APTA STANDARDS PROGRAM
RECOMMENDED PRACTICE

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PRESS Electrical Working Group

Storage Batteries and Battery Compartments

Abstract: This recommended practice for capacity rating for storage batteries in passenger rail car service sets up uniform qualification procedures and criteria for use in such service. It also covers the design of the battery connections and battery compartments. Design chemistries covered in this recommended practice are limited to vented Nickel Cadmium (NiCd), vented lead acid, and valve regulated lead acid (VRLA) varieties.

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

Summary: This recommended practice covers storage batteries used in passenger rail vehicles. It is organized into four 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, and the fourth part covers mechanical considerations.

Foreword

The American Public Transportation Association is a standards development organization in North America. The process of developing standards is managed by the APTA Standards Program's Standards Development Oversight Council (SDOC). These activities are carried out through several standards policy and planning committees that have been established to address specific transportation modes, safety and security requirements, interoperability, and other topics.

APTA used a consensus-based process to develop this document and its continued maintenance, which is detailed in the manual for the APTA Standards Program. This document was drafted in accordance with the approval criteria and editorial policy as described. Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

This document was prepared by the Electrical Working Group as directed by the Passenger Rail Equipment Safety Standards Policy & Planning Committee.

This document represents a common viewpoint of those parties concerned with its provisions, namely transit operating/planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any recommended practices or guidelines contained herein is voluntary. APTA standards are mandatory to the extent incorporated by an applicable statute or regulation. In some cases, federal and/or state regulations govern portions of a transit system's operations. In cases where there is a conflict or contradiction between an applicable law or regulation and this document, consult with a legal adviser to determine which document takes precedence.

This document supersedes APTA PR-E-RP-007-98, Rev. 1, which has been revised. Below is a summary of changes from the previous document version:

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Limited design chemistries to vented Nickel Cadmium (NiCd), vented lead acid, and valve regulated lead acid (VRLA) varieties. Added VRLA requirements.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: "Summary of document changes" and "Document history."
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Names of participants updated.
- Applicability language added to Introduction; Note on alternate practices removed.
- Section 1.1 – Removed five hour and eight hour discharge ratings; Added new Table 1 Capacity by battery technology. Revised content to align with current industry practices. Added VLRA to table.
- Removed former Section 4.2 – Minimum voltage limits
- Removed Former Section 4.3 – Temperature; Temperature rating added to Table 1.
- Split type specific content of former Section 4.4 (now Section 1.2) into Subsections 1.2.1 Nickel cadmium battery and 1.2.2 Lead-acid Battery; Removed specific gravity limits and revised recommendation for temperature coefficient from 4°F intervals to 3°F intervals.

- Split and modified type specific content of former Section 4.5 (now Section 1.3) into Subsections 1.3.1 Nickel cadmium battery and 1.3.2 Vented lead-acid battery; Added nominal cell voltage information. Added new section 1.3.3, Valve regulated lead-acid battery.
- Section 1.4.1 – Added optional nameplate information (by contract); Replaced minimum nameplate/label dimensions and text size/font with "legibility printed." Added VLRA to Table 2.
- Split and modified type specific content of former Section 4.7 (now Section 1.5) into Subsections 1.5.1 Nickel cadmium battery and 1.5.2 Vented lead-acid battery; Revised fully-rated capacity definitions. Added new section 1.5.3, Valve regulated lead-acid battery. Revised testing requirements to correspond with table 1.
- Section 1.6 – Added new Section Load profile testing. Type-specific information split into subsections 1.6.1, Nickel cadmium battery, and 1.6.2, Lead acid battery and added Table 3, Derating Factors for NiCd Batteries and Table 4, Derating Factors for Lead-Acid Batteries; Former Section 4.8, Additional performance requirements moved to subsection 1.6.3, adding BSS 7239 particle concentrations.
- Split and modified type specific content of Section 2 into Subsections 2.1 Nickel cadmium battery and 2.2 Lead-acid battery; revised material recommendation for inter-unit assemblies and removed some specific testing procedures in favor of referencing IEC 60623 for nickel cadmium batteries and IEC 60254-1 and IEC 62973-1 for lead-acid batteries while removing reference to IEC 623 and moving some requirements to new section Load profile testing.
- Section 3 – Replaced AAR Standard Clearance Diagram reference to that of the specific passenger operator/operating entity. Revised battery compartment design requirement to prevent degassing into the occupied passenger volume with battery placement with relation to carbody design performance requirement. Added calculation requirement for free area of opening of ventilation equipment by method described in IEC 62485. Revised accessibility recommendation and added recommendation for securement by APTA PR-CS-S-034-99. Revised ventilation opening protection recommendation. Added enclosure draining recommendation. Added requirement for protection in accordance with IEC 60529 or applicable NEMA enclosure rating. Revised fastening recommendations. Added recommendation for installations utilizing transparent cases.
- Replaced Figure 1 Discharge Characteristics of Lead Acid Storage Batteries and Figure 2 Discharge Characteristics of Nickel Cadmium Storage Batteries with the example discharge characteristics.
- Added new Section 4 – Mechanical design considerations.

