7. APTA PR-E-RP-007-98 Recommended Practice for Storage Batteries and Battery Compartments

Approved June 15, 1998
APTA PRESS Task Force

Authorized March 17, 1999
APTA Commuter Rail Executive Committee

Abstract: The purpose of this recommended practice for capacity rating for storage batteries in passenger rail car service is to set up uniform qualification procedures and criteria for use in such service. It will make available to the Passenger railroad/Operating Entity comparable information as to the capacity to be expected from batteries of the various types and sizes offered for use under conditions of low and high discharge rates. By consideration of the information furnished under this method, determination of the proper battery for a given connection, load discharge rate, and required hours of discharge, both at initial rating and 80 percent final rating will be greatly facilitated and service requirements satisfied.

Keywords: battery, battery capacity, battery storage compartments, passenger rail vehicles, storage batteries

Participants

The American Public Transportation Association (APTA) greatly appreciates the contributions of the following individual(s), who provided the primary effort in the drafting of the *Recommended Practice Storage Batteries and Battery Compartments*:

Doug Warner

At the time that this recommended practice was completed, the Passenger Rail Equipment Safety Standards (PRESS) Electrical Committee included the following members:

Doug Warner, *Chair*

Gilbert L. Bailey
Brad Barkman
Ronald Bartels
Richard Benjamin
Dick Bruss
Daniel L. Davis
James Dietz
Dave Elliott
Hassan A. Fazli
Bert Gagne
Peter Hale
Carl C. Herrmann
Stephen Hilbert
LeRoy D. Jones
Brian Ley
Otto Masek
Rich Mazur
Chuck Olson
David Phelps
Craig Prudian
George Scerbo
Ike Tingos
Steve Zuiderveen

Contents

APTA PR-E-RP-007-98
Recommended Practice for Storage Batteries and Battery Compartments

1. Overview

1.1 Scope

This recommend practice covers storage batteries used in passenger rail vehicles. The recommended practice is organized into three parts. The first part covers qualification of storage batteries for passenger rail car service. The second part covers battery connectors. The third part covers battery compartments.

1.2 Purpose

The purpose of this recommended practice for capacity rating for storage batteries in passenger rail car service is to set up uniform qualification procedures and criteria for use in such service. It will make available to the railroad comparable information as to the capacity to be expected from batteries of the various types and sizes offered for use under conditions of low and high discharge rates. By consideration of the information furnished under this method, determination of the proper battery for a given connection, load discharge rate, and required hours of discharge, both at initial rating and 80 percent final rating will be greatly facilitated and service requirements satisfied.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

AAR Standard Clearance Diagram, in Section 13, Electrical Manual

AAR RP 590 Batteries Lead Acid and Compartments, Locomotive

APTA RP-E-009-98, Recommended Practice for Wiring of Passenger Equipment.

ASTM E 162 -02a Standard Test Method for Surface Flammability of Materials Using a Radiant Heat Energy Source

ASTM E 662-03 Standard Test Method for Specific Optical Density of Smoke Generated Materials

IEEE Std 100-1996, “The IEEE Standard Dictionary of Electrical and Electronics Terms”

3. Definitions, abbreviations and acronyms

3.1 Definitions

For the purposes of this recommended practice, the following terms and definitions apply. IEEE Std 100-1996, "The IEEE Standard Dictionary of Electrical and Electronics Terms", should be referenced for terms not defined in this clause.

3.1.1 rated capacity: The ability of the battery to deliver a stated current for a stated time under stated conditions; measured in ampere-hours.

3.1.2 cell: The smallest, indivisible unit of the battery; the fundamental electrochemical unit.

3.1.3 voltage nominal: The terminal voltage of a fully charged cell or battery.

4. Qualification of storage batteries in passenger rail car service

4.1 Capacity

Storage batteries for use on passenger rail cars should be rated for capacity in accordance with the rated ampere-hour capacity of all cells based on a 8-hour discharge rate for lead-acid and a 5-hour discharge rate for nickel-cadmium-alkali (NiCd) at a specified specific gravity of electrolyte. See Section 4.7 for specific capacity testing information.

4.2 Minimum voltage limits

The terminal voltage of the cell at the end of discharge should conform to the values given below. The rated capacity for the 8-hour or other rates stated by the manufacturer must be delivered at the voltage values set forth for the respective batteries. All voltage readings should be taken at the cell terminals.

