Absorption Charge Characteristics
And How They Affect Your Batteries

After spending large sums of money on the best batteries available, you now need to pay attention to how you care for your battery bank. Properly charging, discharging, and monitoring your battery bank while not inducing too much stress will ensure you get proper performance and adequate life out of your investment.

Here we will try to explain the absorption mode of the typical, non-adaptive, battery charger and how it can affect the performance and life of your battery bank. This is a critical cycle in the charge profile and requires the attention and time to set it properly. By not providing the proper time required for a full charge you WILL sulphate your batteries and cause a sudden end to the battery life.

Consider your batteries as living breathing things. They supply what you ask for to their maximum ability. They work in hot and cold climates. And only ask to be fed properly when they get weak. By replenishing the power properly you will not sulphate or damage your batteries from improper charge profiles or sulphation and stratification from not being fully charged.

During the typical charge profile a battery charger goes through 3 basic cycles; bulk, absorption, and float. In most chargers these are programmable and allow user interaction to set properly for the battery type you are using. In bulk mode, chargers will regulate current but not voltage. In this mode, typically current is regulated to the max rated output. In the absorption mode chargers regulate both voltage and current.
In the float mode chargers regulate voltage.

During a charge cycle of a battery or battery bank the charger will go into the bulk charge mode when the terminal voltage falls below the charger's preset threshold. The charger then supplies the maximum voltage and current to the battery bank. When the absorption voltage threshold is reached the charger cuts back on current and holds the voltage constant. This allows the battery to "absorb" the remaining charge slowly so as not to overheat and damage the battery. This absorption stage is where you will finish the battery charging function.

NOTE: At the point where the bulk charge stage stops and the absorption charge stage begins the battery bank is approximately 75-80% full. This then leaves the remaining 20-25% of the battery bank capacity to be satisfied by the charger at a reduced current output during the absorption charge stage..

EXAMPLE: A battery bank capable of 880ah at a 50% depth of discharge will require 484ah (Approximately 110%) to reach a full state of charge. As the charger goes through the presets it will typically switch to absorption in the 700ah range. This leaves 184ah to reach a full state of charge. If the charger is only putting out 20ah during the absorption period of 1 hour as preset by the manufacturer the battery has only reached an 80% state of charge. Therefore it stands to reason that the absorption time should be increase by 6-7 hours before going into the float mode. NOTE: This is an example and for specific rates the charger manual must be consulted prior to any determination of time changes.

To properly set the absorption time you must go through a few trial and errors. Put the batteries through a normal discharge cycle. Then put the batteries through a normal charge cycle. At the point where the charger goes into the float mode, shut the system down and disconnect ***ALL*** loads from the battery bank. Apply a small load for 1-2 minutes to eliminate the surface charge and allow the battery bank to set for 3-4 hours checking the terminal voltage at the end of this period. This, when compared to the battery manufacturer's charging chart, will tell you the state of charge of your bank. You then can calculate the approximate time required to reach a full charge on the battery bank. Remember that all batteries have a specific terminal voltage when fully charged which will vary between battery manufacturers. Once you have changed the settings go through the test once more to determine if the bank is reaching full charge. Repeat as necessary until you get it right. This may require several cycles. The option is to purchase a quality battery monitor which, when set properly, can show you all of the details regarding your battery bank state of charge.

Finally, relying on a charger's preset is going to result in battery failure. In most cases sulphation is not covered by a manufacturer's warranty. Consulting both the charger manual and the battery manual will provide all of the details needed to make the proper adjustments and get the longest life out of the battery bank.

