C&D TECHNOLOGIES

Valve Regulated Lead Acid Battery
20 to 200 ampere-hours capacity

10 Year VRLA Battery Periodic Maintenance Instructions

Table of Contents

C&D VRLA BATTERY SYSTEM

PERIODIC MAINTENANCE AND TROUBLESHOOTING GUIDE

General Information

This document provides a guide for use during periodic maintenance and troubleshooting of the 10 Year VRLA batteries of 20 through 200 ampere hours capacity.

Other instructional documents which can be used in conjunction with this guide include:

1. Integrity Testing	41-7264
2. Impedance and Conductance Testing	41-7271
3. Acceptance and Capacity Testing	41-7135

For example, as shown in Figure 2, two of each 48 volt 90 ampere hour capacity strings can be connected in parallel to provide a nominal 48 volts at 180 ampere hours.

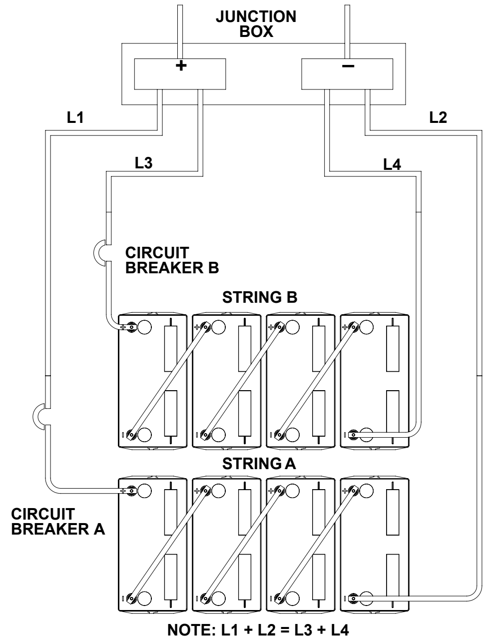

Figure 2-Parallel Strings of Batteries

10 Year VRLA Battery System General Description

In general the battery system is a group of 2, 4, 6, or 12 volt batteries connected in a series string to provide a total system of higher voltage. For example, as shown in Figure 1, four of the nominal 12 volt batteries may be connected in series to provide a 24 cell system with a nominal voltage of 48 volts.

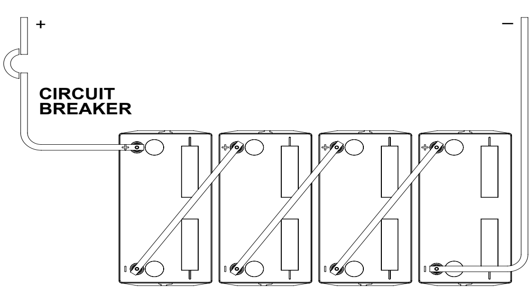

Figure 1-Series Connected String of Batteries

Multiple strings of the series connected batteries may be connected in parallel to provide a total system with a capacity of the sum of the capacities of the individual strings.

The 10 Year VRLA battery is a lead acid battery which facilitates an oxygen recombination cycle. The net result is that under normal conditions there is minimal gas emission and loss of water from the electrolyte. The electrolyte is immobilized by absorbing within an absorbent separator between the plates. Consequently, the battery is maintenance free in terms of electrolyte maintenance-that is, there is no requirement nor capacity to add water to the cells or to measure the electrolyte specific gravity.

VRLA Battery Safety Concerns

Maintenance and servicing of the C&D VRLA battery should only be performed and supervised by personnel knowledgeable of lead acid batteries and required personal safety and equipment safety precautions. Keep unauthorized personnel away from the batteries and maintenance activities.

Electrical Hazards

Battery systems present a risk of electrical shock and high short circuit currents. The following precautions should be observed when maintaining VRLA batteries:

1. Remove all personal metal objects (watches, rings, etc.).
2. Use insulated tools.
3. Wear full eye protection and rubber gloves.
4. Observe circuit polarities.
5. Do not make or break live circuits.
6. Prior to handling batteries on a metal rack, assure the battery is not inadvertently grounded by observing the ground fault detector indicator. In its absence, measure the voltage between the battery and the rack. It should be zero. If not, determine the cause and correct prior to proceeding.
7. Do not lay metal tools and hardware on top of the batteries.
8. As appropriate, use an insulating blanket to cover exposed portions of the battery system when performing extended maintenance that could result in personal or equipment contact with the energized conductors.

Certain types of rectifier circuits used in charging the VRLA battery may not include a line isolating transformer. In these cases extreme caution should be exercised when maintaining and collecting data on the battery system.

The VRLA battery is sometimes enclosed in cabinets with very limited access. Again, extreme caution must be exercised when maintaining and collecting data on the battery system.

Disposal

Lead acid batteries are to be recycled. Batteries contain lead and dilute sulfuric acid. Dispose of in accordance with Federal, State and local regulations. Do not dispose of in a landfill, lake or other unauthorized location.

Chemical Hazards

Any liquid leaking from a VRLA battery is electrolyte which contains dilute sulfuric acid which is harmful to the skin and eyes; is electrically conductive; and is corrosive.

If electrolyte contacts the skin, wash immediately and thoroughly with water. If electrolyte enters the eyes, wash thoroughly for 10 minutes with clean water or a special neutralizing eye wash solution and seek immediate medical attention.

