ENERLYTE ®

Advanced Technology

Flooded Lead Acid Batteries

Installation & Operating Instructions

Battery Energy Power Solutions Pty Ltd

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This Manual should remain with the battery and be referred to for periodic and scheduled maintenance.

Information recorded by the installer in this document will be required should there be a system failure.

Table of Contents

1.0 PURPOSE

The purpose of this procedure is to establish a recommended standard for the operation and maintenance of General Purpose Flooded Lead Acid Stationary Batteries to be implemented by the user.

2.0 OBJECTIVE

To optimise the service life and performance of Flooded (Vented) Lead Acid Batteries by the implementation of regular maintenance inspections and procedures. The reporting of these results will ensure that the correct remedial action will be implemented and the user will undertake a uniform approach to maintenance.

3.0 SCOPE

This procedure is applicable to all General Purpose Flooded (Vented) Lead Acid Stationary Batteries supplied by Battery Energy Power Solutions Pty. Ltd.

This procedure has been developed for the reference of all staff involved in the maintenance of flooded (vented) lead acid batteries.

The user is required to implement these procedures for regular battery maintenance at quarterly and yearly intervals in accordance with section 8.0., to prevent voiding of the warranty.

4.0 DEFINITIONS

4.1 Battery - is an assembly of two (2) or more cells.

4.2 Boost Charging - is the operation of charging the battery at a voltage higher than the normal float voltage and is sometimes called a “Refresher Charge”.

4.3 Capacity - the quantity of electric charge (expressed in ampere-hours [Ah]) which a fully charged battery can deliver under normal operating conditions.

4.4 Capacity Test - is the discharge of a battery to a final voltage (eg - 1.85 Volts per cell). The capacity of the battery is the constant current discharged multiplied by the time taken to discharge to the final voltage and then corrected for an average electrolyte temperature of 25 ° C.

4.5 C3 - is the 3 hour capacity of the battery expressed in Ah when discharged at the 3 hour rate for 3 hours to a defined end voltage (1.85 Volts) and temperature corrected to 25 ° C. (Refer to Capacity Test)

4.6 C10 - is the 10 hour capacity of the battery expressed in Ah when discharged at the 10 hour rate for 10 hours to a defined end voltage (1.85 Volts) and temperature corrected to 25 ° C. (Refer to Capacity Test)

4.7 Cell - in a fully charged state a lead acid cell contains lead dioxide (PbO_2) in the positive plates and spongy lead in the negative plates. The plates are immersed in an electrolyte of dilute sulphuric acid (H_2SO_4). Groups of positive and negative plates are interleaved and connected to the cell terminals. When the terminals are connected through an external circuit a chemical reaction takes place in the cell. The driving force of the reaction is the potential difference (or open circuit voltage) of the cell and is typically 2.08 Volts for a lead acid cell.

4.8 Charging - involves the passage of direct current electricity through the cells in the opposite direction to the normal current flow. This electricity energy is converted to chemical energy and stored in the cell. This energy is measured in ampere - hours (Ah).

4.9 Constant Voltage Charge - the charging of the battery with a constant voltage across the battery terminals irrespective of the charging current.

4.10 Discharging - the delivery of current to an external load by the conversion of chemical energy to electrical energy.

4.11 Duty Cycle - specified output of voltage or current to be achieved by the battery for a given period followed by a charge current to restore the battery state to an acceptable level.

4.12 Electrolyte - is a diluted solution of water (H_2O) and sulphuric acid (H_2SO_4) for a lead - acid battery.

4.13 Electrolyte Density - is the density of the electrolyte measured in Kg/m^3 at a specific temperature (density of pure water is 1000 Kg/m^3 at 4 degrees Celsius).

4.14 Equalising Charge - is given to the battery to ensure uniformity of voltage and density of all cells in a battery. It is a form of boost charge.

4.15 Equalising Voltage - the voltage involved in the equalising charge of a battery. This is commonly "Float 2" or approximately 2.30 Volts per cell.

4.16 Final Voltage - at conventional rates of discharge the voltage of the lead - acid cell is relatively steady at 2 Volts until the cell is near "exhaustion", when the voltage falls rapidly. This point is called the "final" or "end" voltage (typically 1.85 Volts at the 10 hour rate of discharge).

4.17 Flame Arrester Vent Plug - (or better known as safety vent) protects against internal explosions. It is made of a microporous membrane, which allows any gases generated within the cell to escape to the atmosphere, but prevents any sparks or flames from igniting gases present in the cell.

4.18 Float Charge - the permanent connection of a battery, battery charger and load in parallel, so that the battery is always in a fully charged state (ie. the battery charger supplies the normal DC load plus any self discharge or charging current, or both, required by the battery).

4.19 Float Voltage - the voltage required to maintain the battery in a fully charged state by maintaining all cell voltages above but close to the true open circuit potential (typically 2.20 - 2.25 Volts per cell).

4.20 Gassing - the formation and emission of gas produced by electrolysis during a boost charge of the battery and only occurs at voltages above 2.35 Volts per cell.

