12. APTA PR-E-S-013-99, Rev. 1 Standard for Emergency Lighting System Design for Passenger Cars

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APTA PRESS Task Force

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Abstract: This standard specifies the minimum performance criteria for the design of the general emergency lighting system for passenger rail cars.

Keywords: emergency lighting

Introduction

This introduction is not a part of *APTA PR-E-S-013-99, Rev. 1, Standard for Emergency Lighting System Design for Passenger Cars.*

Review of past passenger rail accidents involving passenger and train crew emergency evacuation has indicated that both passengers and emergency responders lacked sufficient information necessary for expedient emergency egress and access due to the absence of clear markings and instructions. Emergency lighting system failures and/or low levels of illumination during these accidents have been cited as a cause for confusion and as a contributing factor to the injuries and casualties that resulted.

The National Transportation Safety Board (NTSB) made the following recommendation to the Federal Railroad Administration (FRA) [1] after investigation of a 1996 passenger train accident:

> "Require all passenger cars to contain reliable emergency lighting fixtures that are each fitted with a self-contained independent power source and incorporate the requirements into minimum passenger car safety standards *(R-97-17)."*

In 1999, FRA issued regulations that require emergency lighting for new passenger rail cars (see 49 CFR, Part 238). The FRA regulations state that minimum levels of emergency lighting must be provided adjacent to doors intended for emergency egress and along aisles and passageways for new equipment.

This American Public Transportation Association (APTA) standard was originally developed to provide guidance for meeting the FRA regulations and specifies the design of emergency lighting systems for passenger rail equipment, as well as minimum illumination levels, that will facilitate the ability of passengers and train crew members and / or emergency responders to see and orient themselves, to identify obstacles, and to move safely through a passenger rail car.

An effective systems approach uses this standard and APTA standards: *APTA PR-PS-S-002-98, Rev. 3, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment*, and *APTA PR-PS-S-004-98, Rev. 2, Standard for Low-Location Exit Path Marking*, to provide a means for passengers and crew to locate, reach, and operate emergency exits in order to facilitate their safe evacuation in emergency. Railroads and car builders should carefully consider the options available to meet emergency evacuation requirements presented in these three standards.

Revision 1 of this standard includes extensive modifications to facilitate the incorporation of the standard by reference by the FRA in 49 CFR, Part 238 (See explanation in next paragraph.). These modifications include:

1) add this introduction;
2) revise the Purpose and Scope in Section 1 Overview to be consistent with that of the Emergency Signage and LLEPM standards;

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[1] National Transportation Safety Board (NTSB). Collision and Derailment of a Maryland Rail Commuter MARC Train 286 and National Railroad Passenger Railroad (Amtrak) Train 29 Near Silver Spring, Maryland on February 16, 1996. Report No. NTSB/RAR-97/02. Adopted July 3, 1997.

3) revise Table 1 in Section 4;

4) extensively revise Sections 4 through 6 to include text from the APTA Recommended Practice for Normal Lighting and reorganize to include the majority of the previous Annex B; and include light meter requirements; and

5) add new Sections 7-10 for Reliability, Operating Conditions, and Maintenance, for consistency with the emergency signage and low-location exit path marking standards.

In addition, Annexes were revised to:

1) add new Annex B relating to automatic testing of emergency lighting systems that use independent power sources;

2) revise remainder of former Annex B and relocate to Annex C;

3) add Annex D to provide guidance to increase illumination levels; and

4) add new Annex E relating to representative sample sizes.

In response to the NTSB recommendation, FRA determined that federal regulations for passenger rail equipment emergency lighting should be updated and improved. APTA proposed to the Railroad Safety Advisory Committee (RSAC) Passenger Equipment Working Group Emergency Preparedness Task Force that this APTA emergency lighting standard be incorporated as a reference into 49 CFR, Part 238. Accordingly, APTA has worked with the FRA, railroads, car manufacturers and suppliers, labor organizations, and NTSB, as part of the FRA RSAC process, to prepare this revision of this standard in order to address the NTSB recommendation and to facilitate the incorporation by reference of the standard into the FRA regulations. The RSAC Task Force had little difficulty reaching consensus on the revisions as they apply to new equipment. However, the debate on how to handle existing equipment proved to be more difficult.

The modifications comprising Revision 1 of this standard will affect equipment in the following ways:

- Text is now included in the Overview that gives the railroads new responsibilities for ensuring that emergency lighting is compatible with their evacuation policies. See Section 1.
- The Scope has been changed to clarify that the standard does not apply to tourist, scenic, historic, excursion operations, or private rail cars. See Section 1.1.
- The effective date of the Standard has been changed to April 7, 2008. See Section 1.1. Note, however, that railroads must remain in compliance with existing requirements for emergency lighting contained in 49 CFR Section 238.115, which apply to passenger cars ordered after September 8, 2000 or placed in service for the first time after September 9, 2002.
- The purpose of the standard has been changed to require tests to validate the design of the emergency lighting system. See Section 1.2.
- The definitions of existing equipment and rebuilt/remanufactured vehicle have been deleted. See Section 3.1.
- Several definitions have been added, including: color temperature, electroluminescence, independent power source, luminaire, main level, representative car/area and room/compartment. These additional definitions are necessary to clearly define requirements contained in the standard. See Section 3.1.