Neutralize any spilled electrolyte with the special solutions contained in a spill kit or with a solution of 1 lb. bicarbonate of soda to 1 gallon of water.

Fire, Explosion and Heat Hazards

Lead acid batteries can contain an explosive mixture of hydrogen gas which can vent under overcharging conditions.

Do not smoke or introduce sparks in the vicinity of the battery.

Prior to handling the batteries, touch a grounded metal object, such as the rack, to dissipate any static charge that may have developed on your body.

Do not charge batteries in a sealed container. The individual batteries should have 0.5 inches of space between the batteries to allow for convection cooling. If contained, assure the container or cabinet and room have adequate ventilation to prevent an accumulation of potentially vented gas.

Caution

Do not attempt to remove the vents (valves) from the 10 YEAR VRLA battery or add water. This presents a safety hazard and voids the warranty.

Handling Hazards

The individual batteries may weigh from 25 to 150 pounds depending on part number. Exercise care when handling and moving batteries. Assure the use of appropriate handling equipment.

Preparation for VRLA Battery Periodic Maintenance

There is little difference between the periodic maintenance associated with a VRLA battery and a vented (wet) cell battery with the exception of that related to the liquid electrolyte. Naturally, it is not required to measure electrolyte specific gravity or add water to the VRLA cells.
For optimum reliability, it is recommended that the battery system be monitored quarterly. If the battery system incorporates an automatic monitoring system to gather the electrical and environmental data, the quarterly checks are limited to the evaluation of the recorded data and a visual check of the battery.
In general the types of checks to be made during the periodic maintenance include:

1. System charging voltage
2. Ambient temperature
3. Battery pilot unit temperatures
4. Interunit connection hardware resistance
5. Individual battery float voltage
6. Momentary high rate load test
7. Battery system capacity test

A test of the individual unit resistance, impedance or conductance, while optional, is also recommended on a periodic basis. This data and its trend can be a valuable aid in troubleshooting the system and predicting the need for a system capacity test.

Prior to starting the periodic maintenance activity assure that all required maintenance tools and equipment and safety equipment is available and functional. Notify anyone who will be affected by the intended maintenance or troubleshooting activity.

Also, all units in the battery should be numbered so as to facilitate the recording and analysis of data unique to each unit.

Required Maintenance Tools and Equipment

At a minimum, the following tools and equipment are required to maintain and troubleshoot the 10 Year VRLA battery.

1. digital voltmeter
2. socket wrenches, insulated
3. box end wrenches, insulated
4. torque wrench calibrated in inch-lbs.
5. rubber gloves
6. full face shield
7. plastic apron
8. potable eyewash
9. spill kit
10. fire extinguisher (class C)

The following equipment is optional depending on the type of maintenance to be performed.

1. micro-ohm meter
2. battery resistance, impedance or conductance test set
3. 100 amp momentary load test set
4. system load bank (DC if to be performed at the battery or AC if to be performed by loading a UPS output)

Quarterly Maintenance

The following checks should be completed quarterly.

1. Assure the battery room is clean, free of debris and well lighted.
2. Assure that all facility safety equipment is available and functional.
3. Measure and record the air temperature within the battery room.
4. Visually inspect the battery for:
   a. cleanliness.
   b. terminal damage or evidence of heating.
   c. container or cover damage.
   d. evidence of overheating
5. Measure and record the battery system DC float charging voltage at the battery. Optionally measure and record the AC ripple voltage at this time also.
6. Measure the DC voltage from each polarity of the battery to ground to detect any ground faults.
7. If possible, measure and record the battery system DC and AC float charging current.
8. Measure and record the temperature of the battery pilot unit. Measure the temperature on the side of the unit in the center or at the negative terminal of the unit.
9. Measure and record the individual unit DC float charging voltage.
10. Measure and record the System Equalization Voltage.

Semi-Annual Maintenance

1 Repeat the quarterly checks,
2. Optionally perform the 10 sec. high rate (e.g. 100 amp) load test to assure the individual batteries are functional.
3. Optionally perform the 10 sec. high rate (e.g. 100 amp) load test to assure the individual batteries are functional.
4. Optionally measure and record the resistance/impedance/conductance of the individual units to trend the condition of the individual units over time and to detect dramatic differences between individual units and the norm.

Annual Maintenance

1. Repeat the semi-annual checks.
2. Retorque all the interunit connecting hardware to the values noted in tables listed in the Table of Contents.
   This can be omitted if the connection resistance is measured and found to have not increased more than 20% from the value at installation.

Bi-Annual Maintenance

The battery should be capacity tested every two years at the service load or at the battery rating related to the service requirements. Ideally, this will be the same rate at which it was acceptance tested when originally installed. Once the battery is found to be at 85% of rating, it should be capacity tested annually. Capacity testing instructions are found in the bulletin "Acceptance and Capacity Testing" #41-7135.

Data Analysis and Corrective Actions

The data accumulated during the periodic maintenance activities should be recorded on a form such as shown in Appendix One. Following is an explanation of how the data would be interpreted and the correction action to be taken. However, it must be recognized that this explanation is not all inclusive and the analysis and corrective action decision must be made by personnel familiar with 10 Year VRLA batteries and their operation and failure modes.

