APTA STANDARDS DEVELOPMENT PROGRAM

STANDARD

American Public Transportation Association
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APTA Vehicle Inspection and Maintenance Working Group

Emergency Lighting System Design for Rail Transit Vehicles

Abstract: This *Standard* specifies the minimum performance criteria for emergency lighting for rail transit vehicles to provide lighting when normal lighting is disrupted as a result of loss of power due to damage or is otherwise unavailable.

Keywords: emergency lighting

Summary: APTA rail transit systems members have expressed a commitment to increase the effectiveness of safety devices and features present on rail transit vehicles, not only for the passengers but also for operators and emergency personnel. This *Standard* specifies minimum performance criteria for the emergency lighting system that operates when the normal lighting system is unavailable. It also requires periodic tests to validate the design. Other complementary emergency systems provide signage and path markings to locate, operate and reach emergency exits and are covered in separate APTA standards. An effective systems approach uses this standard, as well as "Low Location Emergency Path Marking for Rail Transit Vehicles," (APTA RT-VIM-S-022-10 Rev 1) – previously numbered as APTA RT-S-VIM-22-10 and "Emergency Signage for Rail Transit Vehicles" (APTA RT-VIM-S-021-10) – previously numbered as APTA RT-S-VIM-21-10, to provide a means for passengers and rail transit vehicle operators to locate, reach and operate emergency exits to facilitate safe evacuation in an emergency. Each rapid-transit system and car builder should carefully consider the options available to meet emergency evacuation requirements presented in these three standards.

Scope and purpose: This *Standard* applies to rail transit systems that are procuring new vehicles, retrofitting existing vehicles or overhauling existing vehicles. This document is intended to incorporate safety considerations during the design and specification process when procuring new vehicles; to incorporate safety considerations when determining scope of work during the design and specification of major overhauls or retrofit campaigns; to identify those safety-critical standards that provide a high level of passenger safety; and to identify those safety-critical standards that provide a high level of crew safety.

This document represents a common viewpoint of those parties concerned with its provisions, namely operating/ planning agencies, manufacturers, consultants, engineers and general interest groups. The application of any standards, recommended practices or guidelines contained herein is voluntary. In some cases, federal and/or state regulations govern portions of a transit system's operations. In those cases, the government regulations take precedence over this standard. The North American Transit Service Association (NATSA) and its parent organization APTA recognize that for certain applications, the standards or practices, as implemented by individual agencies, may be either more or less restrictive than those given in this document.

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Introduction

This introduction is not part of APTA RT-S-VIM-020-10, Rev 1 "Emergency Lighting System Design for Rail Transit Vehicles."

This *Standard for Emergency Lighting for Rail Transit Vehicles* 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 standards, practices or guidelines contained herein is voluntary. In some cases, Federal and/or State regulations govern portions of a Rail Transit System's operations. In those cases, the government regulations take precedence over this standard. APTA recognizes that for certain applications, the standards or practices, as implemented by individual rail transit agencies, may be either more or less restrictive than those given in this document.

This *Standard* describes the minimum requirements for emergency lighting systems for rail transit vehicles. APTA recommends the use of this standard by:

- individuals or organizations that maintain emergency lighting systems for rail transit vehicles;
- individuals or organizations that contract with others for the maintenance emergency lighting systems for rail transit vehicles; and
- individuals or organizations that design, specify, or approve emergency lighting systems for rail transit vehicles.

This *Standard* is intended to satisfy the following objectives:

- Incorporate safety considerations during the design and specification process when procuring new vehicles.
- Incorporate safety considerations when determining scope of work during the design and specification of major overhauls or retrofit campaigns.
- Identify those safety-critical standards that provide a high level of passenger safety.
- Identify those safety-critical standards that provide a high level of crew safety.

This APTA standard was developed to establish minimum design requirements for emergency lighting systems intended to provide lighting when normal lighting is disrupted as a result of loss of power due to damage or is otherwise unavailable.

An effective systems approach uses this standard, as well as APTA standards APTA RT-S-VIM-022-10, "Low-Location Emergency Path Marking for Rail Transit Vehicles," and APTA RT-S-VIM-021-10, "Emergency Signage for Rail Transit Vehicles," to provide a means for passengers and rail transit vehicle operators to locate, reach and operate emergency exits to facilitate their safe evacuation in an emergency. Each rapid transit system and car builder should carefully consider the options available to meet emergency evacuation requirements presented in these three standards.