4.21 General Purpose - or medium rate discharge lead acid battery is one with a density of 1240 kg/m^3 and designed for 3 to 20 hour rate discharges and connected to a continuously powered float charge system.

4.22 Hydration - is a condition caused by discharging a cell and failing to recharge it in a timely manner. This results in the lead dissolving into the water in the electrolyte and forming into lead hydrate, which then renders the cell useless.

4.23 Intercell Connection - an electric conductor which connects adjacent cells.

4.24 Mossing - is the accumulation of spongy lead material on the negative plates. The cause of mossing is the overcharging of a battery or by charging at excessively high rates.

This material gradually builds up until it results in a short between the positive and negative plates.

4.25 Rated Capacity - see capacity.

4.26 Sediment - active material that separates from the plates and lies at the bottom of the battery case. It is formed by the over-discharging and overcharging of the battery at excessively high rates (continuous overcharge - dark or chocolate brown in colour and located in hills beneath the positive plates; continuous undercharge - grey deposits in hills below the negative plates).

4.27 Separator - the positive and negative plates are separated by chemically inert, non conductive spacers to prevent metallic contact of the plates and have a high degree of microporosity to ensure minimum internal resistance.

4.28 Specific Gravity - is the ratio of the electrolyte density to the density of water (typically 1.240). The specific gravity decreases on discharge and rises on charging. It varies with both temperature and electrolyte level.

4.29 Sulphation - is caused by the undercharging of a battery. The sulphate material accumulates on the plates during normal discharge and if undercharging continues it forms into hard impervious crystals that results in a loss of capacity. If left in this condition, the process of sulphation is generally irreversible.

4.30 Terminal Posts - the external termination points on a cell (negative and positive) to which a circuit is connected.

4.31 Trickle Charge - the current flowing through the battery during float charge conditions.

5.0 OPERATION

The battery may be charged and discharged within the parameters laid down in the procedures outlined in this guide.

REFERENCE MATERIAL

(1) AS 2676.1 - 1992 Guide to the Installation, Maintenance, Testing and Replacement of Secondary Batteries in Buildings.

(2) AS 4029.3 - 1992, Stationary Batteries - Lead Acid. Part 3 : Pure Lead Positive Pasted Plate Type.

(3) M. W. Migliaro, “Maintaining Stationary Batteries” in IEEE Transactions on Industry Applications, VOL 1A - 23, No. 4, July/August 1987.

6.0 RESPONSIBILITY

6.1 Maintenance Staff

Maintenance staff who are assigned the task of battery maintenance are responsible for: -

(1) Ensuring that the battery maintenance is performed on a regular basis in accordance with these procedures.

(2) Ensuring that the tests and visual inspections undertaken are in accordance with these procedures.

(3) Ensuring that all safety precautions are adhered to while undertaking battery maintenance. Any safety precautions not undertaken, for any reason, must be brought to the immediate attention of the Supervisor.

(4) Ensuring correct recording of all tests and checks. Any test or check which cannot be undertaken, for any reason, must be documented and immediately reported to the Supervisor.

(5) Ensuring that any test results that are out of limits or any other abnormalities are documented and immediately reported to the Supervisor.

(6) Ensuring that minimum disruption is caused to other services, due to the implementation of this maintenance practice.

6.2 Supervisory Staff

Supervisory staff are responsible for: -

(1) Ensuring that on the completion of commissioning and acceptance testing of any battery, the following is available on site: -

- Battery Record Book (complete with all initial acceptance and commissioning test results).
- Thermometer (positioned within the labelled “Pilot Cell”).
- Safety goggles or face shield and portable eye wash.
- Hydrometer.
- Bicarbonate of Soda or Soda Ash. (Enough to neutralise the contents of the electrolyte of one cell). Refer to Appendix H for quantities.

7.0 PRELIMINARY PROCEDURES

Maintenance of batteries begins at the completion of the commissioning and acceptance tests. These tests are used as a reference for all future maintenance data, and therefore must be correctly documented. These initial records are also necessary in the event of a possible warranty claim against the battery manufacturer in the event of a premature failure of a cell or battery.

The main criteria of battery maintenance are that it is regularly performed to a set of standards.

All inspections are to be undertaken while the battery is operating under normal float conditions (ie - the battery has not been discharged or recharged within the last 72 hours).

7.1 Test Equipment

The following test equipment is required to undertake the maintenance work as outlined in Section 8.0 :-

- Multimeter Digital (3.5 resolution)
- Thermometer
- Hydrometer
- Torch
- Dummy Load (for capacity test only)

7.2 Safety Equipment

The following safety equipment should be available and used as per the requirements as outlined in Appendix H.

- Goggles or Face Shield
- Acid Resistant Gloves
- Protective Apron or Acid Proof Overalls
- Portable or Stationary Water Facilities
- Personal Respirator
- Bicarbonate of Soda or Soda Ash
- Fully Insulated Tools

7.3 Safety Precautions

The following safety precautions shall be undertaken: -

- No smoking or open flames.
- Use only fully insulated tools.
- Ensure unobstructed access to and from the battery room.