- The option to accelerate installation of emergency signage and LLEPM systems to meet the emergency light levels required by this standard has been eliminated.
- The option to compensate for emergency lighting that did not meet the emergency light levels required by this standard through a safety equivalency plan has been eliminated.
- A new requirement has been added listing the types of lighting permitted as part of emergency lighting systems. See Section 5. This should not impact any existing emergency lighting systems.
- A minimum light level requirement must be maintained at the location of each emergency / manual door control/release on each passenger car. The majority of passenger cars currently in service will meet this requirement without modification. See Section 5.2, Table 1.
- Errors in the required emergency light levels for the stairway and passageway areas of older passenger cars have been corrected. See Section 5.2, Table 1.
- The minimum light levels required in Table 1 for certain passenger cars must be met by January 1, 2015 or the cars must be removed from service. In the mid-1990s, APTA surveyed cars currently in service. Several railroads operated older cars that could not meet these levels without improvements to the emergency lighting system. Most of these cars have since been retired. Plans are in place by the affected railroads to retire all such cars by 2015. See Section 5.2.
- Emergency lighting system installed on each passenger car ordered on or after April 7, 2008, or placed in service for the first time on or after January 1, 2012, must comply with the illumination levels required in Table 1 (and Section 6), by means of an independent power source(s) that is located in or within one half a car length of each light fixture it powers, and that operates when normal power is unavailable. See Section 5.3.
- Batteries that are used as independent power sources must have automatic self-diagnostic modules designed to perform discharge tests (see Annex B). These independent sources must be charged from the normal power sources and shall be capable of operating in any orientation. See Section 5.3.
- Extensive detail has been added to the requirement to do an initial test to determine that each representative passenger car type meets the minimum emergency light levels. This detail was moved from Annex B to Section 6, in the body of the standard. FRA may ask for the results when this standard is incorporated in 49 CFR, Part 238. Most railroads completed this initial test on their existing fleets. See Section 6. Railroads that completed this initial test are probably due to complete the periodic tests required by this standard soon. See Section 9.1.
- The specifications for the light meter required to confirm emergency light levels have been revised and moved into the body of the standard. This means some railroads / suppliers may have to buy new meters or adapters. See Sections 6.3.1 and Annex C.
- Illuminance recordkeeping requirements have been increased. See Section 6.4.
- A new Section 7 covering system reliability requirements has been added to the standard.
- A new Section 8 covering Operating Condition requirements has been added to the standard.
- For passenger cars purchased after September 8, 2000, a requirement has been added for the shock resistance of main batteries and independent power sources. This requirement for main batteries is identical to the requirements in 49 CFR, Part 238 for back-up power. See Section 8.

- A new Section 9 has been added to the standard that includes new requirements for periodic maintenance of passenger cars. The requirements are consistent with the APTA standards for periodic maintenance of other safety -critical systems and comply with 49 CFR, Part 238. See Section 9.
- Representative sampling of the railroad car fleet must be done at an interval not to exceed 8 years to verify that the performance of the emergency lighting system remains in compliance with this standard. See Section 9.1.
- A requirement for defect reporting consistent with 49 CFR, Part 238 has been added to the standard. See Section 9.2.
- The Informative Annexes have been extensively revised and new annexes added that contain additional guidance information. See Annexes B, C, D, and E.

Participants

The American Public Transportation Association greatly appreciates the contributions of the following individual(s), who provided the primary effort in the drafting of the original *Standard for Emergency Lighting System Design for Passenger Cars:*

Dave Phelps
Ralph Dolinger

In addition, APTA would like to thank the Office of Research and Development, Federal Railroad Administration, U.S. Department of Transportation (USDOT), for providing funding to the following individuals from the Volpe Center / USDOT, who contributed extensive technical research and assistance in the preparation of the original standard and Revision 1:

Stephanie Markos
J.K. Pollard

At the time that this standard was originally completed, the 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

The Passenger Equipment RSAC Emergency Preparedness Task Force members that contributed to the modifications resulting in Revision 1 of this standard include:

David Albert
Dan Alpert
Austin Craig
Marina Batzke
Larry Beard
John Bell
Ken Briers
David Brooks
Alex Bunin
Dick Calabrese
Gord Campbell
Art Candenquist
Al Carlson
Stephen Carullo
Paul Cheng
Steve Chrismer
Rich Conway
John Cottingham
Robert Crawford
Tim DePaepe
Ralph Dolinger
Craig Daly
David Elliott
Matthew Enderle
Steve Fritter
Tom Freeman
Marc Gagne
Robert Gagne
Dave Gibson
Cynthia Gross
Lynn Hannah
Herbert Harris
Mark Harvill
Toshi Hasengawa
Robin Hazy
Paul Hewitt
Rich Hollingsworth
Leo Hoyt
Stan Hunter
Andrew Hyer
Dale Kelley
Ullah Kifayat
Dan Knote
Scott Krieger
James Lamond
Sam Liao
Tom Lichterman
Bill Lydon
Susan Madigan
Ken Mannen
David Mao
Stephanie Markos
Eloy Martinez
Peter McGevna
Bob McIntosh
Chris McKay
James Michel
Stuart Miller
Stepfone Montgomery
Brenda Moscoso
Mark Murphy
Ron Owens
Tom Peacock
Wayne Penn
John Pollard
Vicki Porter
Mark Ricci
Tom Rowbottom
Ed Sauer
Richard Seaton
Patrick Sheeran
Blair Slaughter
George Sloan
Rex Springston
Will Smith
Tom Tsai
David Tyrell
Harold Weisinger
Anna Winkle
Dennis Yachechak
Allen Yoder
John Zolock
Al Zubor

At the time that Revision 1 of this standard was completed, the PRESS Electrical Committee and Systems Committee included the following members:

Bill Lydon/Doug Warner, *Chairs*

Larry Beard	Leo Hoyt	Brenda Moscoso
Ken Briers	Stan Hunter	Mark Murphy
Dave Brooks	Andrew Hyer	Scott Ornstein
Gord Campbell	Susan Madigan	Tom Peacock
Art Candenquist	Ken Mannen	J. K. Pollard
Rich Conway	David Mao	Vicki Porter
John Cottingham	Stephanie Markos	Tom Rowbottom
Craig Daly	Eloy Martinez	Patrick Sheeran
Ralph Dolinger	Peter McGevna	Rex Springston
Dave Gibson	Bob McIntosh	Harold Weisinger
Paul Hewitt	Jim Michel	Al Zubor

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1. Overview

Historically, there have been passenger rail car accidents and incidents that have required the emergency evacuation of passengers and/or train crew members.