Note on alternate practices

Individual rail transit systems may modify the practices in this standard to accommodate their specific equipment and mode of operation. APTA recognizes that some rail transit systems may have unique operating environments that make strict compliance with every provision of this standard impossible. As a result, certain rail transit systems may need to implement the standards and practices herein in ways that are more or less restrictive than this document prescribes. A rail transit system may develop alternates to APTA standards so long as the alternates are based on a safe operating history and are described and documented in the system's safety program plan (or another document that is referenced in the system safety program plan).

Documentation of alternate practices shall:

- identify the specific APTA rail transit safety standard requirements that cannot be met;
- state why each of these requirements cannot be met;
- describe the alternate methods used; and
- describe and substantiate how the alternate methods do not compromise safety and provide a level of safety equivalent to the practices in the APTA safety standard (operating histories or hazard analysis findings may be used to substantiate this claim).

Emergency Lighting System Design for Rail Transit Vehicles

1. Types of lighting and power sources

1.1 Normal

Normal lighting is the illumination provided when the rail transit car is in revenue operation. It is generally powered by the car's auxiliary power system.

1.2 Standby

Standby power may continue the operation of much of the normal lighting system when the normal power is unavailable. Standby lighting is typically provided from the main car battery and is activated in response to loss of the low-voltage power supply (LVPS). Standby lighting is typically provided for a fixed time period or until voltage drops to some predetermined level.

1.3 Emergency

The rail transit vehicle lighting system has historically used the main car battery to power emergency lighting. Varieties of emergency lighting approaches are used, but they normally include some combination of the following:

- separate fixtures (i.e., not the fixtures used for normal lighting) that are powered from the main car battery or independent power sources such as capacitive storage or battery packs
- fixtures that are powered from the LVPS and/or main car battery that are illuminated for normal as well as emergency lighting functions
- fixtures that function as part of the normal lighting system but that also contain independent power sources to provide emergency lighting if other power is unavailable

2. Emergency lighting system requirements

The emergency lighting system shall be designed to facilitate the ability of passengers and train crew members, and/or emergency responders, to see and orient themselves and to identify obstacles in order to assist them to safely move through and out of a passenger rail car.

The light sources utilized to comply with the criteria required in Section 2.3 shall be electrically powered (e.g., incandescent, fluorescent, electroluminescent [EL] or light-emitting diode [LED] point sources).

2.1 Location

Emergency lighting shall illuminate the following areas:

- passenger aisles and passageways
- door emergency exit controls/manual releases
- platform, steps and vestibule floor near the door emergency exits (to facilitate safe entrance/exit from the door)
- car diaphragm and adjacent area

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- stairway surfaces, including the step nose (edge wrap) and tread, and landings
- operator areas

2.2 Amount of light

Table 1 contains minimum performance criteria for the emergency lighting system for the various areas of the rail transit vehicle.

2.3 Power source and activation

The emergency lighting system providing the illumination levels, as required in **Table 1**, shall minimally have one but may have multiple independent power sources. Each emergency light fixture shall activate automatically and be energized continuously for the duration specified in **Table 1**, whenever the car is in passenger service and normal lighting is not available.

TABLE 1
Minimum Emergency Lighting Performance Criteria

Area	Illumination Level, Initial	Illumination Level, After 1.5 hours	Where Measured
Door exits	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	At location of emergency/manual door control release/instructions
Entrance/exit/vestibule	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	At doors, at floor, center
Diaphragm area	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	At floor, center
Stairway (interior)	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	At floor, center of steps
Passageway	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	Approximately 25 in. (64 cm) above floor at centerline*
Aisle	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	Approximately 25 in. (64 cm) above floor at centerline*
Operator Areas	1.0 fc (10.8 lx)	0.6 fc (6.5 lx)	At location of emergency/manual door control release/instructions

* Values for these areas are averages of all the measurements made. No single measurement shall be less than one-tenth of the values in **Table 1** (i.e., 0.1 fc initially, and 0.6 fc after 1.5 hours).

Emergency lighting shall continue to function after the standby power and any other stages of load shedding have terminated.

Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests. Capacitive storage devices do not require self-diagnostic modules due to long cycle life count and short charge times. These independent sources shall be charged from the normal power sources and shall be capable of operating in any orientation.

3. Evaluation measurements and tests

To verify design and compliance with the minimum emergency light level requirements in **Table 1**, a qualification test shall be conducted on the emergency lighting system of at least one representative car/area, in accordance with this section.

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Rail transit systems shall retain a copy of the approved test plan describing the procedure used to obtain the measurement readings and a copy of the test data showing the illumination levels measured at the required locations, along with the results of such tests.

Rail transit systems shall retain a copy of the test results until the next periodic test is conducted on a representative car/area, as required by Section 6.1.