Environment Ambient and Battery Temperature

While the VRLA battery will function at extremes of temperature, it is rated at 77°F (25°C) and the ideal operating temperature range for the 10 Year VRLA battery is 70°F (21°C) to 80°F (27°C). Operation at cooler temperatures will reduce the anticipated standby operating time while operation at warmer temperatures will detract from the battery life and will increase the potential of a thermal runaway condition.

The battery will experience a 50% reduction of life for each 18°F (10°C) above 77°F (25°C). High ambient room temperature should be corrected through the use of appropriate ventilation and air conditioning.

The VRLA battery should not be charged at temperatures exceeding 122°F (50°C). A thermal runaway condition could result.

The individual batteries within the string should not exceed the ambient temperature by more than 18°F (10°C). If the entire battery or individual units temperatures are excessively high, the respective units may be experiencing thermal runaway. In this situation the charging current should be terminated by disconnecting the Charger/Rectifier and the cause of the situation should be determined and corrected.

If thermal runaway has occurred, the battery system should be capacity tested and replaced if necessary.

Battery Visual Inspection

Container Cleanliness

It is important that the individual batteries be clean and properly spaced. An accumulation of dirt or dust and moisture on the covers can produce a conductive path between the terminals or to ground which could result in short circuits or ground faults.

When batteries are cleaned, they should be on open circuit. For cleaning, use a cloth moistened in a solution of bicarbonate of soda and water. Do not use cleaners of unknown solutions such as window or glass cleaners and solvents. Use of certain petroleum based cleaners will damage the battery plastic containers and could cause them to crack and craze.

Container and Cover Damage

Should a crack or other penetration of the container or cover of a battery be noted, it should be replaced. A crack in the container could allow conductive electrolyte to wick from the battery and create a ground fault. A ground fault could lead to melting and burning of the container.

A hole in the cover, even without wicking of the electrolyte, can also be a serious situation. The hole will allow drying of the electrolyte in the subject cell resulting in an eventual high resistance and heating of the subject cell.

Containers which are severely swollen and permanently deformed have been overheated and experienced thermal runaway. Thermal runaway will also cause the batteries to gas and dry out and will damage the plates. In this case the entire battery string should be replaced.

Terminals

Bent or otherwise damaged terminals can produce high resistance connections or can hide a fracture that could fuse open under load. Batteries with damaged terminals should be replaced.

If the protective grease at a termination has melted and flowed onto the cover, it is an indication that the connection has been hot and this is, in all probability, the result of a loose or high resistance connection. In this situation the connection should be disassembled, inspected for damage, cleaned and properly reassembled.

Battery System Float Charging Voltage

The recommended battery system float charging voltage for the 10 Year VRLA Batteries with a specific gravity of 1.280 to 1.300 is equal to the number of cells in the system multiplied by the range of 2.25 to 2.30 volts per cell at 77°F (25°C). For example, a string of 30 each 12 volt (6 cell) batteries should be float charged within the range of 405 to 414 VDC (180 cells x 2.25 v/c minimum and 180 cells x 2.30 v/c maximum) at 77°F (25°C).

When temperature extremes are encountered the float charging voltage should be temperature compensated. The temperature compensation coefficient is -0.0028 v/c per degree F (-0.005 v/c per degree C).

For example, if the battery normal temperature is 90°F (13° above 77°F) the average float charging voltage range should be reduced 0.036 v/c (13° x 0.0028 v/c per °F) to between 2.21 and 2.26 v/c. For a 180 cell battery this would be 397.8 to 408.6 VDC. This will help reduce the potential for thermal runaway at elevated temperatures.

If the battery operates at cold temperatures, for example 60°F (17° below 77°F), the charging voltage can be increased to improve recharge time. For example, the charging voltage range could be increased by (17° x -0.0028 v/c per °F) or 0.048 v/c. The float voltage range would be 2.298 to 2.348 v/c. For the 180 cell string this would be 413.6 to 422.6 VDC.

If the battery is undercharged for a period during which there have been multiple discharges, the battery will not fully recharge following each discharge and it will provide progressively lower capacity. This condition may be correctable with an extended equalization charge (eg. 48 to 72 hours). However, if the situation has continued for too long a time, irreversible sulfation of the plates may have occurred and the battery may have to be replaced.

Extended overcharging will cause excessive float current, corrosion of the plate grids, gassing and drying of the limited amount of electrolyte. This constitutes premature aging of the battery and loss of capacity.

Severe overcharging for extended periods can induce a thermal runaway condition. This would also necessitate replacement of the battery system.

While measuring the battery system DC float charging voltage it may also be convenient to measure the AC ripple voltage appearing across the battery system. If the AC ripple voltage is a sinusoidal waveform the maximum reading should be less than 0.5% Vrms of the DC float voltage. In the case of 180 cell string floating at 414 VDC, this is 2.07 Vrms. When measuring the ripple with an oscilloscope, the maximum p-p value should be 1.5% of the float voltage or 6.2 Vp-p when floating at 414 VDC.

Excessive AC ripple voltage across the battery could cause gassing and heating of the battery which would result in reduced life.