This standard requires that each rail passenger car be equipped with emergency lighting that facilitates the ability of passengers, train crew members, and emergency responders to see under conditions of darkness when the normal lighting power source is damaged or otherwise unavailable.

APTA designed this standard to offer flexibility in application, as well as achieve the desired goal of facilitating passenger and crew egress from potentially life threatening situations on passenger rail cars. Each railroad has the responsibility to design, install, and maintain an emergency lighting system that is compatible with its internal safety policies of emergency evacuation, while complying with the performance criteria specified in this standard.

1.1 Scope

This standard applies to all passenger rail cars that operate on the general railroad system in the United States. This standard does not apply to tourist, scenic, historic, excursion operations, or private rail cars.

The effective date of this standard is April 7, 2008, unless otherwise specified. This standard applies to passenger rail cars in different ways depending on when that equipment was / is ordered and first placed in service.

The standard contains requirements for the general illumination portion of the overall passenger rail car emergency lighting system, including minimum interior illumination levels at specified locations.

This standard is an integral component of a systems approach for locating, reaching, and operating emergency exits to facilitate the safe evacuation of passengers and train crew members in an emergency. The other required components of this systems approach include emergency signage and low location path marking (LLEPM), which are described in the following APTA standards:

APTA PR-PS-S-002-98, Rev. 3, Standard for Emergency Signage for Egress/Access of Passenger Rail Equipment; and[2]

APTA PR-PS-S-004-99, Rev. 2, Standard for Low-Location Exit Path Marking. -

[2] For references in Italics, see Section 2 of this standard.

In addition, recommendations for the design and operation of normal passenger car lighting system design are covered in *APTA PR-E-RP-012-99, Recommended Practice for Normal Lighting System Design for Passenger Rail Equipment*.

1.2 Purpose

This standard specifies minimum performance criteria for the design of the general emergency lighting system for passenger rail cars that operates when the normal lighting system is unavailable. This standard also requires tests to validate the design.

Complementary emergency systems provide signage and path markings to locate, operate, and reach emergency exits and are covered in separate APTA standards.

2. References

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

ANSI/ASQC Z1.9-1993, Sampling Procedures and Tables for Inspection by Variables.

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

APTA PR-E-RP-012-99, Recommended Practice for Normal Lighting System Design for Passenger Rail Equipment.

APTA PR-IM-S-001-98, Rev. 1, Standard for Passenger Rail Equipment Battery System Periodic Inspection and Maintenance.

APTA PR-IM-S-005-98, Rev. 2, Standard for Passenger Compartment Periodic Inspection and Maintenance.

APTA PR-IM-S-008-98, Rev. 1, Standard for Electrical Periodic Inspection and Maintenance of Passenger Coaches.

APTA PR-IM-S-013-99, Rev. 1, Standard for Passenger Car Periodic Inspection and Maintenance.

APTA PR-PS-S-002-98, Rev. 3, Standard for Emergency Signage for Egress / Access of Passenger Rail Equipment.

APTA PR-PS-S-004-98, Rev. 2, Standard for Low-Location Exit Path Marking.

49 CFR, Part 238, Passenger Equipment Safety Standards.

49 CFR, Part 239, Passenger Train Emergency Preparedness.

3. Definitions, abbreviations, and acronyms

3.1 Definitions

For the purposes of this standard, the following definitions apply:

3.1.1 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.

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

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

3.1.4 car: a passenger-carrying rail vehicle.

3.1.5 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 sources, such as candle flames or incandescent lamps. Higher color temperatures are associated with cool-white fluorescent lamps, LEDs, blue sky and several types of new lighting technology.

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

3.1.7 entrance / exit: The partially enclosed area of a car adjacent to the side loading doors. It provides access/egress to the car interior. (Also see vestibule).

3.1.8 foot-candle (fc): A unit of illuminance. One foot-candle is one lumen per square foot (Lm/ft^2). In the international system, the unit of illuminance is lux (1 fc = 10.76 lux).

3.1.9 head-end power (HEP): A system by which electrical power is provided to railroad vehicles from a central source via a trainline system. The source of power can be a locomotive or a power car. (Wayside supply from catenary, third rail, or trackside can also be transformed into HEP as it passes through the power system.) HEP is used under normal operating conditions to provide electrical power to the passenger equipment systems, such as "normal" lighting. In the United States, 480 VAC, 3-phase systems are most common.

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

3.1.11 independent power source: A sealed battery 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 HEP, main car battery, auxiliary power, and/or wayside power are unavailable.

3.1.12 lighting, emergency: 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.

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

3.1.14 lighting, standby: Lighting mode which is available (on some cars) when the car loses normal power, but the main car battery has not yet discharged to load shed (see also Sections 3.1.15 and 3.1.20).

3.1.15 load shed: An electrical power system design in which some of the main car battery load is disconnected part way 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 PA 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.

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

3.1.17 luminaire (light fixture): A device to produce, control, and distribute light. A complete unit typically 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 lamp(s).

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

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

3.1.20 power, standby: Power mode that is available (on some cars) when the car loses normal power, but the main car battery has not yet discharged to load shed. This mode is intended to keep a substantial number of the normal lighting fixtures, including emergency lighting fixtures, operating for a short period (90 seconds to 30 minutes or more) so that short term power outages, such as those which occur when adding cars or changing locomotives at the station, will have only a minor effect on passengers. This type of lighting power is used primarily on newer intercity passenger cars.

3.1.21 representative car /area: A car/ area that shares the relevant characteristics as the car(s) / area(s) it represents (i.e., same emergency lighting fixtures, system layout, and power system).

3.1.22 room / compartment: A space that can be occupied by passengers or crew, which is enclosed on at least 3 and usually all 4 sides.

3.1.23 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.

3.1.24 stairway: Continuous set of steps (not interrupted by a landing).