- Ensure that there is adequate ventilation in the battery room / enclosure.
- When load test connections to the battery are made, that there is short circuit protection and the test leads are of sufficient length to avoid arcing in the vicinity of the battery.
- Avoid wearing metallic objects such as jewellery.
- Neutralise personal static buildup by touching a grounded surface before working on the battery.
- The battery room must not be used as a storage area.
- Spilt electrolyte will not evaporate under atmospheric conditions and therefore must be cleaned up and neutralised.
- Stibine and Arsine Gas - This gas is produced in very small quantities when gas charging lead acid batteries and is noticed by its obnoxious smell in the likeness to rotten eggs or garlic. This gas is highly toxic and a personal respirator must be used when working on a battery that is being gas charged.
- Special care shall be taken with the use of hydrometers and thermometers. Electrolyte tends to remain on the ends of these test instruments after they are withdrawn from the battery vents. Careless handling may result in electrolyte droplets being flicked onto the unwary handler.
- Battery safety vents are provided to prevent explosions and shall therefore only be removed when the battery is fully disconnected from both the power source (rectifiers) and the load.
- Staff shall not work on batteries in isolation. Alternative arrangements shall be made where work in isolation is unavoidable (eg. - such as at remote sites by telephoning a supervisory officer immediately prior to and following the work required on the battery).
- Personal hygiene is essential - always wash your hands after working on a battery.
- Before any work likely to cause sparking (eg - cell replacement, etc.) is commenced, all the adjacent cells should be covered with damp cloths. The battery safety vents must not be removed.

7.4 Records

All tests implemented at the time of commissioning shall be recorded in the Battery Record Book and made available on site for future reference.

All inspections and tests undertaken in the process of battery maintenance (Section 8.0) shall be documented in the Battery Record Book.

Any routine test results, which fall outside of the acceptable parameters, must be documented and reported.

8.0 INSPECTIONS

8.1 Three (3) Monthly

(a) Inspection of Container and Cleaning.
(b) Inspection of Connections.
(c) Electrolyte Levels.
(d) Battery Float Voltage.
` (e) Cell Voltages.
(f) Alarm Check.

(a) Inspection of Container and Cleaning.

Inspect all cells for signs of leaking or spilt electrolyte. This must be cleaned up with a Bicarbonate of Soda solution.

Under no circumstances must any cleaning agents, solvents or chemicals be used for removing spilt electrolyte or dirt/dust.

The tops of all cells must be cleaned and neutralised with a Bicarbonate of Soda solution to prevent tracking currents and self-discharge.

Inspect all cells for any cracks, damage to posts and post seals and any other abnormalities.

All cells must be spaced at least 25mm from any metallic parts of the cabinet or stand and at least 10 mm between adjacent rows.

(b) Inspection of Connections.

Inspect all connections for any signs of corrosion, loose and/or high resistant joints. Any corrosion must be cleaned and neutralised accordingly and the connection renewed.

(c) Electrolyte Level.

Check that the electrolyte level is between the high and low level marks as indicated on each cell.

Top up all cells as required with only approved distilled or de-ionised water.
NB - Only fill to the halfway point between the high and low level marks.

Note and investigate any cell, which has unusually excessive loss of electrolyte.

(d) Battery Float Voltage.

Read and record the battery float voltage across the battery terminals.

The voltage must be between 237.6 and 243 Volts for a 108 cell battery (ie - 2.20 to 2.25 Volts per cell). For a 12 cell battery the voltage must be between 26.4 and 27 Volts.

Any discrepancy between the battery terminal voltage and the voltage indicated on the charging device, rectifier or distribution cubicle should be noted and investigated.

(e) Cell Voltages.

Read and record each cell voltage to the second decimal place (2.25 V) with a digital voltmeter.

These cell voltages must all be similar (equalised). The maximum allowable range from the lowest cell voltage to the highest cell voltage must be no more than 0.05 Volts (eg - 2.19 to 2.24 Volts).

An equalising charge will be necessary if any cell is outside of this 0.05 Volt range or any cell is below 2.17 Volts.

(f) Alarm Check.

Check that all alarms associated with the battery are in a working order and received at the point of monitor.

8.2 Twelve (12) Monthly

NB - These routines must be done in the following sequence.

(a) Inspection of Container and Cleaning.
(b) Inspection of Safety Vents.
(c) Inspection of Plates, etc.
(d) Density of all Cells.
(e) Electrolyte Levels.
(f) Battery Float Voltage.
(g) Cell Voltages.
(h) Inspection of Connections.
(i) Short Discharge Test.
(j) Ventilation Check.
(k) Alarm Check.

(a) Inspection of Container and Cleaning.

Inspect all cells for signs of leaking or spilt electrolyte. This must be cleaned up with a Bicarbonate of Soda solution.

The tops of all cells must be cleaned and neutralised with a Bicarbonate of Soda solution to prevent tracking currents and self-discharge.