Minimum Voltage	5-hour rate	8-hour rate
Lead-acid type (no cell below 1.72)	---------	1.75 avg.
NiCd type	1.00	----------

4.3 Temperature

The rated capacity must be available with cell temperature at start of discharge of 77°F (25°C). A time-temperature correction should be made for other temperatures. When testing lead-acid batteries at the 8-hour or other discharge rates, the temperature of the electrolyte during discharge should not exceed 115°F (46°C). When testing NiCd batteries at the 5-hour or other discharge rates, the temperature of the electrolyte during discharge should not exceed 104°F (40°C).

4.4 Electrolyte

All lead-acid cells are to be designed to a dimension of 1 5/8" plus or minus 1/8" from the top of the cell filling hole to the correct electrolyte level in order to permit one fixed cell filling device to be used on all makes and types of cells.

Electrolyte furnished for use in storage batteries should be water-clear and free of sediment of any kind.

The specific gravity at 77°F (25°C) of the electrolyte provided by the manufacturer with the cells fully charged and filled to the normal height should not exceed the limits given below for the various types:

Lead-acid - 1.260

NiCd - 1.300

No lead-acid battery should have a specific gravity less than 1.100 after delivering rated capacity.

When comparing specific gravity readings in service, allowance must be made for variation due to temperature of the electrolyte. The following rules are presented for this correction:

– Lead-Acid Battery - For each 3°F rise in temperature of the electrolyte above 77°F (25°C), add .001 to the actual hydrometer reading and for each 3°F drop below 77°F (25°C), subtract .001 from the actual hydrometer reading.

– NiCd Battery - For each 4°F rise in temperature of the electrolyte above 77°F (25°C), add .001 to the actual hydrometer reading and for each 4°F drop below 77°F (25°C), subtract .001 from the actual hydrometer reading.

4.5 Voltage and capacity data

The manufacturer should furnish the following data applying to the type of battery offered for use on railroad cars:

– Ampere-hour capacity at the lead-acid normal 8-hour rate;

– Ampere discharge rate at the lead-acid normal 8-hour rate;

– Ampere-hour capacity at the NiCd normal 5-hour rate;

– Ampere discharge rate at the NiCd normal 5-hour rate;

– Normal finish charging rate in amperes;

– Time-temperature charging levels and rates;

– Time-temperature correction data for discharge at other than 77°F. (25°C);

– Maximum specific gravity of the electrolyte when lead-acid cells are fully charged and filled to normal height;

– Approximate specific gravity drop for delivering rated capacity at a specific discharge rate; and

– Minimum and maximum height of the electrolyte below top of filling hole and above top of plates or splash cover.

Voltage and capacity data at the 8-hour or 5-hour and other discharge rates should be furnished by the manufacturer upon request in the form of a graph similar to Figure 1 or Figure 2 for lead-acid and NiCd batteries respectively, giving the following information for the 8-5-3-2 or 1 hour discharge rates as applicable:

- Ampere-hours per positive plate;
- Ampere discharge rate per positive plate;
- Initial, average, and final voltage for rates shown;
- Type of cell;
- Manufacturer's name; and
- Date of test.

4.6 Identification

4.6.1 Nameplate

A plastic nameplate or label with a plastic acid/alkali proof overlay should be applied to the front of the smallest divisible battery unit. Nameplate or label to be a minimum of 2 3/4" x 4 3/4" with 16 pt. font or larger lettering with a light base coloring and contrasting print. The nameplate or label should provide the following information:

GENERAL	TECHNOLOGY-SPECIFIC	
	Lead-acid	NiCd
Manufacturer's Name	8 HR. AH Capacity	5 HR. AH Capacity
Battery Type	3 HR. AH Capacity	2 HR. AH Capacity
No. of Cells	Full Charge Spec. Gravity	Spec. Gravity Range
Tray Weight	Finish Charge	Normal Charge
Mfr. No.		
Date New		

4.6.2 Positive terminal

The positive terminal of a cell should be identified by either a red washer or an indented or raised "+" symbol.

4.7 Capacity tests

Test sets are to be picked at random from any lot ordered. The batteries should give 100 percent of full-rated capacity by the third discharge for lead-acid or by the fifth discharge for NiCd. Assuming the manufacturer had previously given all the batteries the necessary developing charge to meet this condition before submitting them for test. The batteries selected are to be tested at the 8-hour lead-acid rate or the 5-hour NiCd rate, followed by a test at such higher rates as may be specified by the railroad, unless otherwise agreed upon.

Previous to the start of the first test cycle, the specific gravity should be adjusted to within plus or minus five points gravity specified by the manufacturer with the electrolyte at the correct level. Readings for lead-acid batteries are to be taken after a sufficient time of charge to thoroughly mix the electrolyte.

