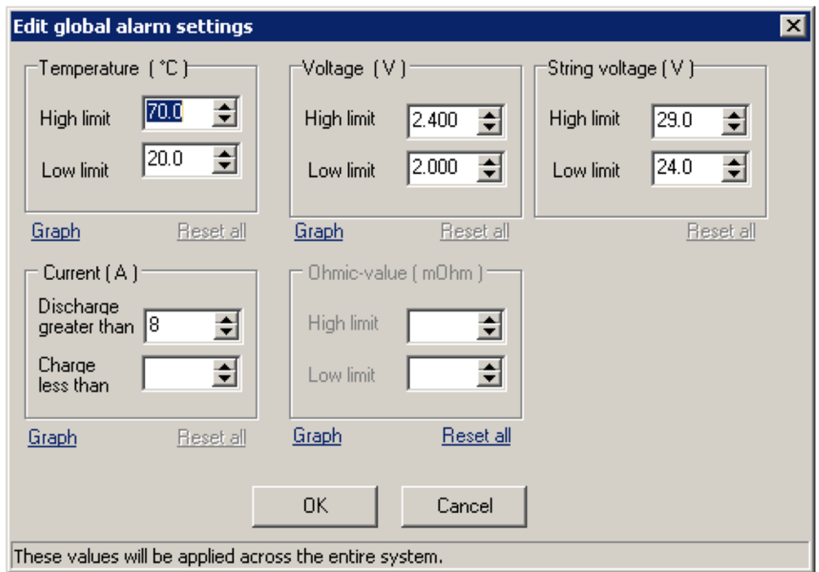
As with the New Battery option the system will automatically set the ohmic value again in 35 days.



Special notes for Ohmic Value Alarms

Unique alarms

If the alarm limits are shown grayed out as in the illustration on the right, this is caused by an alarm having been set for a string or a bloc that is different to the rest of the battery.

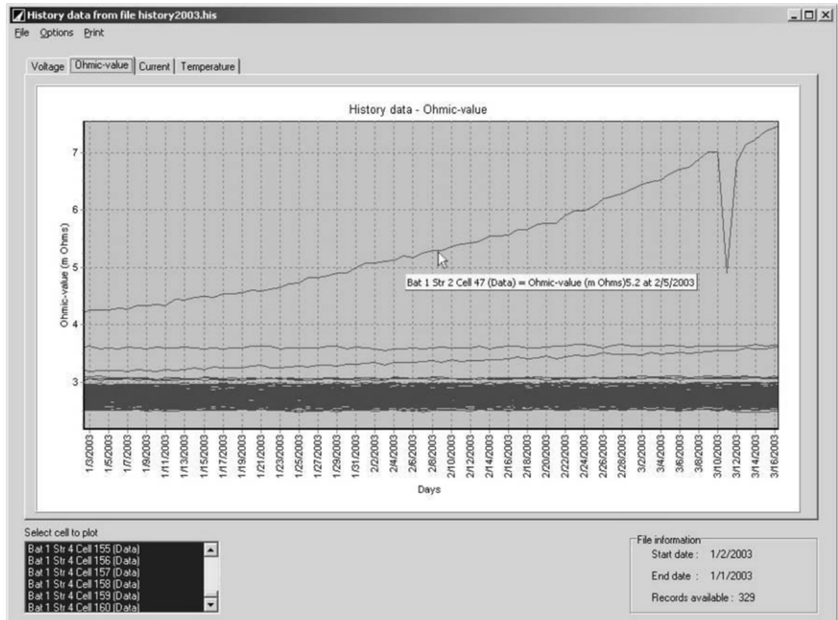


Alarms can be set up for the entire Cellwatch system (all batteries), differently for each battery, different for each string or different for each cell.

To identify which string or cell has been set differently, select ‘Graph’ or left click in the grayed out, white, alarm value data box in the alarm setting window (right). This will bring up an alarm graph showing all alarm settings on the battery.