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Introduction

This introduction is not part of APTA PR-E-RP-007-98, "Storage Batteries and Battery Compartments."

This standard applies to all:

- railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and
- railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This standard does not apply to:

- rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
- tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
- operation of private cars, including business/office cars and circus trains; or
- railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Scope and purpose

This recommended practice covers storage batteries used on passenger rail vehicles specifically qualification, battery connectors, battery compartments and mechanical design considerations. The battery types considered for this recommended practice are limited to vented nickel cadmium, vented lead acid types, and valve regulated lead acid (VRLA).

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, medium and high discharge rates. This recommended practice also covers the design of the battery connections and battery compartments.

Storage Batteries and Battery Compartments

1. Qualification of storage batteries in passenger rail car service

1.1 Capacity (Ah)

The capacity of storage batteries for use on passenger rail cars should be rated in accordance with the conditions shown in **Table 1**.

TABLE 1
Capacity by Battery Technology

Cell/Battery Technology	Discharge Rate, Multiple of Rated Capacity (Amps)	Base Discharge Duration	Final Voltage at Cell Terminals	Temperature	Standard to Comply
Nickel cadmium (NiCd)	$0.2C_5A$	5 hours	1.0 V/cell	68 ±9 °F (20 ±5 °C)	IEC 60623
Vented lead acid	$0.33C_3A – 0.1C_{10}A$	3 -10 hours	1.8 V/cell	59 - 86 °F (15 - 30 °C) but as close to reference of 68 °F or 77 °F (20 °C or 25 °C) as possible	IEC 60896-11
Valve regulated lead acid	$0.33C_3A$	3 hours	1.7 V/cell	68 - 77 °F (20 - 25 °C)	IEC 60896 -21 and -22

1.2 Electrolyte

Electrolyte, if supplied separately, for use in storage batteries should be water-clear and free of sediment of any kind.

Distilled, demineralized or deionized water should be used when topping cells to proper electrolyte levels as identified by the battery OEM.

1.2.1 Nickel cadmium battery

The electrolyte used in NiCd batteries is potassium hydroxide (KOH).

The electrolyte for NiCd cells/batteries does not participate in the electrochemical reaction but acts as an ion transfer; therefore, the specific gravity remains fairly constant and there is no need to measure SG. If an overfill, overflow or spillage occurs, contact the battery OEM for the next steps with the cells/battery.

1.2.2 Lead-acid battery

The electrolyte used in lead-acid batteries is sulfuric acid (H_2SO_4).All vented lead-acid cells should be designed to a dimension of 1⅝ in. plus or minus ⅛ in. from the top of the cell filling hole to the correct electrolyte level. This permits one fixed cell filling device to be used on all makes and types of cells.

The specific gravity at 77 °F (25 °C) of the electrolyte should be provided by the manufacturer with the cells fully charged and filled to the normal height.

No lead-acid battery should have a specific gravity less than a value that may damage the battery after delivering rated capacity.

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

The temperature coefficient of the change in density is −0.001 lb/gal per R (Rankine) (−0.0007 kg/l per K [Kelvin]). For each 3 °F rise in temperature of the electrolyte above 77 °F (25 °C), add 0.001 to the actual hydrometer reading, and for each 3 °F drop below 77 °F (25 °C), subtract 0.001 from the actual hydrometer reading.

> **Note:** Valve regulated lead acid batteries are considered sealed and cannot have electrolyte added, measured or accessed.