Inspect all cells for any cracks, damage to posts and post seals and any other abnormalities.

All cells must be spaced at least 25mm from any metallic parts of the cabinet or stand and at least 10mm between adjacent rows.

Also inspect the battery stand/rack or cabinet for signs of corrosion from acid leakage or any other physical damage that may weaken its structure.

Report any abnormalities.

(b) Inspection of Safety Vents

Check that all safety vents are firmly seated, dry and clean. The rubber seal should not be distorted or show signs of deterioration.

Any vents showing deterioration, damage or contaminated with acid must be replaced.

The bottom of the stem of the safety vent must also be below the level of the electrolyte.

(c) Inspection of Plates, etc.

With the aid of a torch (plastic), inspect the plates to ensure correct colour:-
- Positive Plates - matt black (lead dioxide)
- Negative Plate - steel grey (pure lead)

Also inspect the plates for growth, buckling, cracks and any other abnormalities.

Inspect for any build up of sediment in the bottom of each cell.

Inspect the condition of the negative and positive grid bars and posts internally.

Report any abnormalities.

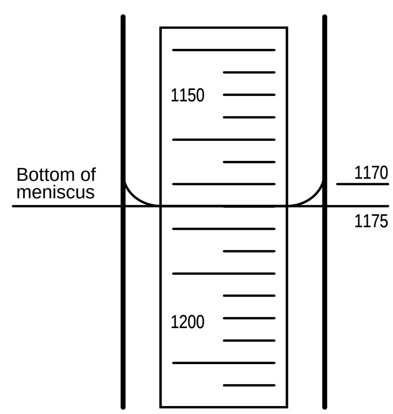
(d) Density of all Cells.

It is a mandatory practice to wear eye protection when doing density readings.

Density readings should be done before cells are topped up with distilled water.

Ensure the hydrometer is in good condition and clean and do not withdraw it from the cell while still full of electrolyte.

Read and record the density of all cells and if necessary correct these readings for a 25 ° C standard. Read at the bottom of the meniscus.



Correct densities should be 1240 Kg/m^3 (± 10) fully charged at 25 ° C. Any readings outside of this range must be reported as corrective action may be necessary.

Temperature correction:-
- for each 1 ° C above 25 ° C, add 0.7 to the observed density reading.
- for each 1 ° C below 25 ° C, subtract 0.7 from the observed density reading.

When finished with the hydrometer, WASH it out with clean water.

(e) Electrolyte Levels

Check that the electrolyte level is between the high and low level marks as indicated on each cell.

Top up all cells as required with only approved distilled or de-ionised water.
NB - Only fill to the halfway point between the high and low level marks.

Note and investigate any cell, which has unusually excessive loss of electrolyte.

(f) Battery Float Voltage

Read and record the battery float voltage across the battery terminals.

The voltage must be between 237.6 and 243 Volts for a 108 cell battery (ie - 2.20 to 2.25 Volts per cell). For a 12 cell battery the voltage must be between 26.4 and 27 Volts.

Any discrepancy between the battery terminal voltage and the voltage indicated on the charging device, rectifier or distribution cubicle should be noted and investigated.

(g) Cell Voltages.

Read and record each cell voltage to the second decimal place (2.25 V) with a digital voltmeter.

These cell voltages must all be similar (equalised). The maximum allowable range from the lowest cell voltage to the highest cell voltage must be no more than 0.05 Volts (eg - 2.19 to 2.24 Volts).

An equalising charge will be necessary if any cell is outside of this 0.05 Volt range or any cell is below 2.17 Volts.

(h) Inspection of Connections.

Inspect all connections for any signs of corrosion, loose and/or high resistant joints. Any corrosion must be cleaned and neutralised accordingly and the connection renewed.

All bolted connections should be tightened using a torque wrench. On larger cells (above 900Ah) a torque setting of 10NM is required. On smaller cells a torque of 6NM is required.

Impedance readings of all connections should be taken and compared with the initial installation readings.
Any high resistant connections must be noted and repaired.

(i) Short Discharge Test.

Carry out the Short Discharge Test as per Appendix “C”.

(j) Ventilation Check.

Where ventilation equipment has been provided, its operation should be checked and reported, if not operational.

(k) Alarm Check.

Check that all alarms associated with the battery are in a working order and received at the point of monitor.

APPENDICES

A Three (3) Monthly Record Sheet.

B Twelve (12) Monthly Record Sheet.

C Short Discharge Test.

D Full Discharge Test.

E Charging Procedures.
- **(a)** Equalisation Charge
- **(b)** Full Recharge
- **(c)** Deep Discharge Recovery

F Cell Replacement and Disposal.

G Charge and Discharge Rates.

H Safety Information.
- **(a)** Protective Clothing
- **(b)** Acid Spills and Neutralisation
- **(c)** Stibine Gas Diagrams.

THREE (3) MONTHLY RECORD SHEET   APPENDIX A

Site Name……….. Date of Test....................................
Battery Number.. Date of Manufacture.........................
Battery Capacity.. Cell Temperature.............................
Battery Terminal Voltage...................................... Site Load Current............................