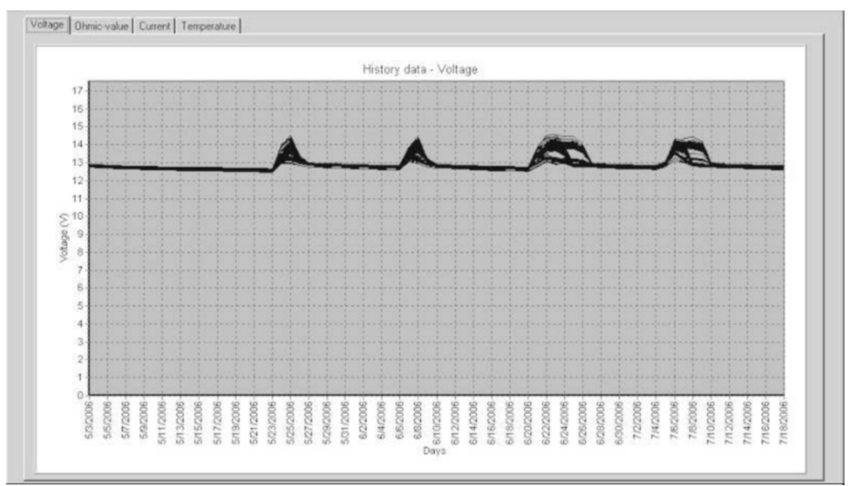
To cancel all special alarms and reset all values back to the value set for the first channel of the first DCM on the entire system, select ‘Reset all’ or press the Ctrl keys while left clicking in a white data box. You will be prompted for a password to reset the alarm indicators. The password is: deafcat.

Repairing ohmic values



Sometimes the electrochemical deterioration of a bloc can be temporarily halted as a result of a significant event such as a discharge and recharge. This can have the appearance of repairing the high trending ohmic value bloc. This is usually not the case. Pretty soon the bloc will pick up its deterioration where it left off and continue its journey to be the weakest link in the battery chain. Change the block after reviewing the history for the failing bloc. To the right is an illustration of the history for bloc 30. It shows that events on the 13th April and again on 27th April caused significant improvement in the ohmic value of the bloc. However, as can be clearly illustrated, the trend always reverts back to an upwards trend.