Battery System Ground Fault Detection

If the rectifier used to charge the battery has a ground fault detection capability, the indicator should be observed to determine the safety of the system. If a ground fault is indicated, it should be isolated and corrected prior to further maintenance on the battery system.

If the rectifier does not have a ground fault detection circuit, use the digital voltmeter and measure the voltage from each polarity of the battery to ground (the grounded rack or cabinet). A detected voltage would indicate a short or leakage current from the battery to ground. The approximate location of the cell with the ground fault, from the battery system output terminal, would be the measured voltage divided by the average per cell charging voltage. For example, if the measured voltage to ground was 135 VDC and the charging voltage.

was 2.25 v/c, the ground fault would be approximately 60 cells (ten 12 volt units) from the battery system output terminal.

Battery System Float Charging Current

If the DC float current can be measured, it can provide an indication of the proper current acceptance of the battery system. Depending on the charging voltage per string and the temperature, the float current per string should be approximately that shown in Figure 3. The float current will approximately double for each 18°F (10°C) above 77°F (25°C).

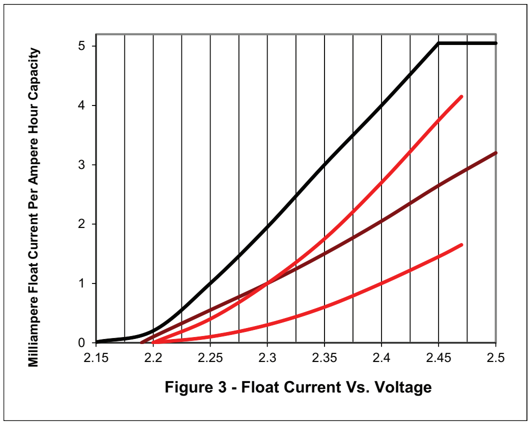

Figure 3-Float Current Vs. Voltage

If the DC float current is zero there is an open circuit in the battery string. If the float current is higher than anticipated, it may be due to elevated temperature of the battery or shorted cells within the string. In either case the cause should be determined and corrected. Elevated temperatures and shorted cells are both situations which can lead to thermal runaway.

Individual Battery Float Charging Voltage

While the battery string may be charged at an average of between 2.25 and 2.3 volts per cell, ot all cells will float at the exact average voltage. Each cell has a somewhat different impedance and rate of oxygen recombination and will therefore exhibit a slightly different float voltage at the same float current. For example, all the 12 volt batteries in a string charged at 2.3 volts per cell will not float at 13.8 VDC but may vary from 13.3 to 14.5 and still be normal. If the system is equalized for 24 hours upon installation, or after with an extended time in float service, this spread in float voltage will normally decrease.

Refer to table 1, Electrical Characteristics, for each series battery as listed in the documents noted in the table of contents, which lists the minimum and maximum DC float voltages to be measured across batteries in a series string. If an individual battery measures too low, it may be an indication of a shorted cell.

If an individual unit measures too high, it may be an indication of increased resistance within the cell. If one unit measures very high while the balance of the units in the string indicate near the open circuit value, the high voltage cell may have an open circuit.

Shorted cells within the string will lead to increased voltage applied to the remaining good cells in the string and higher float current. For example, a 24 cell string charging at 55.2 VDC (2.3 v/c) which has 2 shorted cells will be charging the remaining 22 cells at 2.5 v/c (55.2 VDC/22 cells) and the resulting increase in float current is sure to result in eventual thermal runaway.

A battery with a shorted or open cell can usually be confirmed by comparing the impedance of the individual units or by comparing the AC ripple voltage measured across the individual units.

DO NOT perform a high rate load test on batteries that are suspected of having a shorted or open cell. This would be hazardous since a spark internal to the cell could ignite the internal gases.

A battery suspected of having a shorted or open cell should be removed and replaced immediately.

More information concerning the measurement and interpretation of individual battery float voltages is contained in the Technical Bulletin "Integrity Testing" #41-7264.

High Rate Momentary Load Test

The high rate momentary load test is a functional test of the individual battery within the series string. It does not replace a capacity test but it does indicate if the battery is functional at least up to the ampere capability of the test load.
A typical load used for batteries in the 30 to 600 ampere range is 100 amperes. The voltage of the unit 10 seconds after application of the test load should be at least 1.7 v/c average (10.2, 5.1, 3.4,and 1.7 VDC) for 12, 6, 4 and 2 volt batteries respectively) or the battery should be suspected of being open, shorted, discharged or of very high resistance and low capacity.

Never perform the high rate momentary load test on a battery suspected of having a shorted or open cell. Full face protection should always be worn during this test, since a spark internal to a cell could ignite the residual gasses within the cell.

More information concerning this test and the minimum voltages to be expected by part number is contained in the Technical Bulletin "Integrity Testing" #41-7664.

Impedance Testing

The normal wear out mode of the VRLA battery includes corrosion of the plate grids, deterioration of the plate active material and some drying of the electrolyte. Abnormal failure modes would include deterioration of the conductive path and excessive drying of the electrolyte. These processes will all increase the resistance of the affected cells and periodic measurement of the impedance, resistance or conductance of the cells and trending of this data can indicate string uniform gradual degradation and loss of capacity with time. This is shown in Figure 4.