3.1 Preparation for testing

The following general factors apply to all tests:

- All emergency energy storage devices shall be in good order and fully charged.
- All the battery loads that may be applied under emergency conditions shall be identified. Circuit breaker switches shall be set so that those loads (door operators, public address system, controls, headlights or marker lights, etc.) that are normally present in revenue service are energized during the emergency lighting tests.
- The tests shall be conducted with independent power source(s) only; any feeds from auxiliary or other sources shall be disconnected.
- Capacitive storage independent power source devices shall receive a maximum of a 30-minute charge from main power. Testing shall consist of a functional test whereby the emergency lighting fixture senses a loss of normal power.
- All extraneous light shall be excluded to the extent practicable. Meaningful data shall be collected only if ambient light is eliminated almost completely from the areas being measured. Any approach is acceptable as long as ambient light is reduced below 0.01 fc (0.1 lx) in the areas being measured. Several methods can be used to eliminate ambient light for accurate data collection:
    - Work at night with car parked away from bright yard lights.
    - Locate car in a dark, windowless shop; paint booth; or carwash, if available.
    - Mask windows and vestibules with roofing paper, flooring paper or similar opaque materials.
    - Drape car with opaque tarpaulins.
- When photoelectric cell type instruments are used, the car should be at a temperature above 60 °F (16 °C) and the instruments operated in accordance with the manufacturer's operating instructions. This is not necessary with instruments that have temperature compensation built in.

3.2 Data collection

When testing the illumination of a car, a record shall be taken of the condition of the car and the method of making the test. As a minimum, information shall include the following:

- number of car
- location where test is conducted
- identification of individual(s) conducting test
- date
- time of day
- start and end times
- method of darkening car
- instruments used, date of last calibration and whether equipped with color correction filter
- identification of area tested (e.g., vestibule, aisle, passageway)
- type of lighting fixtures and record of which fixtures were lighted
- location of readings
- individual illumination level measurements taken

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This information shall be contained in test procedure documentation. A copy of such documentation is an acceptable record.

3.3 Documentation

The following information shall be recorded:

- conditions of fixtures:
    - new or old
    - type of reflector and condition
    - cleanliness
- wattage and rated voltage of lamps
- color temperature or manufacturer's model number of lamps
- battery voltage
- description of readings (e.g., how sensor is mounted)
- duration of test
- car interior air temperature
- outside ambient temperature

3.4 Procedures for measuring illuminance of emergency lighting systems

Measurements of the emergency lighting system performance shall be taken as spatial averages in the immediate vicinity of an action point, as specified in this section. No single reading used in the spatial average shall be below 0.1 fc (1 lx) (i.e., no dark spots are allowed). The action points considered within this standard are at the door exit release, at armrest level (25 in. [64 cm] above the floor), on the floor and at specified stairway step locations.

3.4.1 Required equipment

At a minimum, a sensitive, accurate illuminance meter is required. An acceptable instrument will measure accurately down to levels of 0.1 fc (1 lx) and ideally provide at least 6.5 ft. (2 m) separation between the sensor head and the display to eliminate the effects of shadows cast by the observer's body.

Other useful equipment would include a notebook computer or data logger to capture the data stream from the illuminance meter in order to determine the average illuminance levels, small flashlights suitable for reading the instrument displays without introducing significant additional light, and a stopwatch.

3.4.2 Data collection timing

To evaluate the car emergency lighting illuminance performance, readings shall be taken at the start of the test after the emergency lighting is activated, at the halfway point and again at the end of the final applicable time duration. All data shall be recorded**.**

3.4.3 Required location measurements

For the required location measurements, the instrument sensor is generally placed on the floor where the light is brightest, usually directly below the light fixture, with the exception of the door exit release/manual release location, steps and the areas that require measurements at 25 in. (64 cm) above the floor.

To take the measurement readings, the sensor is placed on the locations listed in **Table 1**, using adhesives or supports if necessary. The observer simply records the readings using a form.

The sensor and readout device of the illuminance meter should be held in a manner so that the readout device can be read without the observer's shadow affecting the readings.

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3.4.4 Door exit control/manual release instructions

The measurements shall be taken directly on the surface of the location of the door control/manual release/ and on the surface of the instructions.

Measurements shall be taken at the door exit control/manual release with a light meter with cosine correction accurate to 3 percent or better.

As an alternative, measurements may be taken with a meter with basic accuracy of 3 percent or better (but not necessarily with accurate cosine correction) with the sensor placed flat on the floor at any point within a horizontal distance of 3 ft. (1 m) of the door control. The illumination value shall be at least five times greater than listed in **Table 1**.