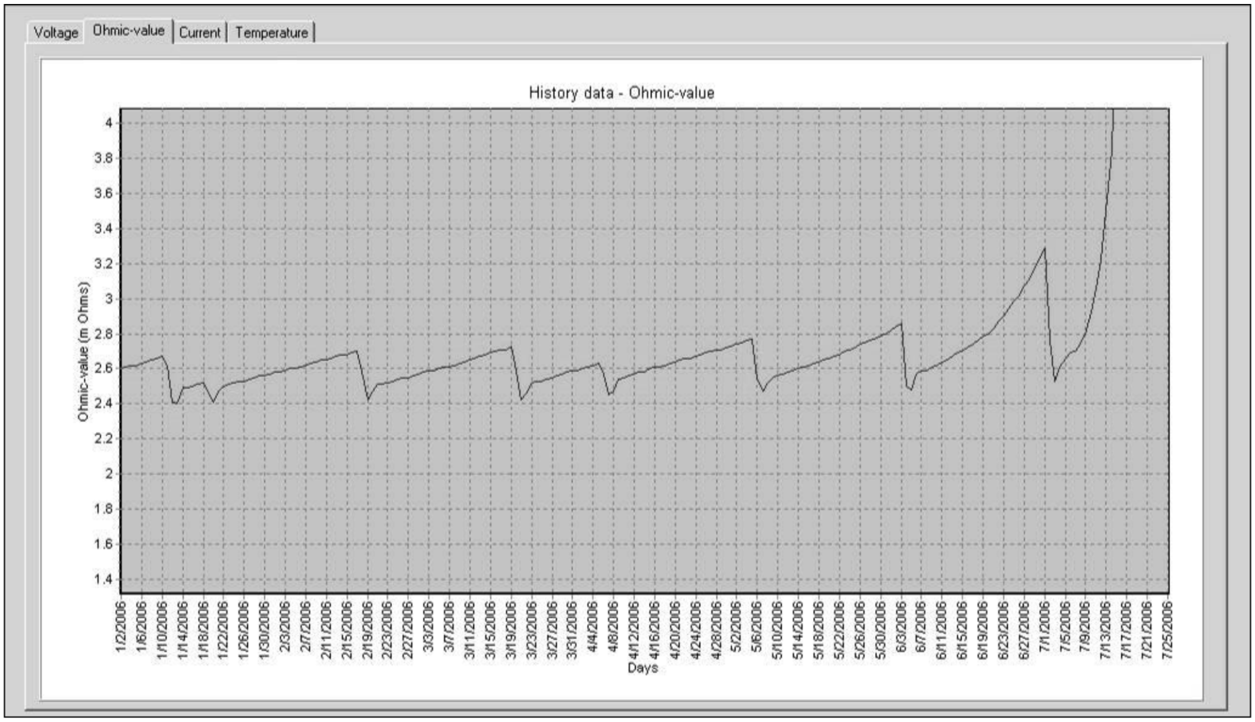
Cyclical Charging



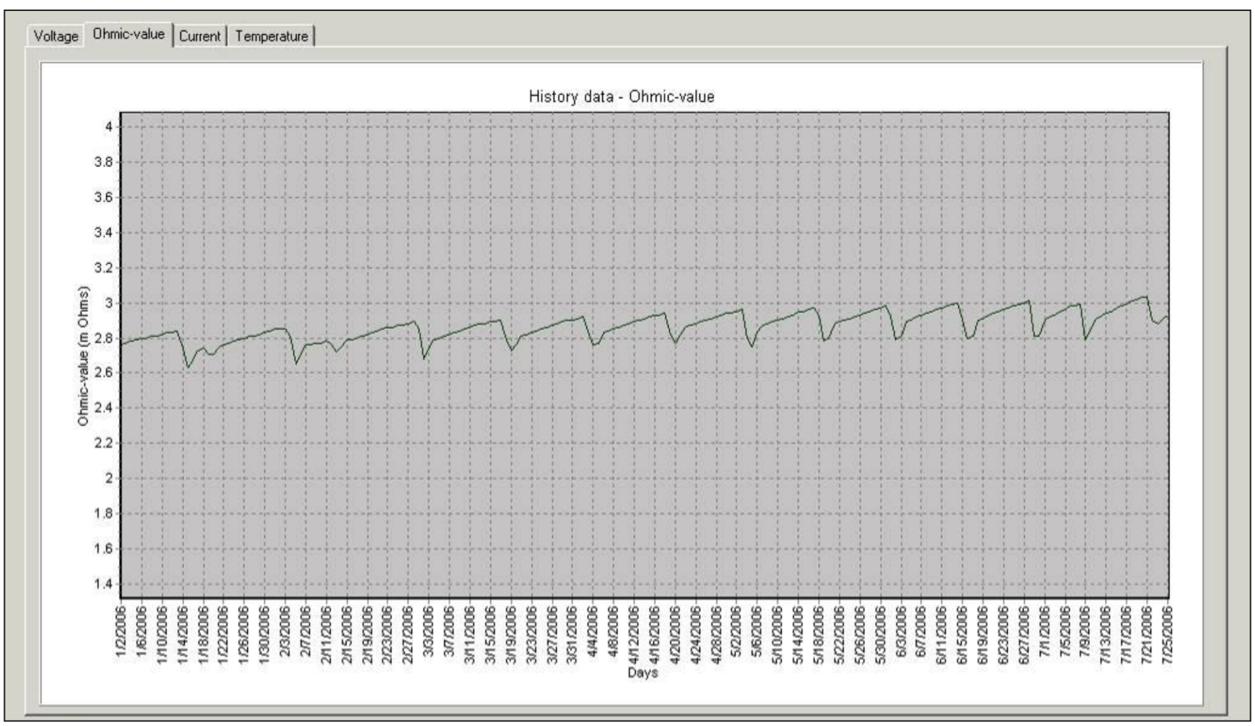
Sometimes, periodic charging is used to re-charge or even boost standby power batteries. These boosts can occur from several times a day to once a month (see voltage graph above for two distinct batteries on a 28 day cycle).