Rapid changes in individual units may indicate shorted, open and drying cells and cells with deteriorating conductive paths.

When an AC ripple voltage appears across a string of batteries it will be subdivided across the

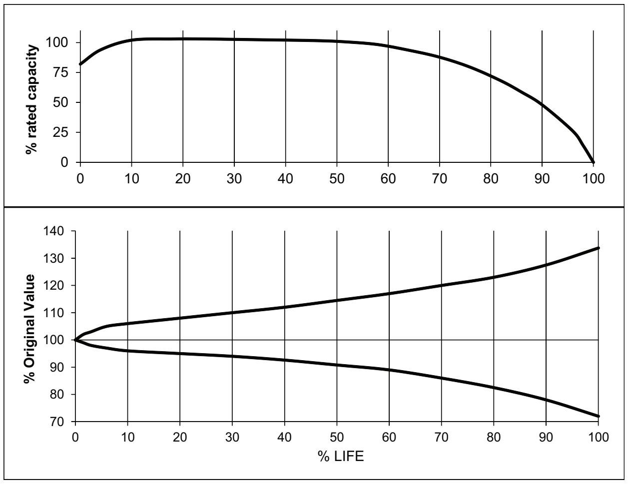

Figure 4 - VRLA Battery Impedance and Conductance Vs. Capacity and Age

individual units in the string proportional to their relative resistance. Therefore in the absence of an impedance, resistance or conductance test set, the AC ripple voltage across the individual units can be measured with a DVM and compared to each other and the norm as an indication of their relative resistance and condition.
If the resistance of the batteries has increased by 30% over that when it was new, the battery should be further tested to determine the cause and if necessary the battery or system should be capacity tested to assure reliability.
More information on this topic is contained in the Technical Bulletin "Impedance and Conductance Testing" #41-7271.

Interunit Connecting Resistance

High resistance in the interunit connections and loose connecting hardware can cause excessive voltage drop during discharge resulting in reduced operating time and in the extreme case even cause melting of the battery terminals and potentially a fire.

The contacting surfaces of all connections should be brushed clean, removing all lead oxide and contamination, protected with a special antioxidation grease, and tighten.

The connection hardware may loosen somewhat with time and repeated cycling of the battery system. The connection hardware should be retorqued to the value indicated for the battery part number as shown on the relevant data sheet. A summary of the battery terminal types and the recommended torque values is given in Table 2.

Performance and Capacity Testing

When the battery degrades to 80% of its rating it should be replaced. That is, if a battery system could support 100 amperes for 1 hour when new, it should be replaced when it can only support 80 amperes for the same 1 hour period. If 100 amperes is the actual load and this must be supported for a minimum of one hour, the battery should have been originally sized to provide 125 amperes for the one hour when new. This sizing factor of 1.25 is referred to as the aging factor when originally sizing the battery.

When the battery capacity declines to 80% of rating is it an indication that the plate grids are corroded and expanded; that the plate active material has deteriated and that the drying of the electrolyte has occurred. The battery should be removed from service and replaced at this time.

Naturally, the other criteria for battery replacement is when it no longer supports the load for the minimum required time-even if the battery is still greater than 80% of rating. However, even at minimal load, the battery should not remain in service beyond that point when it is at 80% of rating.

The 10 Year VRLA batteries are rated at 77°F (25°C). It is important to recognize that operation at lower temperatures, while it does not harm the battery, will reduce the operating time. Performance derating factors for reduced temperature are found in the Technical Bulletin “Capacity Testing” #41-7135.

Continuous operation at elevated temperatures will result in accelerated aging of the battery. For each 18° (10°C) above 77°F (25°C) the battery will age at twice the normal rate. Additional information on this topic is found in the Technical Bulletin "Life Expectancy and Temperature" #41-7329.

Summary of Periodic Maintenance for VRLA Batteries

The 10 Year VRLA battery is maintenance free only as related to the electrolyte. For assurance of the battery reliability it is still important to perform the recommended periodic maintenance. The recommended periodic maintenance, whether performed manually or via automated monitoring systems, is designed to determine the gradual degradation of the system capacity and to detect any abnormal system or individual battery condition which could impact system reliability.

