BATTERY CHARGING REQUIREMENTS

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Foreword

This document is intended for manufacturers of batteries and battery charging systems for renewable energy systems to identify the parameters necessary to properly recharge a lead-acid battery. The values of the parameters will be implemented by the renewable energy system user in the applicable equipment, e.g., charge controller, inverter/charger, battery metering, in order to properly use the battery.

Introduction

In order to obtain the best possible performance and the longest lifetime of a lead-acid battery, the battery must be properly recharged, as well as not overly discharged. The clauses in this document identify which parameters are necessary and sufficient to properly recharge a lead-acid battery.

The values of the parameters will vary by lead-acid technology and battery manufacturer. Not all parameters will need to be specified for some applications. The parameters are entered into the various types of equipment in a variety of ways, including software programming, DIP switches, and variable resistors.

BATTERY CHARGING REQUIREMENTS

1 Scope

This standard applies to all lead-acid based battery technologies used for renewable energy systems, including both flooded and sealed versions.

2 Normative reference

The data sheets from the battery manufacturer and the operation manuals from the charging and metering equipment manufacturers.

3 Terms and definitions

For the purposes of this standard, the following terms and definitions:

absorb charge: The second phase during the battery recharging cycle where the voltage is fixed at the bulk/absorb limit and the charging current decreases to an arbitrarily low limit.

ampere-hour (amp-hour; AH): A measure of current over time, used to measure battery capacity and state of charge.

anode: The positive electrode within a battery cell that during charging undergoes the chemical process of oxidation.

battery: a device that stores energy.

NOTE 1 Electrical batteries consist of a liquid, paste, or solid electrolyte, a positive electrode and a negative electrode to convert chemical energy into electrical energy, rechargeable batteries also convert electrical energy into chemical energy.

NOTE 2 The electrolyte is an ionic conductor; one of the electrodes will react, producing electrons, while the other will accept electrons. When the electrodes are connected to a device to be powered, called a load, an electrical current flows.

NOTE 3 Batteries in which the chemicals can be reconstituted by passing an electric current through them in the direction opposite that of normal cell operation are called secondary cells, rechargeable cells, storage cells, or accumulators.

NOTE 4 The electrolyte is a dilute solution of sulfuric acid, the negative electrode consists of lead, and the positive electrode of lead dioxide. In operation, the negative lead electrode dissociates into free electrons and positive lead ions. The electrons travel through the external electric circuit, and the positive lead ions combine with the sulfate ions in the electrolyte to form lead sulfate. When the electrons reenter the cell at the positive lead-dioxide electrode, another chemical reaction occurs. The lead dioxide combines with the hydrogen ions in the electrolyte and with the returning electrons to form water, releasing lead ions in the electrolyte to form additional lead sulfate. A lead-acid storage cell runs down as the sulfuric acid gradually is converted into water and the electrodes are converted into lead sulfate. When the cell is being recharged, the chemical reactions described above are reversed until the chemicals have been restored to their original condition.

battery capacity: The total maximum charge, expressed in ampere-hours that can be withdrawn from battery under a specific set of operating conditions including discharge rate temperature, state of charge, age, and cutoff voltage.

battery life: The time during which a battery is capable of operating above a specified capacity, typically end-of-life occurs when a fully charged cell can deliver only 80% of the rated capacity

bulk charge: The first phase during the battery recharging cycle when charging current is only constrained by the limits of the charging system and the voltage rises from the discharged battery voltage to the bulk/absorb voltage limit.

cathode: The negative electrode within a battery cell that during charging undergoes the chemical process of reduction.

charge controller: A component of renewable energy systems that controls the charging of the battery to protect the batteries from overcharge and over-discharge.

charge rate: The current applied to a battery to restore its available capacity, specified in relation to total battery capacity.

NOTE A C/20 charge rate is 1/20th of the total battery capacity measured in amp-hours, e.g., if the capacity is 100 amp-hours, a C/20 would be 5 amps taking at least 20 hours of bulk charging to recharge.

deep-cycle battery: A battery designed to regularly discharge 50 to 80 percent of the battery capacity before requiring recharging, with minimal impact on battery life.

depth-of-discharge (DOD): The ampere-hours removed from a fully charged battery, expressed as a percentage of rated capacity.

discharge rate: The current removed from a battery measured in amps.

equalization: When required, the process of restoring all cells in a lead-acid battery to an equal state-of-charge, typically for a duration longer than normal recharging.

float charge: A trickle charge to keep a battery fully charged at a safe voltage level with minimal gassing.