The test should include three cycles, if necessary, each consisting of a charge at the 8-hour discharge rate for a period of not more than two hours longer than the period of discharge (or a charge not to exceed 125 percent of the previous discharge should it be desired to vary the rate or hours of charge, 140 percent in the case of NiCd batteries), followed by a discharge at the 8-hour rate to a final voltage as given in Section 5. Before the first discharge, the cells should be given a freshening charge at the finishing rate until the voltage has remained constant for not less than two hours. This charge should be considered as the completion of the charging portion of the first test cycle. Refer to IEC 623 for detailed NiCd conditioning procedures.

The capacity of the battery should be the number of ampere-hours delivered during the final test cycle, the cell temperature at the start of discharge to be approximately 77°F (25°C), a time-temperature correction to be made for other temperatures. The interval between the start of the test discharge and the end of previous charge should be not less than one hour nor more than 16 hours for lead-acid or four hours for NiCd.

In the case of batteries to be used in service where the discharge rate is to be higher than the normal 8-hour lead-acid/5-hour NiCd rates, the battery, after having successfully met the 8-hour lead-acid/5-hour NiCd tests, should then be given the test at the higher rate specified by the railroad to determine its ability to meet the manufacturer's rating for such high rate. This high rate discharge is to be made after recharging the battery at not more than 125 percent of the previous discharge for lead-acid batteries, or 140 percent of the previous discharge for NiCd batteries. The period between the end of this charge and the start of the high rate discharge must not be less than 1 hour or more than 16 hours for lead-acid or four hours for NiCd. Under this high rate discharge test, the battery must meet the voltage, temperature, and ampere-hour requirements specified. The capacity of the battery at this high discharge rate should be the number of ampere-hours delivered during this discharge.

Batteries should be tested in simulated operating conditions. This test should be conducted as follows:

- The battery should be fully charged according to section 4.7;
- The battery should be discharged at a 0.2 C5A discharge rate until the remaining capacity is representative of a battery in service. To determine the capacity that is representative of service conditions, the battery manufacturer and the railroad should agree upon a set of derating factors that will be applied to the IEC-623 rating. As a minimum, these factors should address charging method, minimum

service temperature, aging over the design service life, expected state of recharge, and design margin;

– The partially discharged battery should then be discharged according to a load profile. The load profile should consist of the controlled time-sequence of loads for the application, including emergency loads. Load calculations should consider the effect of battery voltage on load current (i.e. some loads are resistive, some constant current, and some constant power). The battery should supply the loads with greater than or equal to the minimum voltage over the entire load profile. The minimum voltage should be according to the design minimum of the battery system.

Note: Typical derating factors for NiCd batteries fall into the following ranges, depending upon technology, environment, and user preference:

Factor	Range	In Part, Influenced By
Charging method	0.85 to 0.9	Float vs. constant current charging
Minimum service temperature	0.7 to 0.95	e.g. Canada vs. Florida
Aging over the design life	0.8 to 0.9	Property specific service life vs. technology
Expected state of recharge	0.8 to 0.95	Rare vs. frequent battery use. Max. temperature
Design margin.	0.95 to 1.0	Future expansion or comfort zone

4.8 Additional performance requirements.

Batteries should be capable of supplying the required load profile, as determined in Section 4.7, in a worst case orientation at 45 degrees from vertical.

Battery cases should be tested for Smoke and Flammability in accordance with *ASTM E 162 and 662*[1] procedures as follows:

Test Procedure	Performance Criteria
ASTM E 162	$I_s \leq 35$
ASTM E 662	$D_s\,(1.5) \leq 100$
ASTM E 662	$D_s\,(4.0) \leq 200$

Where batteries are utilized for starting engines rated 600 horsepower and lower (and thereby not covered by AAR RP 590 Batteries Lead Acid and Compartments, Locomotive), the customer should specify the engine starting requirements, and the

[1] For references in Italics, see Section 2.

manufacturer should rate the batteries for such service, in accordance with the format used in *AAR RP-590*.

Note – examples of such engine starting service include propulsion engines on diesel multiple unit (DMU) cars, head-end-power auxiliary power unit (APU) engines, and the like.

5. Battery connectors

All intercell connectors should be of a corrosion-resistant type with low joint resistance and ample current carrying capacity to keep down losses.