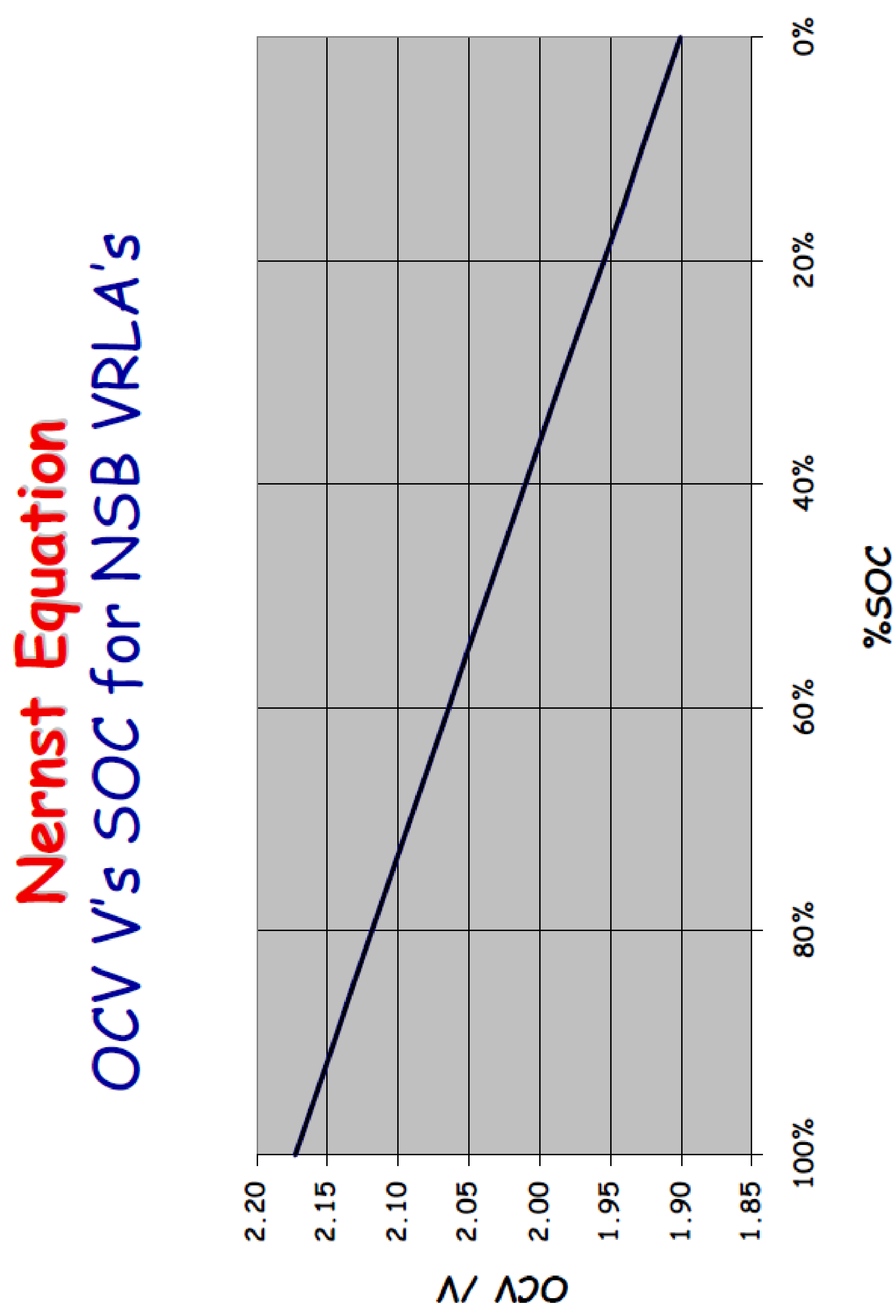
We also highly recommend that all battery charging equipment have battery temperature compensation.

As further help we have enclosed the Energy1/Northstar Battery Charge Voltage Compensation Chart and a report showing sulphation as caused by undercharging a battery bank.