1.3 Voltage and capacity data

The nominal cell voltage of a NiCd is 1.2 V and of a lead acid is 2 V. The nominal voltage is not measurable.

The battery manufacturer should furnish the data in the rest of this section (as available) applying to the type of battery offered for use on passenger rail cars relative to specified requirements or agreed-upon testing.

1.3.1 Nickel cadmium battery

- Cell/battery rated capacity per IEC 60623
- For charge (at various temperatures and/or charge voltages and/or currents):
  - SOC / Available Capacity vs. Time, and/or
  - SOC / Available Capacity vs. Charge Voltage, and/or
  - Temperature Compensation − Charge Voltage vs. Temperature
- For discharge (at various temperatures and/or discharge rates):
  - Discharge Voltage vs. Capacity (refer to example in **Figure 1**), and/or
  - Discharge Voltage vs. Time, and/or
  - Discharge Current vs. Time

NOTE: Curves should have the cell type and manufacturer’s name.

1.3.2 Lead-acid battery

- Cell/battery rated capacity per IEC 60896-11:
  - For charge (at various temperatures and/or charge voltages and/or currents):
    - SOC / Available Capacity vs. Time, and/or
    - SOC / Available Capacity vs. Charge Voltage, and/or
    - Temperature Compensation − Charge Voltage vs. Temperature
  - For discharge (at various temperatures, and/or discharge rates):
    - Discharge Voltage vs. Capacity, and/or
    - Discharge Voltage vs. Time, and/or
    - Discharge Current vs. Time

NOTE: Curves should have the cell type and manufacturer’s name.

1.3.3 Valve regulated lead-acid battery

- Cell/battery rated capacity per IEC 60896 -21 and -22:
  - For charge (at various temperatures and/or charge voltages and/or currents):
    - SOC / Available Capacity vs. Time, and/or
    - SOC / Available Capacity vs. Charge Voltage, and/or
    - Temperature Compensation − Charge Voltage vs. Temperature
  - For discharge (at various temperatures, and/or discharge rates):
    - Discharge Voltage vs. Capacity, and/or
    - Discharge Voltage vs. Time, and/or
    - Discharge Current vs. Time

NOTE: Curves should have the cell type and manufacturer's name.

1.4 Identification

1.4.1 Nameplate

A plastic or metal nameplate and/or label with a plastic acid/alkali proof overlay should be applied to the front of the smallest divisible battery unit (e.g., crate or tray but not cell). Nameplate or label information should be printed legibly with a light base coloring and contrasting print. The nameplate or label should provide, but not limited to, the information shown in **Table 2**.

TABLE 2
Required Nameplate Information

GENERAL	TECHNOLOGY-SPECIFIC		
All	**Ni-Cd**	**Vented lead acid**	**Valve regulated lead acid**
Manufacturer's Name	5-hour Ah capacity per IEC 60623	5-hour Ah capacity per IEC 60896-11	3-hour Ah capacity per IEC 60896 -21 and -22
Battery Type	Normal charge in amps	Normal charge in amps	Normal charge in amps
No. of Cells			
Crate or Tray Weight			
Mfr. Part No.			
Date of Manufacture			

OPTIONAL INFORMATION (BY CONTRACT):

- Owner
- Owner Reference or Part No.
- Set No.
- Serial No.
- Warranty Expiration Date
- Barcode
- Date Installed (to be filled by owner)

1.4.2 Positive terminal

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

1.5 Capacity testing

The testing in this section should be performed by the battery manufacturer.

Test battery car sets should be picked at random from any lot ordered.

The battery manufacturer should conduct the necessary developing charge as per the corresponding conditions for each battery technology as identified in Section 1.1.

The battery/batteries should give at least 100% of full-rated capacity by the:

- 5th charge–discharge cycle for NiCd;
- 50th charge–discharge cycle for vented lead acid or 80% after 100 cycles; or
- 5th charge-discharge cycle for valve regulated lead acid.

Once the rated capacity is met, there is no need to perform any further cycles.

Further tests at higher discharge rates may be specified by the railroad/operating entity unless otherwise agreed upon.

Prior to the discharge tests for the capacity, the charge and other conditions in the rest of this section should be followed.