Weak jars or cells in the battery will respond sluggishly to the boost charge and the healthier jars will take on more of the ‘over-charge’ until the weaker jars are able to take their share. Hence the wide spread of voltages during the boost period causing the obvious ‘humps’.

The ohmic-value data also varies significantly between boost charges. This can make alarm setting a challenge. The reader should be aware of two ways failing jars are shown in Cellwatch through the ohmic-value graphs…



In the example shown above, failure of the jar can be predicted one month or more before failure by observation of both the slope of the ohmic value increase and by the high level the ohmic value reached just before the recharge cycle started.



In this more subtle example, the overall slope of the ohmic-value is increasing but it is harder to detect at this early stage. Careful and frequent review of the data is required. The alarm criteria however is very helpful and should be based on the ohmic value measured when the jar is on charge (2.5 milli-ohms in the example above). If the upper ohmic value alarm limit is set to 120% of this value (3 milli-ohms), the alarm would be triggered during the end part of the non-charge period as the jar deteriorates. During or following a recharge the alarm setting may clear as the ohmic value falls within limits.

Conclusion: *for periodic charge systems, set the upper ohmic-value alarm to 120% to 125% of the value measured while the jar is on charge.*

Thermal Runaway

Cellwatch 4.1 introduced a new alarm setting in the Cellwatch system for Thermal Runaway detection and mitigation. This feature works alongside new hardware called the Thermal Runaway Controller (TRC). This controller introduces several new relays that can be integrated into a users' battery system which can take a string offline if thermal runaway conditions persist for a defined period of time. Hardware installation instructions and relay configurations are described in the hardware section of this manual.

Conditions for Thermal Runaway

Heat is generated when the battery chemistry is in the recombination phase during a recharge cycle. When the cell/jar/battery is in the fully recombinant mode the excess energy is converted to heat. When a cell is able to dissipate this excessive heat into the environment and remain stable, thermal runaway will not be an issue. However, if the amount of heat generated exceeds the rate at which the jar dissipates heat into the environment, thermal runaway can occur. As the temperature rises, more current is required to maintain the float voltage increasing the heat dissipated by the already recombinant jar. The result is a continual increase in float current and temperature of the cell until thermal runaway occurs. The net effect of thermal runaway can be accelerated dry-out (predominantly flooded lead acid cells) and/or melting of the battery (predominantly VRLA cells).[1]

Measuring float current of each jar is the initial indicators that thermal runaway is could occur. Often times a string level measurement float current measurement is suitable to determine if thermal runway is possible. A by-product of increased float current is increased cell temperatures, as heat is dissipated and increased cell voltage. Cellwatch monitors both ambient or pilot cell temperatures and cell voltages for thermal runaway conditions.

[1] IEEE Standard 1188-2005, Appendix C2 Thermal Runaway

To prevent thermal runaway the source of the float charge current must be removed. This is done by removing the string from operation, i.e. opening the battery string. It is recommended to monitor and remove each string independently. Strings should be isolated from other strings and not simply the UPS as the paralleled strings could continue to provide the float current continuing the generation of heat.

Configuring Thermal Runaway Protection

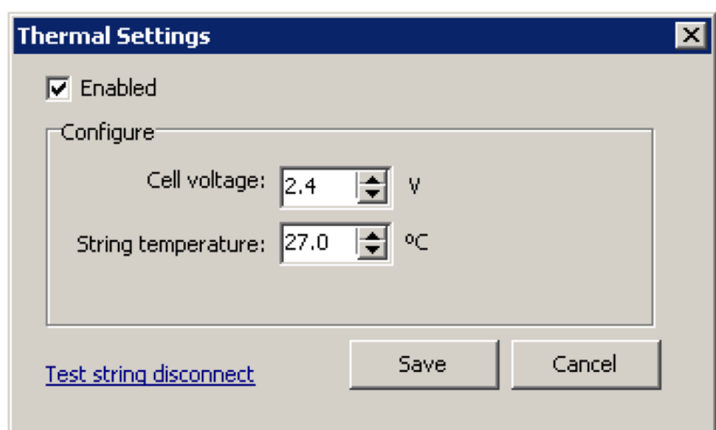
Thermal Runaway alarms are configured on a per string basis. Note that for thermal runaway settings to be accessible the string must be on a TRC. Thermal Runaway Alarm settings can be configured by right clicking on an eligible string and selecting Thermal Runaway Protection in the drop down menu. Once the string is configured you will note a shield icon on the string tab.