TABLE 1-VRLA Battery Symptoms and Solutions

Symptom	Possible Causes	Possible Result	Corrective Actions
CAPACITY TEST RESULTS			
Reduced operating time at 77°F with smooth voltage decline.	Normal wear out	Eventual failure to support the load followed by potential for shorted cells.	Replace battery system when at 80% of rated capacity or before.
Reduced operating time at 77°F with step voltage decline or voltage plateaus.	Individual low capacity cells.	Reversed cells during discharge-reversed cells will become very hot and will not fully recharge.	Replace the isolated low capacity batteries.
Excessive initial voltage drop even to the point of dropping load in the first several seconds.	Battery is cold. Cabling is too small. High resistance connections. Battery is undersized. Shorted cells.	Excessive voltage drop. Excessive voltage drop. Cells will become hot, could develop thermal runaway; internal arcing could result in explosion.	Heat the battery. Run parallel cables. Add required parallel strings. Replace isolated units with shorts and evaluate entire string.
TEMPERATURE CHECKS			
Elevated room temperature.	Lack of adequate air conditioning/ventilation.	Reduced battery life.	Cool the room or accept reduced battery life.
Elevated battery temperature.	Elevated room temperature. Inadequate cabinet ventilation. Discharge-Charge cycle AC ripple current greater than 5 amperes rms/100Ah battery capacity.	Reduced life and potential thermal runaway. Reduced life and potential thermal runaway. Can be normal if not exceeding 18°F (10°C) increase. Reduced life and potential thermal runaway.	Improve room air conditioning. Improve cabinet ventilation and temperature. Limit recharge current. Determine cause of excessive AC ripple current and correct.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Symptom	Possible Causes	Possible Result	Corrective Actions
High current recharge.	High charging voltage. Shorted cells.	This combination can lead to thermal runaway.	Limit recharge current. Reduce to within specifications. Replace shorted cells and evaluate total string.
VISUAL BATTERY CHECKS			
Cover/container crack.	Handling or impact damage.	Cell dryout or ground fault. Potential internal gas ignition.	Replace damaged unit.
Cover/container explosion.	Ignition of cell internal gasses due to external source, fusing of internal conductive path, or internal spark due to shorting. This potential exists for batteries not maintained and continued in service beyond useful life.	Personal injury and equipment damage at time of explosion. Failure to support load.	Replace damaged unit and evaluate the balance of string.
Burned area on container.	Crack in container wicking electrolyte to grounded rack, etc. Ground fault.	Could result in personal hazard due conductive path to rack, etc. Could result in smoke or a battery fire. Could result in a thermal runaway.	Clear the ground fault and replace defective unit. Evaluate balance of the string.
Permanently deformed (swollen) container.	Thermal runaway possibly caused by high temperature environment, overcharging, excessively high recharge current, shorted cells or a ground fault or a combination of these items.	Could result in the emission of hydrogen sulfide which is detectable as a rotten egg odor, battery fire and inability to support the load.	Replace the battery system and correct the items leading to the thermal runaway condition.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Symptom	Possible Causes	Possible Result	Corrective Actions
Rotten egg odor.	Possibly caused by high temperature environment, overcharging, excessively high recharge current,shorted cells or a ground fault or a combination of these items.	Odor is a product of extended thermal runaway.	Replace the battery system and correct the items leading to the thermal runaway.
Melted grease at terminals.	Connections were hot probably due to excessive resistance caused by loose connection, dirty contact surfaces or corrosion within the connection.	Excessive voltage drop perhaps leading to short operating time or damaged terminals. In extreme case could lead to melted terminal and ignition of the battery cover.	Clean and reassemble the connection if undamaged. Replace any battery with damaged terminals.
Corrosion at terminals.	There is possibly either residual electrolyte from manufacturing or electrolyte leaking from the battery terminal seal that is attacking the interunit connector.	Increased connection resistance and resulting increase in the connection heating and voltage drop at high rate discharge.	Disassemble connection, clean, coat connecting surfaces and terminal area and seal with antioxidation grease and appropriately reassemble the connection. If leakage about the terminal area is obvious, the battery should be replaced.
Burned area on container.	Crack in container wicking electrolyte to grounded rack, etc. Ground fault.	Could result in personal hazard due conductive path to rack, etc.	Clear the ground fault and replace defective unit. Evaluate balance of the string.
VISUAL BATTERY CHECKS			
System float voltage greater than 2.3 v/c average at 77°F (25°C).	Charger output set incorrectly.	Overcharging will cause excessive gassing and drying of the electrolyte and will contribute to potential thermal runaway.	Reset the charger output voltage to the recommended value.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Symptom	Possible Causes	Possible Result	Corrective Actions
DC VOLTAGE CHECKS (CONTINUED)			
System float voltage less than 2.25 v/c average at 77°F (25°C).	Charger output set incorrectly.	Undercharging will result in a gradual loss of operating time and capacity with successive discharge cycles. If allowed to persist, an irreversible level of lead sulfate will develop on the plates with the result of a permanent loss of capacity.	Reset the charger output voltage to the recommended value. Equalize the battery system for from 48 to 72 hours and perform a capacity test. If capacity loss is permanent, replace the total battery system.