3.4.4.1 Operator Areas

The measurements shall be taken directly on the surface of the location of the door control/manual release and on the surface of the instructions.

Measurements shall be taken at the door exit control/manual release with a light meter with cosine correction accurate to 3 percent or better.

As an alternative, measurements may be taken with a meter with basic accuracy of 3 percent or better (but not necessarily with accurate cosine correction) at any point within a horizontal distance of 3 ft. (1 m) of the door control. The illumination value shall be at least five times greater than listed in **Table 1**.

3.4.5 Doors, vestibules, diaphragms and stairs

No less than 0.1 fc at any of the measurement locations is permitted at the beginning of the test, and no less than 0.06 fc is permitted at the end of the test at any of the measurement locations.

Measurements shall be taken on the floor at the center of each entrance/exit door threshold and diaphragm. In vestibules, an average of three measurements shall be taken on the floor for the spatial average calculation. For cars with steps for non-level boarding, measurements shall be taken near the centerline at the top and bottom steps. An average of these two measurements shall be calculated.

For interior stairways, a measurement shall be taken near the centerline at the top landing, at a step in the middle of the stairway and at the bottom landing. An average of these three measurements shall be recorded.

3.4.6 Aisles and passageways

Because emergency lighting illumination levels may vary within a car, an average based on at least 20 measurements shall be taken at equidistant intervals along the aisle centerline at a height of approximately 25 in. (64 cm) above the floor to represent the mean illuminance level throughout the car length.

To ensure that the minimum illuminance level reading in the spatial average is at least 0.1 fc at the beginning of the test and 0.06 fc at the end of the test, the measurements shall be taken at whatever location along the aisle appears darkest to the observer. Whether measurements are recorded manually or by computer, they shall be taken in a manner that the observer’s shadow does not affect the readings.

If measurements are to represent system performance at a given point in time along the battery discharge curve, then these readings must be collected within a short time period. Collecting this quantity of readings manually is difficult to accomplish quickly. Therefore, the computerized data collection method is recommended.

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3.4.7 Multilevel cars

Illuminance measurement readings shall be taken at the required locations on the main level of the car and on all subsequent levels of multilevel cars (e.g., low-floor section, high-floor section).

4. System reliability

The emergency lighting system for rail transit vehicles shall be designed so that at least 50 percent of the emergency lighting fixtures operate, notwithstanding the failure of any single individual light fixture or individual sealed battery, captive storage unit, or other power source.

Independent power sources making use of firmware, software, and/or microcontrollers shall follow the guidelines within IEEE 1558-2004 – *"Standard for Software Documentation for Rail Equipment and Systems"* Type 3 or higher.

5. Operating conditions

Each main car battery and each independent power source in a rail transit vehicle shall be capable of operating in all equipment orientations within 45 degrees 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 emergency lighting system components for rail transit vehicles shall be designed to function normally in the presence of mechanical vibrations and shock, in any orientation, and despite electromagnetic interference and other conditions.

6. Maintenance

6.1 Periodic inspections and tests

A periodic inspection and functional test shall be made of the emergency lighting system, including all power sources. Routine cleaning of the light fixtures and components also should be part of the rail transit system maintenance program.

After the initial design and functional verification tests required by Section 3, tests to confirm the minimum illumination level and duration of the emergency lighting system shall be conducted no less frequently than once every eight years. This may be accomplished by using a statistically valid documented sampling method on a representative group of cars and areas.

Corrective action shall be taken whenever the tested values are less than the minimum values stated in **Table 1**.

Sealed batteries used as an independent power source for each emergency light circuit shall be replaced at the interval specified by the manufacturer or, if not specified, at least every five years.

Capacitor-based energy storage devices do not have a replacement requirement. However, a functional test of the devices shall be conducted as part of a periodic inspection.

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6.2 Defect reporting, repair and recordkeeping

Defects, such as nonoperational emergency lighting fixtures, shall be reported and repaired in accordance with established local transit system procedures and OEM recommendations.