3.1.25 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 Section 3.1.7, entrance.)

3.2 Abbreviations and acronyms

APTA American Public Transportation Association
CFR Code of Federal Regulations
CIE Commission Internationale de l'Eclairage (International Commission On Illumination)
EL Electrolumninescent
FRA Federal Railroad Administration
HEP Head-end power
LED Light emitting diode
PRESS Passenger Rail Equipment Safety Standards
NTSB National Transportation Safety Board
UL Underwriters' Laboratories

4. Types of lighting and power sources

4.1 Normal

When normal power is available, all normal lighting is also available. Normal passenger rail car lighting is powered from some combination of sources derived from HEP, auxiliary or wayside power. Because these sources are generally 480 VAC or higher, the voltage must first be reduced to a suitable operating voltage for a light fixture – usually 240 or 120 VAC. While the bulk of the normal lighting load is generally AC-powered, a growing portion of the lighting load is now connected directly to the low voltage DC and battery supply. This has allowed higher car interior light intensity when the HEP/auxiliary/wayside power source is not available, during momentary power losses or even longer intervals, such as during a locomotive change.

Typical lighting power voltages for lighting are 240, 120, and 28 VAC, the latter primarily for reading lights and 74 and 37.5 VDC.

4.2 Standby

Standby power (when included as part of the design and available) normally continues the operation of much of the normal lighting system, when the normal power is unavailable. Standby power is typically provided from the main car battery and is activated in response to loss of HEP, or is already operational as part of the Low Voltage Power Supply (LVPS) load. Upon loss of normal power, standby power for lighting typically remains available until battery voltage drops to some predetermined level, usually after 2 to 30 minutes and a load-shed relay, sensing battery voltage drop below the predetermined level, deactivates the standby load.

Since the power demand for standby lighting and other loads can be high, the length of time the main battery system supports the standby loads is limited. The power load is significantly reduced when the standby mode changes over to emergency mode, which powers a reduced number of car functions, allowing the remaining load to be supported for a longer time.

After the main battery voltage has dropped below a predetermined level, standby power for lighting deactivates and power for emergency lighting activates and / or stays on until the battery is discharged to a level that cannot support the emergency lighting load.

4.3 Emergency

The overall passenger rail car lighting system has historically used the main car battery to power emergency lighting. (However, some cars have been equipped with localized independent batteries or other energy storage devices.) A variety 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.
- Fixtures that are powered from the low voltage power supply 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.

5. 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, 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 5.2 shall be electrically powered (e.g., fluorescent, EL, incandescent, or LED).

5.1 Location

Emergency lighting shall illuminate the following areas:

- Passenger car aisles, passageways, and toilets;
- Door emergency exit controls / manual releases;
- Platform, steps, and vestibule floor near the door emergency exits (to facilitate safe entrance/exit from the door;
- Within the car diaphragm and adjacent area;
- Stairway surfaces, including the step nose (edge wrap) and tread, and landings;
- Specialty car locations, such as crew offices, food service areas, sleeping car rooms, etc.

5.2 Illuminance Criteria

Table 1 contains minimum performance criteria for the emergency lighting system for the various areas of the passenger rail car. The values are the initial minimum values and minimum values at the end of 1.5 hours and 1 hour, as applicable.

Emergency light illumination levels shall be tested in accordance with Section 6 (also see Annex C) and shall be maintained in accordance with Section 9.

TABLE 1. Minimum Emergency Lighting Performance Criteria

Area	**Foot-candles (lux)** Equipment ordered before September 8, 2000 and placed in service before September 9, 2002)* Initial / after 1 hour	**Foot-candles (lux)** Equipment ordered on or after September 8, 2000, or placed in service for the first time on or after September 9, 2002 Initial / after 1.5 hours	**Where Measured**
Door exits	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	At location of emergency/manual door control release/instructions **
Entrance/exit/ vestibule	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	At doors, at floor
Stairway (interior)	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	At floor, center of steps
Passageway	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	25” (64 cm) above floor at centerline**
Aisle	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	25” (64 cm) above floor at centerline **
Toilet area	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	25” (64 cm) above floor **
Crew area of MU / Cab car	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	25” (64 cm) above floor ******
Other coach / specialty car areas	0.5 / 0.3 (5.4 / 3.2)	1.0 / 0.6 (10.8 / 6.5)	25” (64 cm) above floor **

* Required by January 1, 2015 or when equipment is transferred, leased, or conveyed to another railroad for more than 6 months of operation, whichever occurs first.

** Values for these areas are averages of all of the measurements made. For equipment ordered on or after September 8, 2000, or placed in service for the first time on or after September 9, 2002, no single measurement shall be less than one tenth of the values in Table 1 (i.e., 0.1 fc initially, and 0.06 fc) after 1.5 hours. For equipment ordered before September 8, 2000 and placed in service before September 9, 2002, no single measurement shall be less than one tenth of the values in Table 1 (i.e., 0.05 fc initially, and 0.03 fc after 1 hour. See Section 6.3.3.3.

5.3 Power source and activation

Each emergency lighting fixture providing the illumination levels, as required in Table 1, shall be powered from either the main battery system, or independent power source(s). Each emergency light fixture shall activate automatically or be energized continuously for the duration specified in Table 1, whenever the car is in passenger service and normal lighting is not available.

Emergency lighting system installed on each passenger car ordered on or after April 7, 2008, or placed in service for the first time on or after January 1, 2012, shall comply with the illumination levels required in Table 1 (and Section 6), by means of an independent power source(s) that is located in or within one half a car length of each light fixture it powers, and that operates when normal power is unavailable.

Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests (see Annex B). These independent sources shall be charged from the normal power sources and shall be capable of operating in any orientation.

6. Evaluation measurements and tests

To verify design and compliance with the minimum emergency light level requirements in Table 1, railroads shall ensure that a qualification test is conducted on at least one representative car / area for each emergency lighting system layout, in accordance with this section and Annex C.