System equalize voltage is greater than 2.4 v/c average.	Charger equalization voltage is set incorrectly.	Overcharging will cause excessive gassing and drying ot the electrolyte and will contribute to potential thermal runaway.	Reset the charger output voltage to the recommended value.
System equalize voltage is less than 2.4 v/c average.	Charger equalization voltage is set incorrectly.	Equalization and boost charging will be less effective and will require extended time.	If possible, reset the charger output voltage to the recommended value or accept longer equalization time.
Individual battery float voltage less then 2.2 v/c average.13.2 VDC for 6 cell battery. 6.6 VDC for 3 cell battery. 4.4 VDC for 2 cell battery. 2.2 VDC for 1 cell battery.	Potentially the individual battery has a shorted cell. Could be verified with an impedance or conductance check.	Reduced operating time under load. Increased float current. Heating of cell during discharge. Contributes to potential thermal runaway.	Replace the individual battery.
Individual battery float voltage greater than 2.42 v/c average.14.5 VDC for 6 cell battery. 7.3 VDC for 3 cell battery. 4.8 VDC for 2 cell battery. 2.4 VDC for 1 cell battery.	Potentially there may be open cell in the individual battery. This can be confirmed by checking for zero float current or checking for a very high impedance of the battery.	Failure to support the load. Could result in an internal arc which could ignite the gasses within the cell.	Replace the individual battery.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Symptom	Possible Causes	Possible Result	Corrective Actions
DC VOLTAGE CHECKS (CONTINUED)			
DC voltage measured between either of the battery system output terminals and ground (rack) or a ground fault indicated by automatic monitoring equipment.	Damaged battery container allowing electrolyte to wick out to the grounded surface (rack).	Personnel shock hazard which could result in serious injury or electrocution. Potential burning of the container at damaged area or battery fire.	Determine the source of the ground fault and replace battery.
AC RIPPLE VOLTAGE CHECKS			
AC ripple (p-p) voltage on the system is greater than 4% of the value of the DC float voltage.	Poor filtering of the charger output.	Excessive AC ripple could cause the battery to cycle at the ripple frequency and result in heating and deterioration of the plate active material.	Improve the charger output filtering.
Individual battery in string exhibits AC ripple voltage of twice that of the other typical batteries in string.	Battery with the high AC ripple voltage has a proportionately higher impedance and should be further evaluated for performance. Subject battery could have a deteriorating conductive path or a dry, shorted or open cell.	Reduced operating time. Potential conditions could be conducive to thermal runaway.	Verify the battery condition and replace as required.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Symptom	Possible Causes	Possible Result	Corrective Actions
FLOAT CHARGING CURRENT CHECKS			
Float current to the string is zero.	A battery or connection in the series string is open. This can be verified via the float voltage check or AC ripple voltage or impedance check of the individual batteries.	Failure to support the load. If an internal arc should occur during discharge, it could ignite the gasses internal to to the cell. If there is a open/loose connection in the external conductive path, it could damage the termination under load.	Replace the battery with the open cell or repair the open/loose external connection.
Float current exceeds 3.0 milliamperes per ampere hour of rated capacity at 77°F (25°C) at float voltage.	Batteries are not yet fully recharged. Batteries are above 77°F (25°C). Potentially shorted cells in battery. Depending on the degree, the battery may be entering or in thermal runaway.	Not at 100% of capability. Conducive to thermal runaway. Conducive to thermal runaway. Thermal runaway results in eventual meltdown of the battery and the potential of hydrogen sulfide emissions and fire.	Determine the specific cause and take necessary corrective action.
AC ripple current exceeds 5 amperes per 100 Ah rated battery capacity	Poor filtering of the charger.	Excessive AC ripple current will result in battery heating, reduced service life and potential thermal runaway.	Improve the charger output filtering.
HIGH RATE 10 SEC. LOAD TEST			
Terminal voltage is marginally below the minimum voltage specified for 10 sec. point.	Battery is perhaps not fully charged or is an older battery that has been in service and is of somewhat lower capacity.	Perhaps reduced operating time.	Fully recharge the battery.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Symptom	Possible Causes	Possible Result	Corrective Actions
Terminal voltage is significantly below the minimum voltage specified for 10 sec. point.	Battery is discharged or battery conductive path, plate grid or active material or electrolyte volume deterioration. Shorted. Open cells.	Reduced operating time. Conducive to thermal runaway. Will not support load.	Charge and retest battery or replace as required.
BATTERY IMPEDANCE/ CONDUCTANCE TEST			
Impedance/ resistance increase by 50% from original values when new or conductance decline to 50% or the value when new.	Battery is discharged or Battery conductive path, plate grid or active material or electrolyte volume deterioration. Shorted cells. Open cells.	Reduced operating time. Conducive to thermal runaway. Will not support load.	Charge and retest battery or replace as required.
CONNECTION HARDWARE RESISTANCE/ TIGHTNESS CHECK			
Connection resistance increase of 20% or more from original value.	Repetitive cycles resulting in heating and cooling of connection can result in relaxation of torque and an increase in connection resistance. Contamination within the connection can result in corrosion and high terminal resistance.	Loose connections can result in heat damaged or melted terminals during high rate discharge. Excessive voltage drop during high rate discharge and resulting reduced operating time.	Retorque the connection as required. Correct the source of contamination, clean the contact surface areas, grease the contact surfaces with antioxidant grease and reassemble.