Related APTA standards

APTA RT-VIM-S-021-10 Rev 1, *"Emergency Signage for Rail Transit Vehicles"*
APTA RT-VIM-S-022-10 Rev 1, *"Low-Location Emergency Path Marking for Rail Transit Vehicles"*
APTA PR-E-S-013-99 Rev 1, *"Standard for Emergency Lighting System Design for Passenger Cars"*

Definitions

action point: The position where a function or task is performed. Such functions may include, but are not limited to, activities such as reading a label or operating a release mechanism.

aisle: A path through a vehicle that is not bordered by walls, such as down the center of a rail transit car that has a row of seats on each side.

auxiliary power system: An onboard source of electrical power (e.g., alternator/generator/car battery) typically used under normal operating conditions to supply such functions as lighting and air conditioning.

color temperature: A numerical descriptor of the hue of a light source. It is expressed in terms of degrees on the Kelvin scale and refers to the temperature of a black-body radiator that produces light of the same hue as the source specified. Low color temperatures correspond to reddish (or warm) colored sources, such as candle flames or incandescent lamps, whereas higher color temperatures are associated with bluish (or cool) colored sources. Fluorescent and LED sources are available in a wide range covering low to high color temperatures.

electroluminescence (EL): Luminescence resulting from the application of an alternating electrical current to phosphor.

entrance/exit: The partially enclosed area of a car adjacent to the side loading doors. It provides access/egress to the car interior. See also *vestibule*.

foot-candle (fc): A unit of illuminance. One foot-candle is 1 lumen per square foot (lm/sq. ft.). In the international system, the unit of illuminance is lux (1 fc = 10.76 lux).

illuminance: The amount of light falling on a unit of area (e.g., 1 sq. ft. of surface). English units are foot-candles (fc) or lumens per square foot (lm/sq. ft.). International units (SI) are lumens per square meter (lm/m^2) or lux (lx). One fc equals 10.76 lux.

independent power source: A sealed battery, capacitive storage or other energy storage device located within the car body that is designed to power one or more emergency light fixtures or other devices when the normal head-end power, main car battery, auxiliary power and/or wayside power are unavailable.

lighting, emergency: A lighting mode that is available whenever power for the normal lighting is unavailable. The main car battery or one or more independent power sources can be used to supply the power to operate the fixtures that provide emergency lighting.

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lighting, normal: A lighting mode that is available when the car is in operation with the normal power system.

lighting, standby: A lighting mode available (on some cars) when the car loses normal power, but the main car battery has not yet discharged to load shed. See also *independent power source* and *load shed*.

load shed: An electrical power system design in which some of the main car battery load is disconnected partway through the discharge cycle so that the remaining battery capacity can be used exclusively to provide power to the most important loads—e.g., a portion of normal lighting, emergency lighting and the public address system. The effect is to considerably extend the length of time these critical loads can be supported. The approach may include disconnecting such items as door operators, controls and some of the lighting from the main battery power source.

lumen: The international unit of luminous flux or the time rate of flow of light.

luminaire (light fixture): A device to produce, control and distribute light. A complete unit consisting of one or more lamps, sockets to hold and protect the lamps, optical devices to direct the light, and circuitry to provide the required electric power to the lamps.

lux: The international unit of illuminance (1 lux = 0.0929 fc).

main level: A level of a rail transit car that contains a passenger compartment whose length is equal to or greater than half the length of the car.

passageway: A path directly bordered by walls that allows a passenger or crew member to move from one location to another.

representative car/area: A car/area that shares the relevant characteristics of the car(s)/area(s) it represents.

room/compartment: A space that can be occupied by passengers or crew, enclosed on at least three and usually all four sides.

spatial average: The average of all samples taken in the vicinity of a specific location. The area of a spatial average varies. For a stairway, it includes only the area of the stair step(s). For an aisle, the entire length of the aisle is included.

vestibule: An area of a passenger car that normally does not contain seating and is used in passing from the seating area to the side exit doors. See also *entrance*.

Abbreviations and acronyms

EL	electroluminescent
fc	foot-candle
LED	light-emitting diode
lm	lumen
LVPS	low-voltage power supply
NATSA	North American Transit Services Association
OEM	original equipment manufacturer

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Summary of document changes

- Sections have been moved and renumbered.
- Sections of definitions, abbreviations and acronyms have been moved to the rear of the document.
- Five new sections added: "Introduction," "Note on alternate practices," "Related APTA Standards", "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.
- Working group membership updated.
- Table 1 – Added entry for 'Operator Areas'
- Added a new Section 3.3 'Documentation'.
- Old Section 3.3 'Required location measurements' subdivide into five new Sections namely – 3.4.4 'Door exit control/manual release instructions', 3.4.4.1 'Operator Areas', 3.4.5 'Doors, vestibules, diaphragms and stairs', 3.4.6 'Aisles and passageways', and 3.4.7 'Multilevel cars'.
- Section 5 'Operating conditions' – Individual applied accelerations increased Longitudinal from 5g to 8g, Lateral from 2g to 4g, and vertical from 3g to 4g.
- An additional document added to the Reference Section APTA PR-E-S-013-99 Rev 1, *"Standard for Emergency Lighting System Design for Passenger Cars"*

Document history

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First published	—	—	—	—	June 6, 2010
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