Temp /°C	Minimum Float Voltage /VPC	Nominal Float Voltage /VPC	Maximum Float Voltage /VPC	Minimum Cyclic Voltage /VPC	Nominal Cyclic Voltage /VPC	Maximum Cyclic Voltage /VPC
0	2.35	2.37	2.39	2.52	2.55	2.58
5	2.33	2.35	2.37	2.50	2.53	2.56
10	2.31	2.33	2.35	2.49	2.51	2.54
15	2.29	2.31	2.33	2.47	2.49	2.51
20	2.27	2.29	2.31	2.45	2.47	2.49
25	2.25	2.27	2.29	2.43	2.45	2.47
30	2.23	2.25	2.27	2.41	2.43	2.45
35	2.21	2.23	2.25	2.39	2.41	2.43
40	2.19	2.21	2.23	2.37	2.39	2.41
42	2.18	2.20	2.22	2.36	2.38	2.41
45	2.17	2.19	2.21	2.35	2.37	2.39
50	2.17	2.17	2.19	2.33	2.35	2.37

Figure 3: Charge voltage compensation for NSB batteries

The chart on this page shows the relationship between OCV (Open Circuit Voltage) and SOC (State of Charge) for the Energy1 Battery line using the Nernst Equation.



Factory lab report of failure analysis on an Energy1 AGM battery failure found to be caused by to short of an absorption charge time.

Pre-Testing Data

Upon receiving the batteries, all were photographed, weighed, conductance and voltage measurements taken and recorded as indicated below. Also included with this data are the weights of the batteries prior to shipment for analysis of weight loss.

Battery S/N	Post Form Weight	Weight as received	Impedance received	Conductance as received
J10110621352	58461	N/A	O.F	0
J10110621356	58389	N/A	O.F	0
J10110621185	58595	56519	O.F	0
J10110621359	58811	57092	O.F	0

Received weights were not able to be taken on two of the batteries due to them being melded together and could not be pried apart.
Noted was the large amount of disfigurement on the batteries.

Battery Autopsy

All batteries were autopsied and analyzed for internal flaws or failure modes. Neither of the returned batteries showed any signs of a shorted cell with voltage distributions being equal from cell to cell. Every battery was inspected for the following items with no findings:

1) Free standing acid in the cell
2) Dendrites
3) Bent grid wires
4) Paste lumps
5) Missing separator

The analysis of the positive grid did reveal some corrosion but what was more significant was the amount of sulfation on the plates. This preliminary finding indicates the possibility of either an undercharge condition or the batteries stood in a discharged state for too long of a period.

Weight Loss Analysis

At this point the weights of the batteries as received were subtracted from the weights of the batteries prior to shipment to determine weight loss (electrolyte).

Battery S/N	Post Formation Weight (g)	Weight as received (g)	Weight Loss (g)
J10110621352	58461	N/A	0
J10110621356	58389	N/A	0
J10110621185	58595	56519	2076
J10110621359	58811	57092	1719

Further review of the electrolyte loss in each battery coupled with the batteries case distortion, it is very evident that a thermal runaway condition occurred with these batteries. The calculated average battery temperature figures below are based on each batteries weight loss and the 1.6 years it was in the application according to the manufacturing date. From this we can figure the grams of electrolyte loss per day in use and arrive at the life expectancy of the battery at this battery temperature.

Battery S/N	Weight Loss (g)	Normalized Wt Loss Rate (g/day)	Estimated Temp °F/°C	Life Expectancy (yrs)
J10110621352	N/A	N/A	N/A	N/A
J10110621356	N/A	N/A	N/A	N/A
J10110621185	2076	2.09	159 / 70	0.4
J10110621359	1719	1.73	154 / 68	0.5

Conclusion

From this analysis the results are very clear in that the extremely high weight losses (electrolyte loss) and the heavy sulfation on the plates are a direct result of batteries being left in a discharged state for too long, thus causing stratification. The fact that the electrolyte in the battery is a mixture of water and acid, and like all mixtures, one component, the acid, is heavier than water and will begin to settle and concentrate at the bottom of the battery.

When attempts are made to charge the battery in this state, thermal runaway will occur because the battery can not sufficiently accept the current and begins to get excessively hot, thus burning off the electrolyte.

Field Service Manager
NorthStar Battery Company

3504 Shipwright St
Portsmouth, VA 23703

757-673-7200
www.energy1batteries.com