For passenger cars placed in service before January 1, 2008, this test shall be conducted by December 31, 2008.

For passenger cars placed in service for the first time on or after January 1, 2008, this test shall be completed before the equipment is released for operation in revenue service.

6.1 Preparation for tests

The following general factors apply to all tests:

- The condition of the battery system shall be identified. The battery should be fully charged.
- All of 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, PA 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 battery power only; any feeds from HEP, auxiliary, or wayside sources must be disconnected.
- All extraneous light should be excluded to the extent practicable. Meaningful data can be collected only if ambient light can be 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 lux) in the areas being measured. Several methods can be used to eliminate ambient light for accurate data collection:

- Work at night with cars parked away from bright yard lights**;**
- Locate cars in a dark, windowless shop or carwash, if available**;**
- Mask windows and vestibules with roofing paper, flooring paper, or similar opaque materials; or
- Drape cars with opaque tarpaulins.

- When photoelectric cell type instruments are used, the car should be at a temperature above 60^{o}F (16^{o}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.

NOTE 1-- It is recommended that information be recorded identifying date of manufacture and time in service of batteries.

NOTE 2-- Fluorescent lamps should have at least 100 hours in service before tests are made and be warmed up for at least 15 minutes before any readings are taken so that they will achieve full rated light output.

If the ambient light can't be reduced to 0.01 fc, there are two alternative measurements that can be used to meet the requirements in Table 1:

1) Measure the ambient light at each location and subtract that value from the value measured with the emergency lighting operating; or

2) If the emergency lighting is at least twice the required levels in Table 1 plus the ambient light reading, consider that the required levels to be met.

APTA PR-E-RP-007-98 Recommended Practice for Storage Batteries and Battery Compartments contains additional guidance for the conduct of car main battery tests.

6.2 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 if 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.

Some of this information may be contained in test procedure documentation. A copy of such documentation is an acceptable record.

NOTE 3-- It is recommended the following information be recorded:

- Condition of fixtures
  - New or old
  - Type of reflector and condition
  - Cleanliness
- Wattage and rated voltage of lamp
- Color temperature or manufacturer's model number of lamps
- Battery voltage
- Duration of test
- Car interior air temperature
- Outside ambient temperature

Annex C contains a survey form suitable for recording all of the above information.

Annex D describes steps to follow if the illumination levels do not meet the criteria specified in Sections 5 and 6.3.

6.3 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 lux) (i.e., no dark spots are allowed). The action points considered within this standard are at the door exit release, at armrest level (25 inches (64 cm) above the floor), on the floor, and at specified stairway step locations.

NOTE 4-- Each section below specifies the minimum number of illuminance measurements required in a particular area of a car. Railroads and car builders are permitted to take more measurements and calculate averages of such measurements.

6.3.1 Required equipment

To ensure accurate illuminance measurements including measurements on vertical surfaces at which the angle of incident light is large, the light meter must be designed to take such measurements and possess:

- Basic accuracy: ± 3% of reading ±1 digit or better,
- Resolution: 0.01 fc or better,
- Cosine error: no more than 6%, measured at 50 degrees, and
- Color correction to CIE photopic curve.

Unless the floor measurement value is known to be at least 5 times the value in Table 1, a 6.5 foot (2 m) separation between the sensor head and the display must be used to ensure that the close proximity of the person taking the measurements does not affect the readings.

Other required equipment includes 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 stop watch. (Annex C contains a sample data collection form that includes all necessary data items.)

NOTE 5-- Clipboards, a personal audio recorder and data-collection forms are also useful.

6.3.2 Data collection timing

To evaluate the car emergency lighting illuminance performance, readings should 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.

An acceptable alternative is to measure illuminance as a function of battery discharge, as long as the other factors that affect the performance of lighting systems are considered (see Annex E). The discharge curve of the battery in a particular car can be measured, and then an external power supply can be used to deliver a fixed voltage corresponding to a particular point in time on the discharge curve. Illumination measurements can be conducted using those voltage points at a later convenient start time and, as applicable, 30 or 45 minutes and 60 and 90 minutes (see Table 1).

6.3.3 Required location measurements

For the required location measurements, the instrument sensor is placed on the floor, landing and step tread where the light is brightest, usually directly below the light fixture, with the exception of the door exit release/manual release location, and the areas that require measurements at 25 inches (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 reading(s) using a form similar to that contained in Annex C.

The sensor and the readout device of the illuminance meter must be held in a manner so that the sensor is not affected by the observer’s shadow.

6.3.3.1 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.

As an alternative, measurements may be taken with a meter with basic accuracy of 3% or better (but not necessarily have accurate cosine correction) with the sensor placed flat on the floor at any point within a horizontal distance of 3 feet (1 m) of the door control. The illumination value shall be at least 5 times greater than listed in Table 1.

6.3.3.2 Doors, vestibules, and stairs

Measurements shall be taken on the floor at the center of each entrance / exit door threshold.

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.

6.3.3.3 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 inches (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 or .05, as applicable, at the beginning of the test text and .06 or .03, as applicable, 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, 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 described in Annex C is recommended.

6.3.3.4 Toilets and other occupied spaces

The measurements shall be taken at a height of approximately 25 inches (64 cm) above the floor.

6.3.3.5 Multi-level cars

Illuminance measurement readings shall be taken at the required locations on each main level and each other than main level of multi-level cars (e.g., intermediate, mezzanine).

6.4 Recordkeeping

Railroads 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, and the results of such tests.

Railroads shall retain a copy of the test results until the next periodic test is conducted on a representative car / area, as required by Section 9, or until cars of that type are retired, or are transferred, leased, or conveyed to another railroad. A copy of such records shall be transferred to the accepting railroad along with any such car(s).

7. System reliability

Standby power for lighting may be used to meet the emergency lighting illumination and duration requirements in part or in whole.