Setting Thermal Runaway alarms
Thermal events

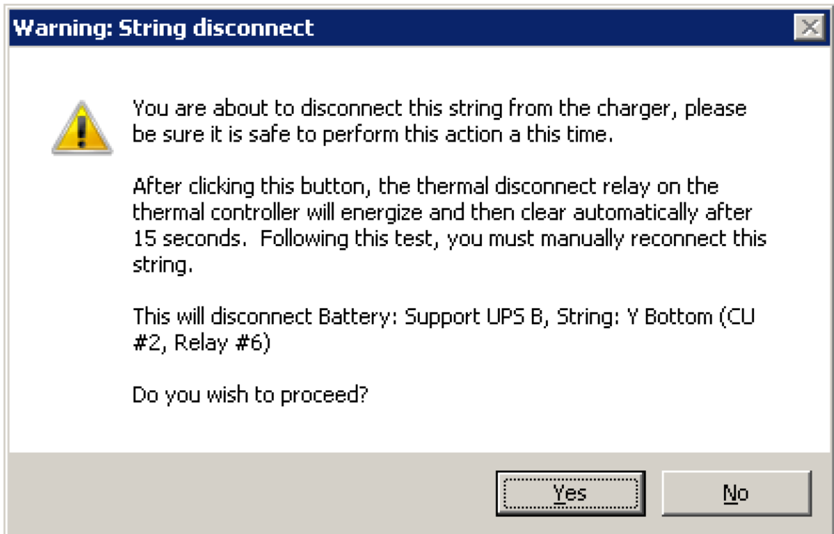
Alarm Settings

Shield Icons
Shield icons are only seen on strings with Thermal Runaway protection enabled. Users can right click on a string to determine if the string is available for Thermal Runaway protection. To activate this feature right click on the string tab and select the "Thermal Runaway Protection" option from the menu. The Thermal Settings (see the next section) will appear to enable or disable protection. The box to enable the feature must be selected followed by the selection of the cell voltage and string temperature.

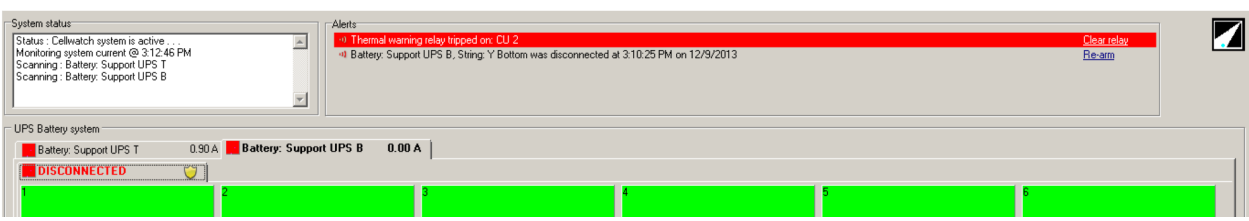
Testing String Disconnect settings
This is an important part of every configuration where Thermal Runaway Protection is implemented. It is highly recommended that every system with thermal runaway protection be tested prior to commissioning a Cellwatch system for operation. This ensures that Cellwatch is in the best suited position to help mitigate, detect, and prevent a thermal event.



Using the 'Test string disconnect' allows users to verify that the relay circuit is configured correctly to remove a string from operation. Once activated, the relay tied to this physical string will be activated for 15 seconds. If configured properly to an external breaker, the string should be taken offline until manually reconnected. To proceed with the test feature a password must be entered and the operator must manually proceed with the test as this could take an operational string offline. The user will be warned that actuating the relay will take a string offline.



Selecting “No” will cancel the test, while selecting “Yes” will proceed to activate the displayed relay attempting to remove the string from operation. Cellwatch will indicate that the string has been disconnected and ask the user to clear the relay and ‘re-arm’ Cellwatch in the alerts window. Before proceeding verify that the string was taken offline and that Cellwatch was connected properly to the circuit that removed the string from operation.