Cell No.	Voltage	Cell No.	Voltage	Cell No.	Voltage
1		37		73	
2		38		74	
3		39		75	
4		40		76	
5		41		77	
6		42		78	
7		43		79	
8		44		80	
9		45		81	
10		46		82	
11		47		83	
12		48		84	
13		49		85	
14		50		86	
15		51		87	
16		52		88	
17		53		89	
18		54		90	
19		55		91	
20		56		92	
21		57		93	
22		58		94	
23		59		95	
24		60		96	
25		61		97	
26		62		98	
27		63		99	
28		64		100	
29		65		101	
30		66		102	
31		67		103	
32		68		104	
33		69		105	
34		70		106	
35		71		107	
36		72		108	

Comments………………………………………………………………..
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TWELVE (12) MONTHLY RECORD SHEET APPENDIX B

Site Name.. Date of Test...
Battery Number.. Date of Manufacture................................
Battery Capacity.. Cell Temperature.....................................
Battery Terminal Voltage............................... Site Load Current.....................................

Cell No.	Voltage	Cell No.	Voltage	Cell No.	Voltage
1		37		73	
2		38		74	
3		39		75	
4		40		76	
5		41		77	
6		42		78	
7		43		79	
8		44		80	
9		45		81	
10		46		82	
11		47		83	
12		48		84	
13		49		85	
14		50		86	
15		51		87	
16		52		88	
17		53		89	
18		54		90	
19		55		91	
20		56		92	
21		57		93	
22		58		94	
23		59		95	
24		60		96	
25		61		97	
26		62		98	
27		63		99	
28		64		100	
29		65		101	
30		66		102	
31		67		103	
32		68		104	
33		69		105	
34		70		106	
35		71		107	
36		72		108	

Comments..
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SHORT DISCHARGE TEST APPENDIX C

This test is an integrity test of the full DC system using the station load to discharge the battery for a short period of no more than 15 minutes.

The load should ideally be between the 3 hour and 10 hour rate of the battery. It may be necessary to augment the station load with a load cage if the battery reserve is greater than 10 hours. Refer to Appendix “G” for these rates.

Do not carry out this test until all of the previous tests in the Twelve Monthly routines have been done with satisfactory results. The battery should now be in good condition and capable of supporting the load during a power failure condition.

1. Connect a Voltmeter across the battery terminals and note the float voltage.

2. Turn off the charging devices (rectifiers) and immediately monitor the Voltmeter and note the lowest voltage reached (bottom of dip).
NB - If the voltage falls below 1.91 Volts per cell, immediately turn the charging devices (rectifiers) back on and report the situation. Do not proceed with the test.

3. Record the Voltages readings every 15 seconds for the first 2 minutes or until it has stabilised after recovering from the initial dip.

4. Continue to record the overall voltage now at 2 minute intervals.

5. Record the total discharge (load) current.

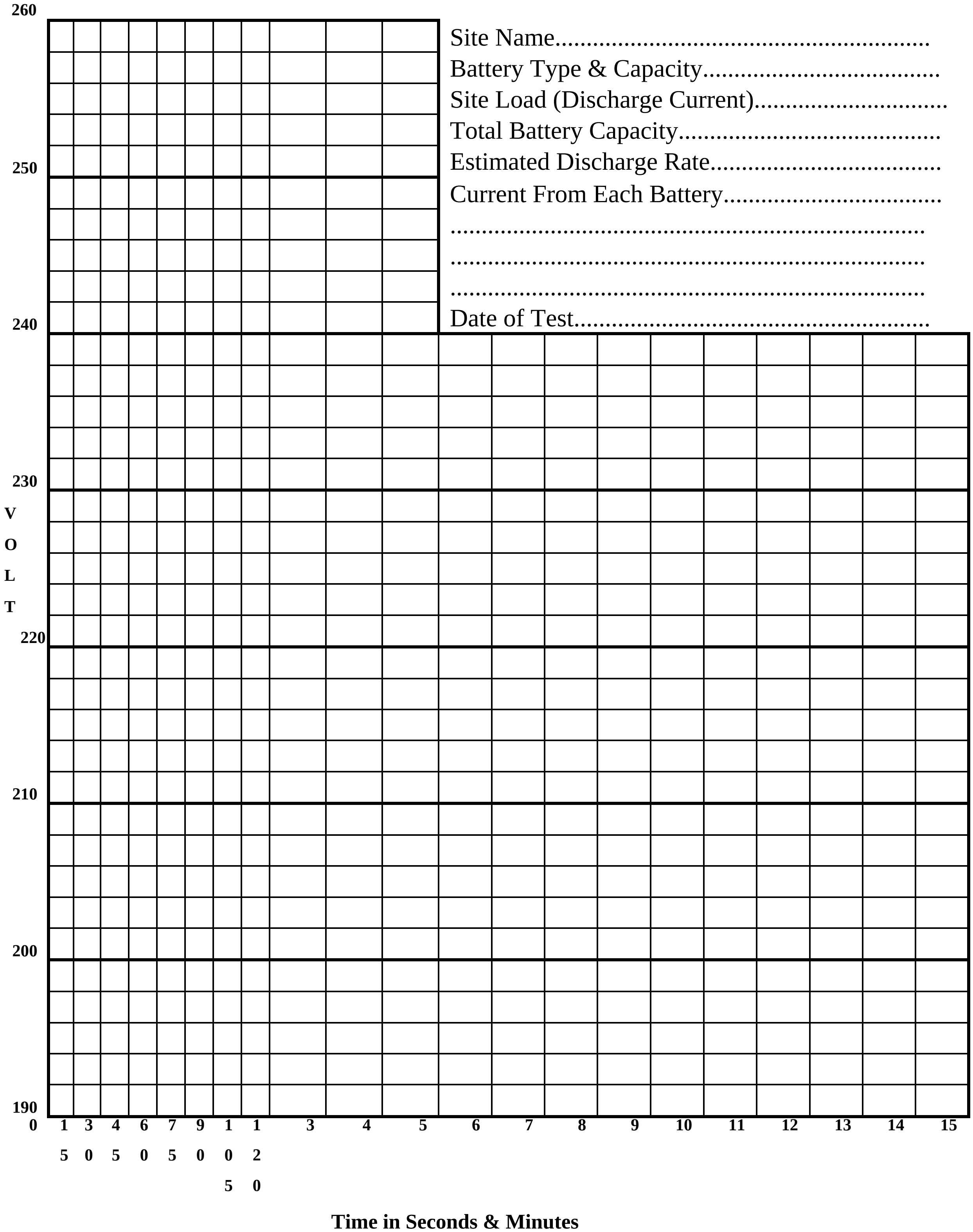
6. If the site has more than one battery, measure the current being supplied by each battery with a current tong meter, to ensure they are sharing the load equally.
NB - Be aware that batteries of different capacities in parallel will load share differently.