Emergency lighting shall continue to function after standby power and any other stages of load shedding have terminated, so that illumination at the minimum levels are maintained for at least the time periods specified in Table 1.

The emergency lighting system for passenger cars ordered on or after April 7, 2008, or placed in service for the first time after January 1, 2012, 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 or other power source.

NOTE 6-- Batteries may fail to achieve normal service lives unless measures are taken to prevent their discharge when the emergency lighting system is not needed. To avoid this situation, lighting circuits of emergency lighting systems that use batteries for independent power sources should be turned off manually or by an automatic (voltage or timer-based) controller (e.g., when the car is not in passenger service). (See Annex B for additional guidance.)

8. Operating conditions

The required illuminance criteria shall be met under all conditions including build up of dust, dirt and discoloration of the lighting fixtures, including light diffusers.

For passenger cars ordered on or after September 8, 2000 or placed in service for the first time on or after September 9, 2002:

1) Each main car battery and each independent power source(s) 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, and
    - vertical: 4g.

2) Emergency lighting system components shall be designed to operate without failure under the conditions typically found in passenger rail equipment including expected mechanical vibrations, and shock, as well as comply with electromagnetic interference and other criteria in *49 Code of Federal Regulations (CFR), Part 238, Passenger Equipment Safety Standards*, Sections 238.225 and 238.425).

For each passenger rail car ordered on or after April 7, 2008, or placed in service for the first time on or after January 1, 2012, all emergency lighting system components shall be designed to operate in all car orientations.

9. Maintenance

9.1 Periodic inspections and tests

Railroads shall ensure that periodic tests and inspections in conformance with the requirements are conducted of the emergency lighting system, including all power sources, that conforms with the requirements in *APTA PR-IM-S-001-98, Rev. 1, Standard for Passenger Rail Equipment Battery System Periodic Inspection and Maintenance; APTA PR-IM-S-005-98, Rev. 2, Standard for Passenger Compartment Periodic Inspection and Maintenance; APTA PR-IM-S-008-98, Rev. 1, Standard for Passenger Car Electrical Periodic Inspection and Maintenance;* and *APTA PR-IM -S-013-99, Rev. 1, Standard for Passenger Car Periodic Inspection and Maintenance.*

NOTE 7-- Criteria for acceptable main car battery characteristics are specified in *APTA PR-E-RP-007-98.*

After the initial verification tests required by Section 6, railroads shall ensure that periodic tests to confirm the minimum illumination level and duration of the emergency lighting system are conducted no less frequently than once every eight years.

A representative sample of cars or areas shall be tested using the procedures in Annex E or other statistically valid documented sampling method. If the first two randomly selected sample cars or areas exceed the illumination levels specified in Table 1 of this standard by a factor of four or greater, no further testing is required for the car or area represented by the sample car / area tested for the periodic test cycle.

Each sealed battery used as an independent power source for each emergency light circuit shall be replaced at two-year intervals, unless equipped with controllers that automatically prevent unnecessary battery discharge or other measures are taken to prevent routine discharge (e.g., maintaining equipment on wayside power or HEP). If so equipped, the battery-replacement interval shall be according to manufacturer’s specifications, or if not specified, at least every five years.

For emergency lighting systems that use capacitors as independent power sources, a functional test of the devices shall be conducted as part of the periodic inspection. Due to their long life, the two-year replacement requirement does not apply to capacitor-based energy storage devices. However, a functional test of the devices shall be conducted as part of the periodic inspection.

9.2 Defect reporting, repair, and recordkeeping

Defects, such as non-operational emergency lighting fixtures, shall be reported and repaired in accordance with railroad procedures that comply with FRA (*49 CFR, Part 238)* defect reporting procedures.

Recordkeeping shall be in accordance with railroad procedures that comply with FRA (*49 CFR, Part 238)* recordkeeping procedures.

Annex A (informative)

Bibliography

[B1] AAR Manual of Standards and Recommended Practices, Section A-Part III, Section 26, Emergency Lighting, Revised 1984.

[B2] Demaree, J. "Examination of Aircraft Interior Emergency Lighting in a Postcrash Fire Environment." Federal Aviation Administration, FAA Technical Center, Final Report. No. FAA-DOT/FAA/ct-82/55.

[B3] FAA 14 CFR, Part 25, Airworthiness Standards, Transport Category Airplanes, Subpart D, Design and Construction, Subsection 25.812, Emergency Lighting.

[B4] FAA 14 CFR, Part 121, Operating Requirements, Domestic, Flag, and Supplemental Operations, Subpart K, Instrument and Equipment Requirements, Subsection 121.310, Additional Emergency Equipment.

[B5] FAA Advisory Circular 20-38A. Measurement of Cabin Interior Emergency Illumination. 2/8/66.

[B6] Illuminating Engineering Society (IES). Lighting Handbook, Reference and Application, Chapter 29, 9th edition, 2000.

[B7] National Fire Protection Association NFPA 70, National Electrical Code, 2006. Quincy, MA. 2006.

[B8] NFPA 101, Life Safety Code, Chapter 7, Means of Egress. 2006.

[B9] NFPA 130, Fixed Guideway and Passenger Rail Systems, NFPA, Quincy, MA, 2006.

[B10] UL 924, Standard for Emergency Lighting and Power Equipment, 9th edition, dated February 24, 2006. Effective Date, August 24, 2006.

Annex B (informative)

Automatic testing of electrically powered lighting systems that use batteries as independent power sources

Emergency lighting systems using independent power sources have important advantages since they are not vulnerable to loss of the main car battery power supply and/or damage to the main car battery power supply wiring. However, for the independent power supply to the emergency lighting system to be reliable and operate when necessary, multiple individual batteries must be periodically tested for each rail car (for cars with only two such batteries, each one must be tested).