Thermal Runaway Considerations and Recommendations

CAUTION: *Alarms can be set such that it is possible for Cellwatch to accurately detect thermal runaway.*

With release CW 4.1 the thermal runaway protection is best suited for sealed VRLA cabinet based systems. Temperature probes should be mounted in the hottest part of the cabinet or away from any air conditioning supply vents which will drop the ambient temperature of the probe. Probes should be mounted on a pilot cell at the top of the cabinet or on the top of the cabinet away from vents.

Recommended settings:

Voltage Recommendation	Nominal Jar Voltage					
	2 V	4 V	6 V	8 V	12 V	16 V
2.5 volts per cell	–	–	7.5 V	10 V	15 V	20 V

Cabinet environment:

Alarm	Forced Air Environment (actively cooled cabinet)		Non-Forced Air Environment (passively cooled cabinet)		General Peak Ambient
	C	F	C	F	C/F
High Temp Alarm	Peak Ambient + 3 C	Peak Ambient + 8 F	Peak Ambient + 4 C	Peak Ambient + 12 F	30 C / 86 F
Thermal Runaway Alarm	Peak Ambient + 8 C	Peak Ambient + 12 F	Peak Ambient + 10 C	Peak Ambient + 18 F	

Open Rack Environment:

Alarm	Environment		General Peak Ambient
	C	F	C/F
High Temp Alarm	Peak Ambient + 3 C	Peak Ambient + 8 F	30 C / 86 F
Thermal Runaway Alarm	Peak Ambient + 8 C	Peak Ambient + 12 F	

Both a thermal warning voltage alarm and a thermal warning temperature alarm must occur before Cellwatch will begin a disconnection timer. Prior to this condition Cellwatch should have acknowledge high float voltage and high temperature alarms. Both a thermal warning high voltage must be detected on a cell and a thermal warning high string temperature must be detected on the same string for the thermal warning alarm to activate.

It is always recommended that high temperature alarms be lower than the thermal runaway alarm settings.

If not configured properly (i.e. the temperature probe is mounted to the wrong string) Cellwatch may not respond in proper time to prevent thermal runaway. Always verify that the probes and the alarm settings are set correctly before commissioning a system.

NOTE: *Thermal runway conditions can occur due to improper charging schemes on any cell. For example, charging a 12 volt jar at 80 volts will cause thermal runaway faster than charging a jar floating at 14 volts. This is due to the amount of heat dissipated from the jar.*

NOTE: *Thermal Runaway protection is available for cabinet based systems (jars and containers located within a metal enclosure with or without vents in an enclosed room). Systems utilizing rack or stack configurations should not utilize this feature as the ambient or pilot cell temperature reading may not adequately describe the temperature of the system. A version for open rack systems is under development and will be released soon.*

Preventing Thermal Runaway without the Thermal Runaway Controller

Users with properly configured alarm settings and that adequately monitor their Cellwatch system will identify characteristics of thermal runaway long before it ever becomes an issue. While thermal runaway could occur on any system, it is most likely to occur on systems where the battery is left unmonitored or where the battery monitoring system is ignored.

In these situations, customers using non-thermal controllers can still detect thermal runaway conditions however Cellwatch will not remove the string from operation or provide thermal alarm notifications. Instead high voltage and temperature alarms will be detected. IFC 608.3 requires a listed device like Cellwatch to meet the specifications.

References

1. Resistance recommendations see C&D Technology paper “Valve Regulated Lead Acid Battery” series, “Impedance and Conductance Testing” 41-7271 Rev 8.99.
2. Float Voltage high and low limits see C&D Technology paper “Valve Regulated Lead Acid Battery” series, “Integrity Testing”. 41-7264 Rev 8/99.
3. For upper temperature performance data see C&D Technology paper “Valve Regulated Lead Acid Battery” series, “Life Expectancy and Temperature” 41-7329 Rev 5.99
4. For lower temperature performance data see C&D Technology paper “Valve Regulated Lead Acid Battery” series, “DYNASTY VRLA batteries Electrolyte Freeze Protection Testing” 41-7953 Rev 3.99