TABLE 1-VRLA Battery Symptoms and Solutions (Continued)

Connection hardware tightness is less than the specified retorque value.	Repetitive cycles resulting in heating and cooling of connection can result in relaxation of torque and an increase in connection resistance.	Loose connections can result in heat damaged or melted terminals during high rate discharge.	Retorque the connection as required.

TABLE 2 - BATTERY PARAMETERS BY PART NUMBER

Individual Battery Electrical Characteristics										
Battery	Terminal Type	Bolt Size	Annual Retorque in.-lbs.	Open Circuit Voltage	Float Voltage (VDC)	15 Min Watts/Cell to 1.67 VPC*	8hr Ampere rate to 1.75 VPC	20Hr Ampere rate to 1.75 VPC	Impedance @ 60Hz (Ω)	Conductance (Mhos)
UPS12-100MR	"L"	#10-32	32	12.9	13.5-13.8	90.9	3	1.3	0.0060	603
UPS12-150MR	Inserted	#10-32	30	12.9	13.5-13.8	148	4	1.7	0.0060	1007
UPS12-210MR	Inserted	#10-32	30	12.9	13.5-13.8	206	6	2.7	0.0045	1138
UPS12-300MR	Inserted	1/4-20	110	12.9	13.5-13.8	300	9	3.9	0.0040	1669
UPS12-350MR	Inserted	1/4-20	110	12.9	13.5-13.8	350	11	4.7	0.0030	1914
UPS12-400MR	Inserted	1/4-20	110	12.9	13.5-13.8	400	12	5.2	0.0025	2079
UPS12-490MR	Inserted	1/4-20	110	12.9	13.5-13.8	488	16	7.1	0.0023	1844
UPS12-490MRLP	Inserted	1/4-20	110	12.9	13.5-13.8	488	14	5.8	0.0022	2222
UPS12-540MR	Inserted	1/4-20	110	12.9	13.5-13.8	537	17	7.5	0.0023	2032
UPS12-615MRF	Inserted TFA	1/4-20	110	12.96	13.5-13.8	614	21	8.8	0.0020	2400
UPS6-620MR	Inserted	1/4-20	110	12.9	6.75-6.90	620	22	10.0	0.0012	Limited Data
UPS12-700MRF	Inserted TFA	1/4-20	110	12.96	13.5-13.8	697	24	10.3	0.0021	2500
TEL12-30/SLC	Inserted	#10-32	25	12.84	13.5-13.8	--	4	1.7	0.0100	752
TEL12-45/SLC	Inserted	#10-32	25	12.84	13.5-13.8	166	6	2.5	0.0060	858
TEL12-70	Inserted	1/4-20	110	12.84	13.5-13.8	245	9	3.8	0.0050	1326
TEL12-80/SLC	Inserted	1/4-20	110	12.84	13.5-13.8	283	10	4.4	0.0040	1467
TEL12-90	Inserted	1/4-20	110	12.84	13.5-13.8	331	11	5.0	0.0035	1549
TEL12-105FS	Inserted	1/4-20	110	12.84	13.5-13.8	--	13	5.5	0.0034	1300
TEL12-105FNSG	Inserted TFA	M8	160	12.84	13.5-13.8	339	13	5.8	0.0030	1050
TEL12-115FNG	Inserted TFA	M6	110	12.84	13.5-13.8	358	14	6.0	0.0030	1090
TEL12-125	Inserted	1/4-20	110	12.84	13.5-13.8	464	16	6.7	0.0023	1747
TEL12-145FW	Inserted TFA	M6	110	12.96	13.5-13.8	--	18	7.9	0.0023	1700
TEL12-155F/FG	Inserted TFA	M8	160	12.96	13.5-13.8	437	19	9.0	0.0031	1120
TEL12-160FW	Inserted TFA	1/4-20	110	12.96	13.5-13.8	--	20	8.8	0.0027	1780
TEL12-160F	Inserted TFA	1/4-20	110	12.96	13.5-13.8	--	20	8.6	0.0031	1500
TEL12-170F/FG	Inserted TFA	M8	160	12.96	13.5-13.8	536	21	9.3	0.0033	1400
TEL12-180F	Inserted TFA	1/4-20	110	12.96	13.5-13.8	--	23	10.0	0.0037	1510
TEL12-190F/FG	Inserted TFA	M8	160	12.94	13.5-13.8	575	24	10.4	0.0035	1450
TEL12-210F/FG	Inserted TFA	M8	160	12.96	13.5-13.8	605	25	11.5	0.0040	1500
TEL6-180	Inserted	1/4-20	110	12.84	6.75-6.90	--	22	10.0	0.0012	Limited Data
DCS-33IT/HIT	Inserted	#10-32	30	12.84	13.5-13.8	--	4	1.7	0.0070	784
DCS-50IT	Inserted	#10-32	30	12.84	13.5-13.8	--	6	2.5	0.0060	916
DCS-75IT/HIT	Inserted	1/4-20	110	12.84	13.5-13.8	--	9	3.8	0.0045	1328
DCS-88HIT	Inserted	1/4-20	110	12.84	13.5-13.8	--	10	4.4	0.0045	1592
DCS-100HIT	Inserted	1/4-20	110	12.84	13.5-13.8	--	11	5.0	0.0035	1515

*Excludes models with SLC

Please refer to 12-1110 and 12-1111 for additional Ohmic reference values.

C&D Valve Regulated
Lead Acid Batteries
Historical Data and System Status

Company:
Location:
Supervisor in Charge: Phone:
Type Charger/Load:
Unit Part Number: Cells /Unit:

System Float Changing Voltage: VDC
Date Batteries Installed:
Load (K.W. or Ampere):
System Equalize Voltage: Amps:

Room Temperature: Unit Temperature Range:

Date:					Date:				
Unit No.	Charging Volt&Unit	Impedance Conductance AC Millivolts	10 Sec. Vmin o 100 Amps.	Connection Resistance	Unit No.	Charging Volts Unit	Impedance Conductance AC Millivolts	10 Sec. Vmin o 100 Amps.	Connection Resistance
1					31				
2					32				
3					33				
4					34				
5					35				
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9					39				
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