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DETERMINATION OF CAPACITY OF LEAD-ACID INDUSTRIAL STORAGE BATTERIES FOR MOTIVE POWER SERVICE			

FOREWORD

This standards publication has been prepared by the Motive Power Battery and Electric Vehicle Subcommittee of the Industrial Battery and Charger Committee, Battery Council International. This publication supersedes the previous document. It incorporates updated test procedures, instrumentation and editorial changes.

TABLE OF CONTENTS

- 1. SCOPE AND DEFINITIONS 2
- 1.1. Scope 2
- 1.2. Definitions 2
- 2. PERFORMANCE REQUIREMENTS 2
- 2.1. Initial Capacity 2
- 2.2. Life Cycle Capacity 2
- 3. TEST CONDITIONS 2
- 3.1. Charged and Dry Batteries (Flooded types) 2
- 3.2. State of Charge 2
- 3.3. Voltage 3
- 3.4. Electrolyte Level (Flooded type cells) 3
- 3.5. Temperature 3
- 3.6. Specific Gravity 3
- 3.7. Readings 3
- 4. TEST EQUIPMENT 3
- 4.1. Equipment Condition 3
- 4.2. Thermometers or other Temperature Sensors 3
- 4.3. Hydrometers (Flooded Cells / Batteries) 3
- 4.4. Meters 4
- 4.5. Shunts 4
- 4.6. Timers 4
- 5. TEST METHODS 4

1. SCOPE AND DEFINITIONS

1.1. Scope

1.1.1. This standard covers performance requirements; test conditions and methods for determining the 6-hour ampere-hour capacity of flooded and valve regulated lead-acid industrial storage batteries for motive power service. This standard does not cover Electric Vehicle and Cycling Batteries used in applications other than material handling equipment.

1.2. Definitions

1.2.1. Battery – A battery shall consist of one or more cells.

1.2.2. Flooded Cell – A cell with excess electrolyte in which the products of electrolysis and evaporation are freely allowed to escape into the atmosphere as they are generated. These cells can be classified as “vented”.

1.2.3. Valve Regulated Cell – A cell that is sealed with the exception of a valve which opens to the atmosphere when the internal gas pressure of the cell exceeds atmospheric pressure by a predetermined amount. A VRLA (valve regulated lead-acid cell) provides means for recombination of internally generated oxygen and suppression of hydrogen gas evolution to limit water consumption.

1.2.4. Cell Temperature – The average temperature of the cell. For a vented cell, the cell temperature shall be based on direct measurement of the electrolyte temperature. For a VRLA cell, the temperature shall be equated to the temperature measured at the negative terminal or the temperature can be measured by inserting a temperature measuring device or probe between the corners of 4 cells, a minimum of 4 inches below the top of the cover.

2. PERFORMANCE REQUIREMENTS

2.1. Initial Capacity

2.1.1. A battery shall deliver a minimum of 90 percent of its rated 6-hour ampere-hour capacity on or before the third cycle and a minimum of 100 percent on or before the tenth cycle, when all cycles are performed in accordance with Section 5.

2.2. Life Cycle Capacity

2.2.1. A new battery shall deliver a minimum of 80 percent of its rated 6-hour ampere-hour capacity throughout its life when tested in accordance with Section 5.

3. TEST CONDITIONS

3.1. Test batteries should be in the charged and wet condition. They may be flooded, VRLA cells with AGM mats, VRLA cells with Gel electrolyte, Charged and Dry cells activated per manufacturers published instructions, or charged and Moist cells activated per manufacturers published instructions.

3.2. State of Charge

3.2.1. Batteries shall be fully charged in accordance with the manufacturer's published instructions within 24 hours before the start of the test discharge.

- 3.3. Voltage
 - 3.3.1. The final voltage (refer to Paragraph 5.4) of a battery shall equal 1.70 volts times the number of cells. The battery voltage shall be measured on the terminal posts, excluding the battery cables.
- 3.4. Electrolyte Level (Flooded Type Cells)
 - 3.4.1. The electrolyte level shall be adjusted to the high level in accordance with the manufacturer's instructions.
- 3.5. Temperature
 - 3.5.1. The electrolyte cell temperature during charging shall be within the range of 63°F (17.2°C) through 115°F (46.1°C).
 - 3.5.2. The ambient temperature during the test discharge shall be within the range of 63°F (17.2°C) through 91°F (32.8°C).
 - 3.5.3. The temperature of all cells at the start of the test discharge shall be within the range of 63°F (17.2°C) through 91°F (32.8°C).
- 3.6. Specific Gravity (Flooded Type Cells)
 - 3.6.1. The specific gravity of the electrolyte of a fully charged flooded battery, when corrected to 77°F (25°C), and with the electrolyte at the high level, shall be within the range shown on the battery nameplate or in the manufacturer's published instructions.
 - 3.6.2. If the specific gravity of the electrolyte of any cell is not within the specified range, the electrolyte shall be adjusted in accordance with the manufacturer's published instructions.
 - 3.6.3. The specific gravity of the electrolyte shall be corrected to a temperature of 77°F (25°C) in accordance with the manufacturer's published instructions.
- 3.7. Readings
 - 3.7.1. All voltage, specific gravity (flooded cell batteries) and temperature readings shall be taken from the positive terminal cell to the negative terminal cell, recorded and numbered in this order.