1.5.1 Nickel cadmium battery

- Charge at $0.2C_5A$ for 7 to 8 hours at 20 °C ±5 °C.

1.5.2 Vented lead-acid battery

- The test should include three cycles as defined by IEC 60896-1. The battery is considered fully charged when the specific gravity does not change after two hours of charging.
- Charge as per manufacturer recommendation .
- SG to be taken after a sufficient time of charge to thoroughly mix the electrolyte and adjusted to the manufacturer's specification at the correct level.

1.5.3 Valve-regulated lead-acid battery

- Charge at $0.33C_3A$ for 7 to 8 hours at 20 °C or 25 °C.

1.6 Load profile testing

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

- A temperature chamber should be used for customer-specified worst-case scenario temperature outside the temperature range prescribed in **Table 1**. A portion of the carset battery can be used that provides the equivalent discharge performance relative to a complete carset battery.
- The battery or a representative portion of the battery should be fully charged according to Section 1.5.
- Load profile testing should be performed according to IEC 62973-1, Annex B, and specific to the battery technology:
    - **For NiCd:** IEC 62973-2
    - **For valve regulated lead acid:** IEC 62973-3

1.6.1 Nickel cadmium battery

The battery should be discharged at a $0.2C_5A$ 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 should apply the derating factors used in the battery sizing simulation to the IEC 60623 capacity rating. The following factors should be addressed:

- charging method (SOC)
- aging over the design service life
- design margin (if required by the railroad/operating entity)

The partially discharged battery should then be discharged according to the agreed-upon load profile that includes load shed. The load profile should consist of the controlled time sequence of all loads for the application. As used in the load profile battery sizing simulation (i.e., some loads are resistive, some constant current and some constant power), the load profile testing should consider the equivalent load current. The battery should supply the loads with greater than or equal to the minimum voltage over the entire load profile. The minimum voltage at the battery terminals should be according to the operating minimum voltage at the loads minus the cable voltage drop.

> **NOTE:** Typical derating factors for NiCd batteries fall into the ranges shown in **Table 3**, depending upon the battery technology, environment and user preference.

TABLE 3
Derating Factors for NiCd Batteries

Derating Factor	Typical Range	In Part Influenced By
Charging method/SOC	0.8 to 0.9 (80 to 90%)	Float vs. constant current charging (temperature, charge voltage, temperature compensation, number of cells).
Operating ambient temperature range	Sizing simulation driven	Location of operation and battery location. Should not be the worst-case min/max temperature on record.
Aging over the design service life	0.8 to 0.9 (80% to 90%)	Railroad property–specific service life required (depending on but not limited to operating ambient temperature, cycling and corresponding DoD, maintenance) vs. battery technology.
Design margin (if required by the railroad/operating entity)	0.8 to 1.0 (80% to 100%) or the inverse	Future expansion of loads or comfort zone.

1.6.2 Lead-acid battery

The battery should be discharged as per **Table 1** until the remaining capacity is representative of a battery in service. To determine the capacity that is representative of service conditions, the battery manufacturer should apply the derating factors used in the battery sizing simulation to the IEC 60896 capacity rating. The factors shown in **Table 4** should be addressed (see also IEC 62973-1, B.4).

TABLE 4
Derating Factors for Lead-Acid Batteries

Derating Factor	Typical Range	In Part Influenced By
Charging method/SOC	0.9 to 1.0 (90% to 100%)	Float vs. constant current charging (temperature, charge voltage, temperature compensation, number of cells).
Operating temperature range	Sizing simulation driven	Location of operation and battery location. Should not be the worst-case min/max temperature on record.
Aging over the design service life	Up to 0.9 (90%)	Railroad property–specific service life required (depending on but not limited to operating ambient temperature, cycling and corresponding DoD, maintenance) vs. battery technology.
Design margin (if required by the railroad/operating entity)	0.8 to 1.0 (80% to 100%) or the inverse	Future expansion of loads or comfort zone.

The partially discharged battery should then be discharged according to the agreed-upon load profile that includes load shed. The load profile should consist of the controlled time sequence of all loads for the application. As used in the load profile battery sizing simulation (i.e., some loads are resistive, some constant current and some constant power), the load profile testing should consider the equivalent load current. The battery should supply the loads with greater than or equal to the minimum voltage over the entire load profile. The minimum voltage at the battery terminals should be according to the operating minimum voltage at the loads minus the cable voltage drop.