Manual testing requires that a worker first determine that all independent power sources using batteries have been connected to a source of charging power for the necessary amount of time to reach full charge. Then, car-by-car, the charging power must be disconnected and the emergency lighting system switched into emergency mode. After the prescribed 1 or 1.5 hour time period for discharge, the worker must then revisit each car and note which emergency light fixtures are working properly and which are not. While such tests are in progress, some kinds of maintenance work are effectively precluded by the lack of light inside the car.

To avoid the substantial labor costs of conducting periodic discharge tests of these independent power sources, manufacturers of emergency light systems for buildings have developed self-test modules for their battery ballasts that perform periodic discharge tests automatically. (A discharge test is necessary for independent batteries because they are sealed devices and therefore cannot be tested easily by other means.)

These self-test modules display the results of the most recent test by means of a multi-color LED on the light fixture. For a typical fixture, the LED can indicate any of the following conditions:

CONDITION		STATUS INDICATION
Normal mode		Steady green
Self-testing		Flashing green
Emergency mode		Off
Insufficient charge		Flashing red / green
Battery pack failure		Single-flash red
Emergency lamp failure		Double-flash red
Self-diagnostic module failure		Triple-flash red
Under / over charge		Quadruple-flash red

The status indication remains displayed until the next scheduled periodic test or until a repair is performed. Only a momentary observation is required to see that a unit is functioning normally. Only failed components require action by maintenance staff.

Automatic testing offers the important advantage of allowing one worker to determine the condition of every emergency light fixture in the time it takes to walk the length of an entire train and requires no special preparation. In addition, it is not necessary to turn off normal lighting, so there is no interference with other inspection and maintenance activities.

All of the test modules on the market are microprocessor-based. The frequency and duration of the discharge tests are specified in software. Test modules for the commercial building market perform 5-minute discharge tests at 30-day intervals and 30-minute discharge tests at 6-month intervals.

The economics of automatic testing of independent power sources using batteries are persuasive. Battery packs have an average life of more than six years or about 500 discharge cycles, whichever comes first. However, a small percentage will fail prematurely. The current retail price of an automatic self-test module is about $80 in single units - about equal to the cost of a replaceable battery and substantially less than the cost of a battery ballast with a non-replaceable battery. Compared with replacing all batteries at two-year intervals, use of automatic testers and replacement of batteries at the time of actual failure will be substantially cheaper over the life of the car on a materials-cost basis alone. Additional savings will accrue because of the labor costs avoided from replacing all batteries three or more years before they actually fail.

Annex C (informative)

Data collection guidance

C.1 Equipment

There are at least three hand-held meters on the market with adequate accuracy and sensitivity for this application. These meters are listed below and illustrated in Figure C1:

- Minolta T-10 Illuminance meter and cable
- Gigahertz-Optik X9 1 with VL 3704 illuminance detector
- Hagner E4-X digital luxmeter

Other meters that meet the performance specifications listed in Section 6 are also acceptable.

Illuminance sensors may need recalibration if the meter is dropped. Special care is required to avoid this. Gigahertz-Optik offers an optional foam rubber shock protector for its sensor.

Railroads with fleets consisting entirely of brightly illuminated cars may forego the use of a meter with precise off-axis response, because high levels of floor illumination can be used to establish that illumination on vertical surfaces is adequate for door control signs / markings. Low-cost meters that conform to CNS 5119 [3]**,** Class II (which permits unlimited errors for angles of incidence greater than 60º) may be used for floor and arm-rest level measurements of illumination. Because field data have shown that illuminance values on vertical surfaces are at least 20% of the illuminance on adjacent floors, the floor measurements made with inexpensive meters can be used to demonstrate compliance with this standard whenever the values at the floor are five times greater than required illuminance on the surface of the exit door / control sign / marking in question. Meters for this application are widely available from vendors such as Extech, TES, Tenmars, etc.

Other considerations: The Minolta can be set to readout in foot-candles or lux; the Gigahertz-Optik meter may be ordered with either fc or lux displayed; while the Hagner meters readout in lux only. The Minota and Gigahertz-Optik meters have RS-232 data outputs and require an external USB adapter to work with most notebook computers. The Hagner meter has an analog data output and requires an external USB data-acquisition adapter. The Minolta meter has a detachable head that can be connected to the meter body with ordinary LAN cable of 6.5 ft (2 m) provided the optional A20 and A21 adapters are purchased. The other meters have 6.5 ft (2 m) cables permanently attached to the sensor.

C.2 Timing of readings

Readings should be taken at least 15 minutes after the normal illumination charging light is placed in operation to allow the lamps to reach full output and per Section 6.

[3] CNS 5119 is a standard developed in Taiwan. It is available for viewing in Mandarin at: http://www.cnsonline.com.tw/en/.

Figure C1. Typical meters for illuminance measurements

C.3 Computer data collection

The measurements required by Section 6 must be performed by manually placing the light sensor at the designated locations. However, the numerous aisle measurement readings to determine the minimum average illumination levels required in Table 1 can be taken much faster and more accurately using a computer. The computer data collection technique is based on moving/dragging a sensor down the aisle at a slow, steady pace while readings are captured to a notebook computer or data logger at the rate of at least one reading per second.

To collect data representative of illumination levels at armrest height, an apparatus must be constructed to support the sensor at a height of 25 inches (64 cm) above the floor and to carry the meter electronics and computer/data logger. Figure C2 shows such an apparatus, built from an ordinary luggage cart, with a bracket to support the sensor. The bracket, meter, and computer are held in place with hook-and-loop self-adhesive tape. A six-foot (2 m) towline is used to pull the cart to keep the observer's shadow from affecting readings.

The average is calculated with spreadsheet software based on 60 or more samples, i.e., the data collector should walk at the rate of about one foot per second. The software will also find the minimum value in each set of readings and may be used to generate a graphic profile of illuminance levels along the length of the car.

The minimum test period duration is either 1.5 hours or 1 hour, per Section 6. All illuminance light levels are measured and recorded immediately at start of test, at the halfway time point, and again at the end of the final time duration.