7. Read the voltage drops in mV. (Do not record) across all battery connections. Note any abnormal readings, as this connection will require attention.
NB - All voltage drops across similar types of connections should be uniform. The voltage drops across longer inter row or inter tier connections will be higher.

8. After 10 minutes read all cell voltages (do not record). Note any cell voltage that is obviously lower than the average as it will require further attention. Readings in the area of 1.95 to 2.05 Volts can be expected depending on the battery type and the load current.

9. Restore the charging equipment to normal and ensure it is operating normally.

SHORT DISCHARGE TEST GRAPH



Site Name...
Battery Type & Capacity.....................................
Site Load (Discharge Current)..............................
Total Battery Capacity...
Estimated Discharge Rate...................................
Current From Each Battery..................................
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Date of Test...

Comments..
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FULL DISCHARGE TEST APPENDIX D

A full test discharge is only carried out when the results of the routine maintenance procedures indicate there is a problem with the battery.

Any rate of discharge can be used but the 3 hour rate is normally used. The rate used may depend on the size of the load bank available.

At a single battery installation a standby battery may need to be provided to support the load or it may be sufficient to support the load with the rectifier alone. At multiple battery installations, only test one battery at a time.

Procedure for 3 hour test discharge :-

1. Read and record the battery voltage, all cell voltages, all cell densities and the temperature of a cell.

2. Completely isolate the battery to be tested.

3. Ensure all switches on the load bank are off, before connecting it to the battery.

4. Start a timer and then switch on the amount of load to equal the 3 hour rate of the battery being tested. Refer to the chart in "Appendix G" for these rates.

5. Read and record the following at 30 minute intervals :-
- Time
- Battery voltage
- Discharge current
- Individual cell voltages
- Cell temperature

6. Re-adjust the load bank switches to maintain the discharge current at the 3 hour rate.

7. Periodically inspect cells and connections for any signs of overheating.

8. The first cell to reach 1.90 Volts should be monitored regularly until it or another cell first reaches 1.85 Volts.

9. Once the first cell reaches 1.85 Volts, read and record the following :-
- Time completed
- Battery voltage
- Individual cell voltages
- Cell temperature

10. Switch off the load cage and disconnect it from the battery.

11. Calculate the 3 hour corrected capacity to 25 ° C using the following formula :-

$$C_{25} = \frac{C_1}{1 + K(t - 25)}$$

C_{25} = Capacity Corrected to 25 ° C in Ampere Hours (Ah)

C_1 = Capacity as Tested in Ah (Discharge Current x Discharge Time)

K = 0.014 for 3 Hour Rate or 0.012 for 10 Hour Rate

t = Electrolyte Temperature in Degrees Celsius
(mean temperature during final 2 hours of test discharge)

12. Calculate the percentage capacity using the following formula :-

$$\%\ \text{CAPACITY} = \frac{\text{3 Hour Corrected Capacity} \times 100}{\text{3 Hour Rated Capacity}}$$

13. A battery, which has a capacity of 80 to 95%, should be recharged and retested. A battery, which has a capacity below 80%, will most probably require replacement.