NOTE: Typical derating factors for lead-acid batteries fall into the following ranges, depending upon the battery technology, environment and user preference.

1.6.3 Additional performance requirements

Battery cell containers should be tested for flammability and smoke in accordance with 49 CFR §238, Appendix B (for both ASTM E162-98, flame generation criteria, and ASTM E662-01, smoke generation criteria), and toxicity in accordance with Boeing BSS 7239 or Bombardier SMP 800C toxicity procedures with the criteria shown in **Table 5**. When ASTM E162-98 is considered invalid for the materials being tested, the authority having jurisdiction should consider a Fire Hazard Analysis (FHA) seeking to demonstrate the acceptability of such materials.

TABLE 5
Additional Test Performance Criteria

Test Procedure	Performance Criteria
ASTM E162-98 (Surface Flammability)	$I_s \leq 35$
ASTM E662-01 (Smoke Generation)	D_s (1.5) ≤ 100
ASTM E662-01 (Smoke Generation)	D_s (4.0) ≤ 200
Boeing BSS 7239 (Toxic Gas Generation)	Maximum limits at 4 minutes in flaming mode: • hydrogen cyanide (HCN): 150 ppm • carbon monoxide (CO): 3500 ppm • nitrogen dioxide (NO_2): 100 ppm • sulfur dioxide (SO_2): 100 ppm • hydrogen fluoride (HF): 200 ppm • hydrogen chloride (HCl): 500 ppm
Bombardier SMP 800C (Toxic Gas Generation)	Maximum limits between 4 and 20 minutes until 6 liters of gas are sampled in flaming mode: • carbon monoxide (CO): 3500 ppm • carbon dioxide (CO_2): 90000 ppm • nitrogen dioxide (NO_2): 100 ppm • sulfur dioxide (SO_2): 100 ppm • hydrogen chloride (HCl): 500 ppm • hydrogen fluoride (HF): 100 ppm • hydrogen bromide (HBr): 100 ppm • hydrogen cyanide (HCN): 100 ppm

Where lead-acid batteries are utilized for starting engines rated 600 horsepower and lower (and thereby not covered by AAR RP-590, “Lead-Acid Batteries and Compartments”), the customer should specify the engine starting requirements, and the 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 cars, head-end-power auxiliary power unit engines, and the like.

2. Battery connectors

The battery manufacturer should use intercrate/intertray or interblock cable assemblies that are soft annealed tinned copper to provide low resistance and are irradiated crosslinked polyolefin insulated.

For the cable assemblies, cable sizes should at a minimum conform to APTA RP-E-009-98, "Ampacities for Wire and Cable Used on Passenger Rolling Stock with Flame, Smoke and Toxicity Considerations."

2.1 Nickel cadmium

All intercell connectors and cable lugs should be nickel-plated copper providing low resistance to keep down losses.

Battery terminals may be threaded posts or may be threaded bolts of appropriate size and be nickel plated material determined by the battery manufacturer.

2.2 Lead acid

The battery manufacturer must ensure that terminals, intercell connectors, intertray connectors and other current carrying parts are protected against the corrosive effect of acid or acid aerosols. Tin plating cannot be used for lead-acid battery components.

3. Battery compartments

Battery compartments and supporting members should meet the clearance diagram requirements of the passenger railroad/operating entity, including those for third-rail territory, in effect as of date of build or remanufacture. It is the responsibility of the vehicle manufacturer or owner, as applicable, to supply the respective documents.

Placement of battery compartments should be located in relation to the carbody design so as to prevent gases from entering the 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 or other means that should not restrict the amount of free opening. The free area of opening of the ventilation equipment must be calculated following the method described in IEC 62485-2.

The battery compartment should be accessible from trackside. The battery should be mounted for ease of replacement and maintenance. The battery compartment should be secured to the carbody in accordance with strength requirements of APTA PR-CS-S-034-99, "Design & Construction of Passenger Railroad Rolling Stock" in position with a retaining system that will retain the battery in any position under 8g longitudinal and 4g lateral accelerations.