For inter-tray connectors, cable sizes should at a minimum conform *to APTA RP-E-009-98, Recommended Practice for Wiring of Passenger Equipment.*

For lead-acid batteries, the terminals on inter-tray connectors should preferably be of the copper-tube type, heavily lead-coated or of a cast lead alloy with wire sealed into the terminal to prevent corrosion due to acid entering the terminal.

Acid/alkali-resisting lead covered, stainless steel, or nickel-plated bolts should be used to connect terminal to battery post. Single-bolt terminals should be used for batteries up to and including 450 ampere-hour capacity; two-bolt terminals should be used for batteries 451 ampere-hours and over.

Battery cable to terminal connection bolts should be 5/16-inch diameter with 18 threads to the inch.

6. Battery compartments

Battery compartments and supporting members should meet the requirements of the latest issue of *AAR Standard Clearance Diagram, in Section 13, Electrical Manual*, including those for third rail territory, or the clearance diagram of the railroad, whichever is more restrictive, in effect as of date of build or remanufacture.

Battery compartments should be designed to prevent out-gassing to the passenger rail car interior. The compartment should be appropriately vented, for the battery type, to the exterior of the carbody, self draining and mounted clear of underframe equipment and trucks. Ventilation openings that are designed to be subject to spray from car washes should be provided with protective hoods that should not restrict the amount of free opening.

The compartment should be fitted with an easily opened, full width cover that should preferably be accessible from the passenger rail car exterior. The cover should be of the split type, the top section being arranged to open independently of the lower section to permit access without opening the full door. The top section should open approximately ten inches to expose top portion of cells and to permit servicing of the battery without pulling the trays from the box. This section should be hinged to the lower section only, so that the entire cover can be opened for installation or removal of the battery. The entire cover should be removable. Separate means should be provided to fasten each door section independently of the other, such fastenings to be of ample strength and of a type that ensures against accidental opening under service conditions. Fasteners should be captive to the compartment and should be removable without the use of tools.

If used, roll out trays for battery compartments should be solidly supported when in the operational position. Tray assemblies should require two separate unlocking operations to prevent inadvertent movement of the battery during normal train operation.

A bottom grating should be incorporated and constructed of a stainless steel or equivalent reinforced non-conductive and non-corrosive material.

Non-metallic buffer strips should be securely fastened with no protruding screws or bolts, to the inside of the cover, to both sides and to the back of the battery box to restrict movement of the battery.