14. Recharge the battery as per “Appendix E”.

15. After the battery has been on float for at least 12 hours after the recharge a full set of cell voltage and density readings should be taken. The densities of all cells after the recharge must be equal to or higher than they were prior to doing this test discharge.

TEST DISCHARGE RECORD SHEET

Site Name... Date of Test.....................................
Battery Type.. Date of Manufacture.........................
Battery Capacity.. Cell Temperature.............................
Battery Terminal Voltage....................................... Site Load Current............................
Battery Number.. Discharge Current............................
Time Test Started.. Percentage Capacity..........................

Cell No.	Float Cell Volts	Float Cell Density	1st Cell Volts	2nd Cell Volts	3rd Cell Volts	4th Cell Volts	5th Cell Volts	6th Cell Volts	Final Cell Volts
1									
2									
3									
4									
5									
6									
7									
8									
9									
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Cell No.	Float Cell Volts	Float Cell Density	1st Cell Volts	2nd Cell Volts	3rd Cell Volts	4th Cell Volts	5th Cell Volts	6th Cell Volts	Final Cell Volts
35									
36									
37									
38									
39									
40									
41									
42									
43									
44									
46									
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Cell No.	Float Cell Volts	Float Cell Density	1st Cell Volts	2nd Cell Volts	3rd Cell Volts	4th Cell Volts	5th Cell Volts	6th Cell Volts	Final Cell Volts
78									
79									
80									
81									
82									
83									
84									
85									
86									
87									
88									
89									
90									
91									
92									
93									
94									
95									
96									
97									
98									
99									
100									
101									
102									
103									
104									
105									
106									
107									
108									

Comments..

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CHARGING PROCEDURES APPENDIX E

(a) Equalisation Charge

Boost charging is required to maintain the equalisation of all cells in a battery so they will stay in a fully charged state while being subjected to the one float current.

When the range of cell voltages from the lowest reading to the highest reading is greater than 0.05 Volts then a boost charge is necessary (eg - 2.16 to 2.23 Volts).

NB - A respirator must be worn when doing readings on a battery that is being gas charged.
The site must be adequately ventilated during the boost charge.
Density readings are not to be taken during a boost charge, only voltage and temperature readings.
If any cell temperature reaches 43 °C then the charge must be discontinued until the cell temperature drops to 35 °C.

Procedure

1. Disconnect the battery from the load and connect to a rectifier capable of boost charging the battery at the 20 hour rate. Refer to “Appendix G”.

2. Charge the battery at the 20 hour rate and monitor the cell voltages on the low cells, which are out of limits.

3. Continue the boost charge until the voltage on these low cells becomes stable and is no longer rising.
NB - Cell Voltage readings to be expected from a good fully charged cell being charged at the 20 hour rate will be in the vicinity of 2.75 Volts. Initially the low, out of limit cells, will boost at a much lower voltage than this.

4. When all cell voltages have stabilised, the boost is complete.

5. Allow the battery voltage to drop back to float voltage and when it is equal to the float voltage, it can be reconnected to the load.

6. After 12 hours minimum on float a full set of cell voltages and densities must be taken to ensure that the boost charge has been successful and the battery is equalised.

(b) Full Recharge

Boost charging is also required after a discharge resulting from an extended power failure or after a test discharge.

Procedure

1. Disconnect the battery from the load and connect to a rectifier capable of boost charging the battery at the 10 hour rate.

2. Charge the battery at the 10 hour rate until the cells start to gas. This will occur when cell voltages have reached 2.35 Volts.

3. When all cells are gassing reduce the charge rate to the 20 hour rate and continue the charge.

4. When all cell voltages have stabilised and remained constant for 3 consecutive half-hourly readings the battery should be fully charged.

5. To determine if a battery has been fully recharged after a full test discharge, 120% of the Ampere hour capacity taken from the battery during the test discharge must be returned during the boost.

As an example for a 200 Ah Battery with a 3 hour rate of 50 Amps:

Discharge for 3 hours at 50 amps per hour	=	150 Ah
Capacity to return on recharge is 150 Ah x 120%	=	180 Ah
Assume 6 hours charge at the 10 hour rate (20 x 6)	=	120 Ah
Plus 6 hours charge at the 20 hour rate (10 x 6)	=	60 Ah
Therefore total charge returned	=	180 Ah

(c) Deep Discharge Recovery

Boost charging after a deep discharge where the site has failed because of low voltage (eg - below 1.60 Volts per cell) requires special procedures to prevent permanent damage to the battery.

Procedure

1. Firstly recharge the battery at the 50 hour rate until cell voltages have reached approximately 1.90 Volts per cell.

2. Increase the charge rate to the 10 hour rate and continue charging until all cells are gassing. This will occur when cell voltages are at approximately 2.35 Volts per cell.