Ventilation openings of the enclosure should be equipped with stainless steel mesh to prevent ingress of leaves and other foreign matter. The enclosure should drain freely to the ground to allow easy battery washing. The degree of protection shall be in accordance with IEC 60529 or the appropriate NEMA enclosure rating.

Note: Small mesh sizes can restrict natural convection and are susceptible to rapid blockage by debris.

Nonmetallic buffer strips securely fastened, with no protruding screws or bolts, should be provided to both sides and to the back of the battery box/enclosure, as well as the inside of the cover or battery securement system to restrict movement of the battery. If fasteners are used, they must be non-protruding. A small amount of space should be provided around the battery to allow for expansion/contraction due to battery temperature change. Dimensions of battery boxes/enclosures should take into account that dimensions of batteries vary by manufacture. The enclosure should be sized to allow for this.

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. Alternatively, the battery enclosure and tray assemblies should require mechanical or electrical interlocks, to prevent or/and detect inadvertent battery tray movement inside the enclosure during normal train operation.

If a battery tray is used, a bottom grating should be incorporated and constructed of stainless steel or an equivalent reinforced, electrolyte-resistant non-metallic material, or sufficient volume reservation should be provided to contain electrolyte leakage from one or more cells. The battery tray should be equipped with a drain plug to allow easy and controlled washing.

If batteries with transparent cases are employed, it is desirable to place successive rows of trays on steps to allow easy viewing of the electrolyte level without having to disturb the battery. Spatial issues may prevent this in some circumstances.

The exterior of the battery enclosure should be clearly labeled “battery” or equivalent wording.

FIGURE 1

Example of Discharge Characteristics of Nickel Cadmium Storage Battery

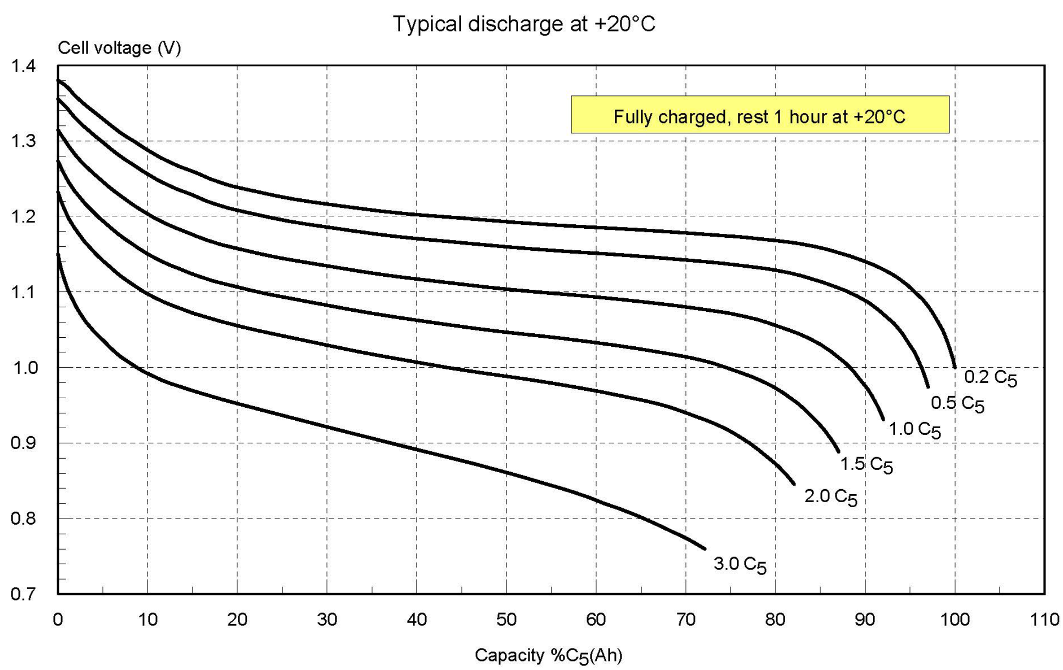
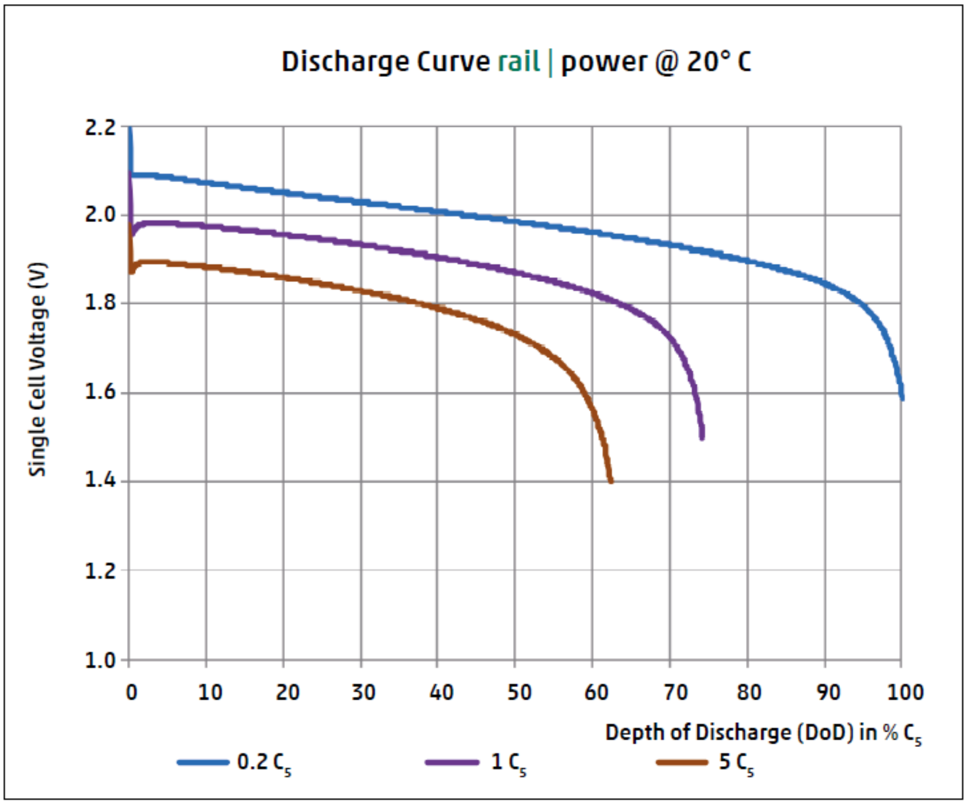