4. TEST EQUIPMENT

- 4.1. All equipment shall be clean, in good working order and calibrated.
- 4.2. Thermometers or Other Temperature Sensors
 - 4.2.1. Temperature sensors shall have an accuracy of at least $\pm 1^\circ\text{F}$ (0.56°C).
- 4.3. Hydrometers (Flooded Cells / Batteries)
 - 4.3.1. Hydrometer floats shall be graduated so that each scale division will not represent more than 0.005 units of specific gravity (5 points) and shall have an accuracy of at least ± 0.0025 units of specific gravity.

4.4. Meters

4.4.1. The instruments and range used shall be chosen to assure the accuracy of the specific measurement.

4.4.2. Digital Meters

4.4.2.1. Digital voltmeters and millivoltmeters shall have a minimum display of 3.5 digits with a resolution of at least 3200 counts and a minimum accuracy of 0.1 percent of reading plus one least significant digit

4.4.2.2. Galvanometer-type voltmeter graduations shall be as follows and readings shall fall in the upper half of the meter scale.

Voltage Range, Volts	Maximum Voltage Per Scale Division, Volts
0 to 3	0.02
3 to 15	0.1
15 to 75	0.2
75 to 150	1.0

4.4.2.3. Ammeter accuracy shall be minimum of 0.5 percent including the entire assembly of shunt, leads and meter. Ammeters shall be used with an appropriate shunt so that current readings will fall in the upper third of the meter scale.

4.5. Shunts

4.5.1. The size of the shunt used during a discharge shall have a current rating between the discharge rate and 1.5 times the discharge rate in amperes. The accuracy of shunts shall be a minimum of 0.5 percent of the current rating of the shunt.

4.6. Timers

4.6.1. Timing devices shall be accurate to within ± 0.05 percent of the specific discharge time.

5. TEST METHODS

5.1. Individual cell voltage, temperature and specific gravity (flooded cells only), as well as total battery voltage and charging rate, shall be recorded during the last 30 minutes of the charge.

5.2. Individual cell temperature and electrolyte specific gravity (flooded cells only) shall be recorded 60 minutes prior to the start of the discharge. The discharge shall be started no sooner than 1 hour after charging and no later than 24 hours after charging.

5.3. When all requirements of Section 3 and 4, and Paragraphs 5.1 and 5.2 have been met, the test discharge may be started.

5.4. The discharge current shall be maintained to within ± 1.0 percent of a rate in amperes equal to one-sixth of the battery's rated 6-hour ampere-hour capacity until the battery voltage at the terminals equals the final voltage.

5.5. The battery voltage across the terminals of the battery (excluding battery output cables) shall be either recorded automatically against time or recorded at a minimum of 30 minute intervals until it reaches a value of 1.70 volts per cell so that the exact time can be recorded when it reaches 1.70 volts per cell. The elapsed time in hours to final voltage shall be recorded.

- 5.6. When the elapsed time to final battery voltage has been recorded, the voltage of each cell shall be recorded and the discharge test shall then be terminated. The temperature of all cells, and electrolyte specific gravity of all flooded cells, shall be recorded within 10 minutes of the termination of the test discharge.
- 5.7. The measured capacity in ampere-hours or percent of ampere-hours obtained during the test discharge shall be the product of the discharge rate in amperes and the time in decimal hours required to reach final voltage. The percent capacity is the elapsed time in decimal hours divided by the rated time (6 hours) expressed as a percentage.
- 5.8. If the average cell temperature recorded at the start of the discharge (see Paragraph 5.2) differs from 77°F (25°C), the measured capacity in ampere-hours obtained shall be corrected by using the formula:
- Corrected Ampere-hour Capacity = (Measured Ampere-hour Capacity)/(1 + 0.0025 (T-77))
- Where: T = The average cell temperature (°F) taken before the start of the discharge (see Paragraph 5.2)
- 0.0025 = capacity temperature coefficient
- 5.9. The battery shall be recharged in accordance with the manufacturer's published instructions.