3. Decrease the charge to the 20 hour rate and then continue the charge as described above in Section (a).

CELL REPLACEMENT AND DISPOSAL APPENDIX F

Any cell or battery which has a capacity of 80% or less of the manufacturers rating and cannot be recovered, should be considered for replacement. Any cell, which has registered unsatisfactory maintenance results (after attempts to fully charge), should also be considered for replacement.

Isolate the battery from the charger and load before undertaking any cell replacements. The replacement cell must be of the same type, capacity and ideally of a similar age to ensure compatibility with the rest of the cells in the battery.

On completion of the cell replacement an equalising charge should be done and then a check for equalisation done after the battery has been on float for a minimum of 12 hours.

All cells should be disposed or recycled through a recognised dealer.

Battery Energy Power Solutions Pty. Ltd. disposes of all recovered cells to “Simsmetal”.

CHARGE AND DISCHARGE RATES APPENDIX G

The term rate is the amount of current per hour discharged from a battery for a given time to a defined end voltage. The most common rates used are the 3 hour and the 10 hour rate.

The rate will vary depending on the battery design, temperature and the defined end voltage. If a battery is discharged at a higher rate to the same end voltage then its actual capacity will be less.

Example: For a 225 Ah. battery the 10hr capacity would be 225 Ah (C10). This means the battery will supply 22.5 Amps for 10 Hours to an end voltage of 1.85 Volts giving a 10 Hour capacity of 225 Ampere Hour (C10).

When discharged at the 3 Hour rate this battery will only be capable of supplying approximately 68% of the 10 Hour capacity.
ie. - 68% of 225 = 153 Ah.

Therefore the 3 Hour capacity of this battery is 153 Ah (C3). This means the battery will supply 51 Amps for 3 Hours to an end voltage of 1.85 Volts giving a 3 Hour capacity of 153 Ampere Hour (C3).

APPENDIX H

SAFETY INFORMATION

(a) Protective Clothing

It is **mandatory** to wear the following safety equipment when :-

- Full Face Shield or Goggles
  To be used for all physical work on flooded batteries and where acid is present.

- Respirator and Cartridges
  To be used for all physical work on a flooded lead acid battery while being gas charged.

- Safety Rubber Boots/Footwear
  To be worn when actually carrying and/or installing batteries.

- Portable or Stationary eye wash facilities
  Water must be available on site if there is no running water available.

It is **optional** to wear the following safety equipment when :-

- Acid Resistant Gloves
  For use when the hands come into contact with acid. The use of these gloves when doing tasks such as density readings is not recommended. Disposable surgical gloves are a better alternative.

- Protective Apron
  Normally worn when actually carrying and/or installing batteries and working with large quantities of electrolyte.

- Dust Coat Acid Resistant
  For use to protect personal clothing during any battery work.

- Combination Overalls Acid Resistant (light weight)
  For use to protect personal clothing and exposed limbs during battery installation work.

(b) Acid Spills and Neutralisation

The following table indicates the quantities of Sodium Bicarbonate or Soda Ash required to neutralise the electrolyte of some commonly used flooded lead acid batteries: -

Cell Type	Electrolyte Volume [Litres]	Chemical Required [kg]	
		Sodium Bicarbonate (Bi-Carbonate of Soda)	Sodium Carbonate (Soda Ash)
2V250	4.7	3.5	2.2
2V1060	34	24	15
2V2890	64	46	29

NB - Mix 0.5 Kg to 5 litres of water for general cleaning and neutralising.
As a general rule for acid spills 1 Kg of Bicarbonate of soda will more than neutralise 1 litre of electrolyte.

(c) Stibine Gas

Stibine gas is produced when a flooded lead acid battery is gas charged or under certain fault conditions.

When Hydrogen (in its first stage) is given off during a gas charge it combines with Antimony impurities in the cell to form Antimony Hydride or more commonly known as Stibine.

Stibine is a very heavy and unstable gas in the atmosphere and normal ventilation is generally enough to disperse it.

The following list of respirators and filter cartridges must be worn when working on a battery that is being gas charged: -

Protector

Description
Lunguard II RFF90 Full face mask with attached 0.5lt, RC224 canister.
Lunguard Deluxe RFF92 Full-face mask with flexible hose to 0.5lt RC224 canister.

Available: Protector Safety Pty. Ltd., (all states)

Sundstrom

Description
Mask (½ face, S/M, M/L) SR90 TPE with 19-01350 cart. (315-A1.B1.E1). Box of 5, and Pre-filters 221-1. Pack of 80.
Mask (½ face, S/M, M/L) SR90 Silicone (comfort) with 19-01350 cart. (315-A1.B1.E1). Box of 5, and Pre-filters 221-1. Pack of 80.
Mask (Full face, one size only) SR72 with 20-01354 gas cart. (294-B2.E2). Box of 3. and Pre-filters 221-1. Pack of 80.

Available: Protector Safety Pty Ltd., (all states) & Allsafe Pty. Ltd.

NB - Cartridges and masks **must always** be the same brand. Each manufacturer by law, must produce masks and cartridges which are incompatible with every other manufacturers masks and cartridges.