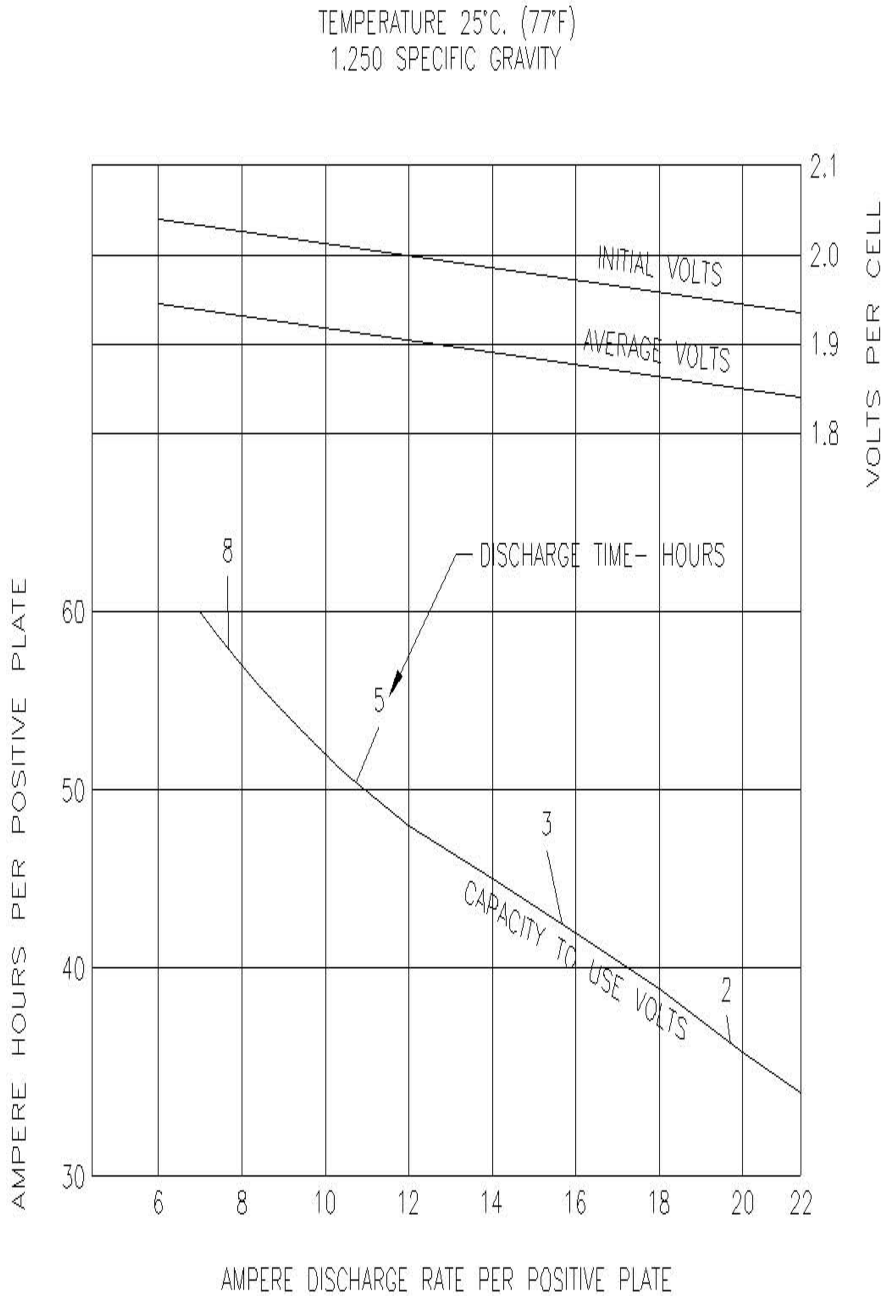

Figure 1. Discharge Characteristics of Lead Acid Storage Battery

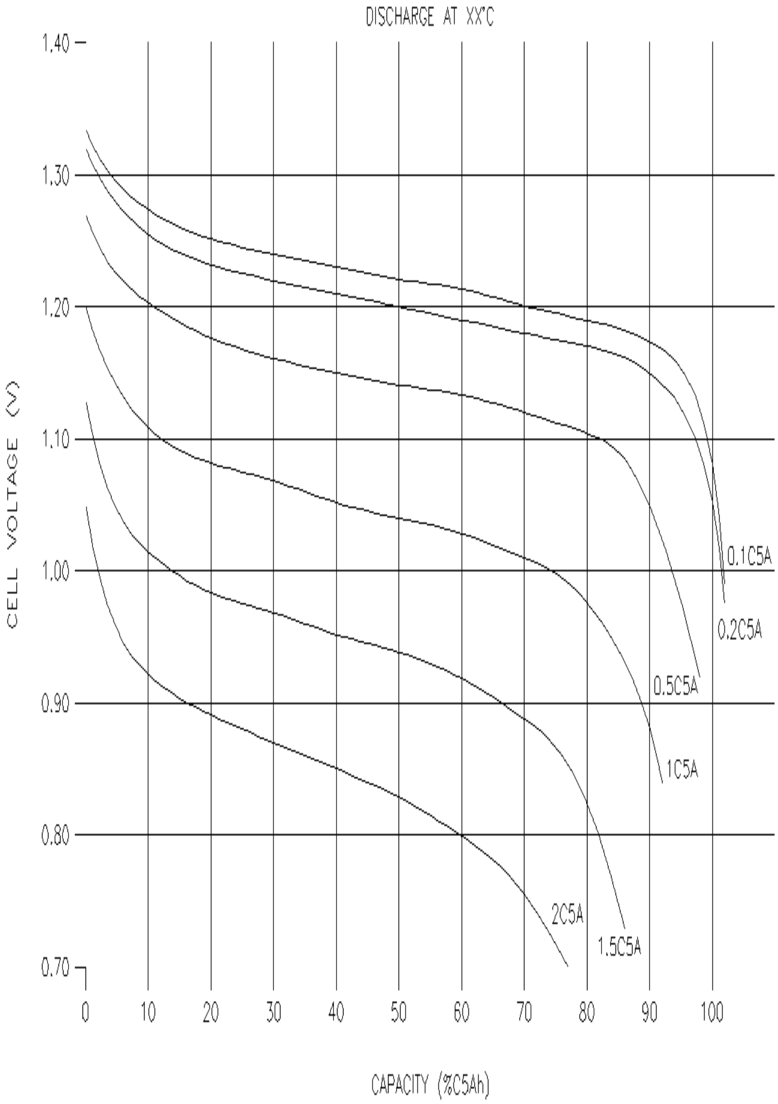

Figure 2. Discharge Characteristics of Nickel Cadmium Storage Battery