FIGURE 2
Example of Discharge Characteristics of Lead-Acid Storage Battery



4. Mechanical design considerations

This section applies to battery crates/trays and battery compartments with all internal components installed (storage battery system).

The following requirements should be considered for all new designs, substantial increases in battery requirements, or substantial structural overhauls to existing vehicle designs. The authority having jurisdiction should consider these requirements in the event of a mechanical change to the design of the storage battery system.

As applicable, the battery crates/trays or battery storage system should operate in all equipment orientations within 45 deg. of vertical and after the initial shock of a collision or derailment resulting in the following individually applied accelerations:

- **Longitudinal:** 8g
- **Lateral:** 4g
- **Vertical:** 4g

The tolerances applicable to the above test can be applied as per Figure 7 of IEC 61373 (2010) except with the peak values above.

Either the 1999 or 2010 version of IEC 61373 can be used when considering vibrational fatigue life of storage batteries and battery storage compartments at the discretion of the authority having jurisdiction.

In order to validate the functional performance of the battery, both open circuit voltage readings and capacity testing should be performed, at a minimum, before and after the testing in this section.

Related APTA standards

APTA PR-CS-S-034-99, "Design & Construction of Passenger Railroad Rolling Stock"
APTA PR-E-RP-009-98, "Ampacities for Wire and Cable Used on Passenger Rolling Stock with Flame, Smoke and Toxicity Considerations"

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Definitions

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

electrolyte: Typically, sulfuric acid for lead-acid batteries or a solution of potassium hydroxide (KOH) for NiCd batteries, and distilled water.

rated capacity: A quantity of current that a fully charged cell or battery can deliver under specified conditions expressed in ampere-hours (Ah).

voltage, nominal: The electrochemical couple voltage of a specific cell or battery technology. For NiCd it's 1.2 V, and for lead acid it's 2 V.

Abbreviations and acronyms

AAR	Association of American Railroads
Ah	ampere-hour
DoD	depth of discharge
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NiCd	nickel cadmium
OEM	original equipment manufacturer
ppm	parts per million
SG	specific gravity
SOC	state of charge

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