NOTE The float voltage is slightly higher than the intrinsic open-circuit voltage of a fully charged battery.

gassing: When a battery is overcharged, the production of oxygen gas at the cathode and when severely overcharged of hydrogen gas at the anode from electrolysis of water in the electrolyte.

intrinsic battery voltage: The open circuit voltage of a fully charged battery after the gassing within the electrolyte from the charging operation has stopped and the resulting polarization of the battery plates has dissipated.

NOTE Sometimes called the battery rest voltage.

open circuit voltage: The voltage across the battery terminals with no load or charger attached.

self-discharge: The tendency of all batteries to lose energy to internal chemical reactions within the cell.

state-of-charge (SOC): The ampere-hours remaining in a battery, expressed as a percentage of rated capacity.

sulfation: The formation of lead-sulfate crystals on the plates of a lead-acid battery, which decreases battery capacity by impeding the opportunity for chemical reaction within a cell, typically caused by leaving the battery in a discharged state for long periods of time.

NOTE An equalization is often performed to mitigate sulfation.

temperature compensation coefficient: The value that the charging voltage must be changed as a function of the difference in temperature between the standard test condition and the battery.

NOTE 1 The temperature compensation coefficient is usually stated as V/ºC-cell (volts per ºC for each cell).

NOTE 2 When calculating the compensation voltage, the ΔT is positive for colder battery temperatures and negative for hotter battery temperatures, e.g., one adds the ΔV when cold and subtracts when hot.

usable battery capacity: The number of amp-hours that are available for use on an ongoing basis.

NOTE The usable battery capacity at a given discharge rate is typically 50% of the maximum battery capacity at that discharge rate. The usable battery capacity is measured from the intrinsic battery voltage level to the minimum recommended battery voltage level, while the maximum capacity is measured from the intrinsic battery voltage level to the minimum allowed battery voltage.

4 Clauses

4.1. The following parameters are to be specified by the battery manufacturer:
- 4.1.1. Intrinsic battery voltage
- 4.1.2. Float battery voltage, e.g., 0.03 to 0.07 V greater than intrinsic
- 4.1.3. Bulk battery voltage
- 4.1.4. Absorb battery voltage
- 4.1.5. Maximum applied voltage
- 4.1.6. Totally discharged battery voltage
- 4.1.7. Recommended minimum battery voltage
- 4.1.8. Total battery capacity (to 100% discharge) for various discharge rates
- 4.1.9. Usable battery capacity (to recommended discharge level) for various discharge rates
- 4.1.10. Maximum battery bulk charge rate in terms of battery capacity, e.g., 2C
- 4.1.11. Minimum battery bulk charge rate in terms of battery capacity, e.g., C/25
- 4.1.12. Maximum absorb time
- 4.1.13. Minimum absorb time
- 4.1.14. Equalization requirement, i.e., under what conditions should an equalization be performed
- 4.1.15. Equalization frequency, e.g., once per quarter
- 4.1.16. Equalization voltage
- 4.1.17. Equalization current
- 4.1.18. Equalization duration
- 4.1.19. Temperature compensation coefficient, e.g., V/ºC-cell
- 4.1.20. Temperature compensation range, e.g., 0 – 40 ºC

4.2. The following parameters are to be specified by the battery charger manufacturer:
- 4.2.1. Voltage setting precision, e.g., ±0.2 VDC
- 4.2.2. Range of applicable voltages for each mode, e.g., float voltage of 13 ± 3 VDC
- 4.2.3. Minimum current capacity in each mode
- 4.2.4. Maximum current capacity in each mode
- 4.2.5. Absorb timer range
- 4.2.6. Voltage/current that initiates the bulk mode
- 4.2.7. Current at which mode switches from bulk to absorb
- 4.2.8. Equalization timer range
- 4.2.9. Temperature compensation coefficient

4.3. The following parameters are to be entered for monitoring State-of-Charge (SOC) or Depth-of-Discharge (DOD):
- 4.3.1. Recommended minimum battery voltage
- 4.3.2. Usable battery capacity