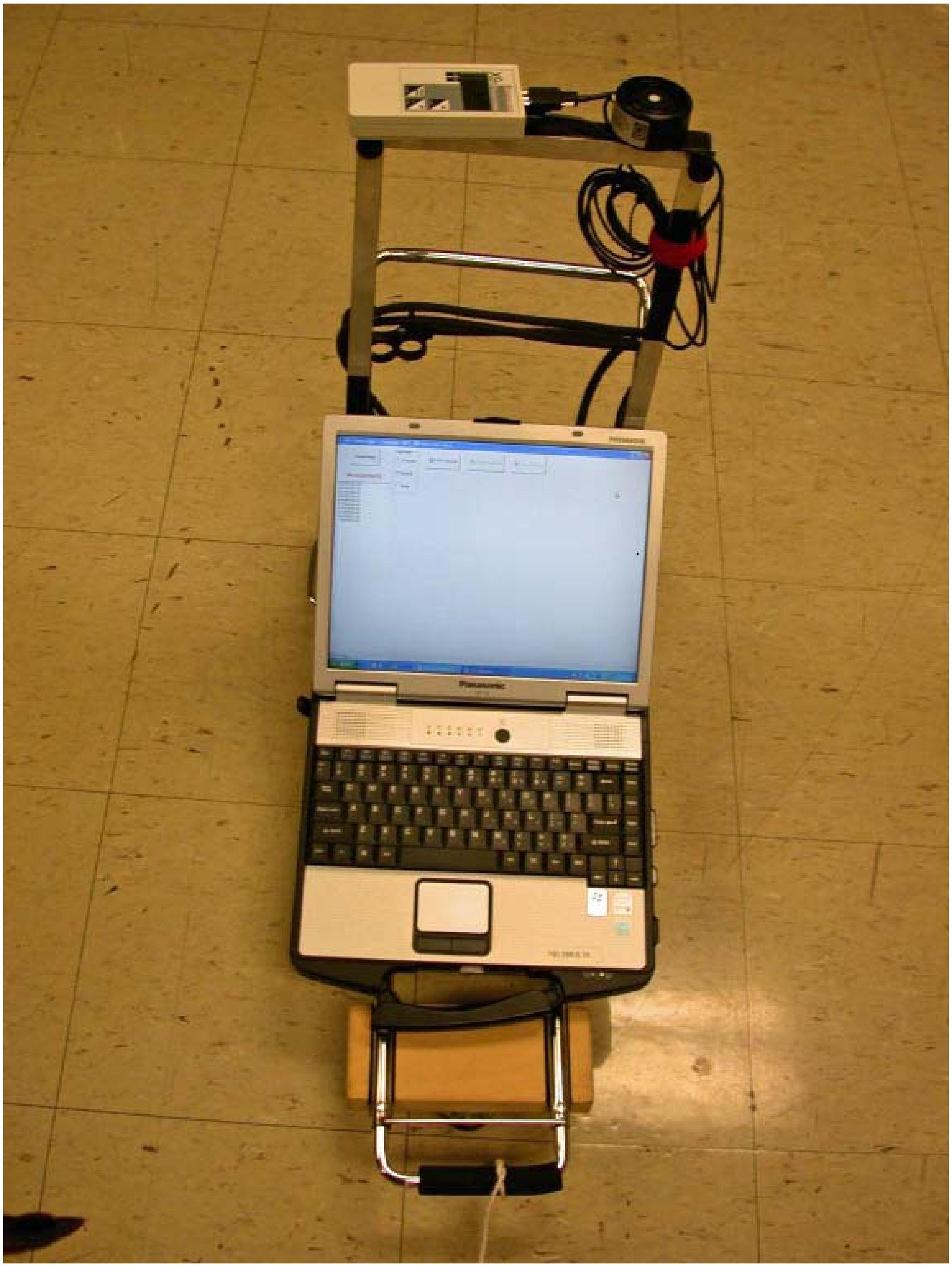

Figure C2. Apparatus for measuring average illuminance levels: Consists of a hand-held illuminance meter with sensor, an analog-to-digital converter (if not built into the meter), a notebook computer, a luggage cart with an added bracket to hold the sensor, an extra caster, and a towline.

C.4 Sample illuminance charging light survey form

See next page

Emergency lighting illuminance survey form

RAILROAD PROPERTY/LOCATION	
CAR BUILDER	
CAR TYPE/ SERIES / CONFIGURATION / YEAR	
BATTERY CAPACITY (A-HR)	
DATA COLLECTOR'S NAME	
LIGHT METER USED	
METHOD OF DARKENING	
CAR PLATE #	
DATE	

Except where noted, all measurements are in foot-candles. They are taken initially after normal power is disconnected, 30 minutes and 1 hour thereafter for existing equipment, and 45 minutes and 1.5 hours thereafter for new equipment.

A END	INITIAL READING	HALFWAY POINT Existing car: 30 minutes New car: 45 minutes	FINAL READING Existing car: 1 hour New car: 1.5 hours
STARTING TIME FOR SERIES OF MEASUREMENTS (HH:MM)			
A END			
Door Sign / control / instructions			
Vestibule/entrance 1			
Vestibule/entrance 2			
Vestibule/entrance avg.			
Diaphragm area			
Passageway			
Interior stair (if any)			
Top landing			
Middle step			
Bottom Landing			
Toilet 1 (if any)			
Toilet 2 (if any)			
Crew area			
Other special area			

ALONG AISLE & PASSAGEWAYS (EQUIDISTANT, A TO B)	INITIAL	HALFWAY POINT Existing car: 30 minutes New car: 45 minutes	FINAL READING Existing car: 1 hour New car: 1.5 hours
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
Aisle and Passageway Average			
B END			
Door Sign / control / instructions			
Vestibule/entrance 1			
Vestibule/entrance 2			
Vestibule/entrance avg.			
Diaphragm area this is now optional			
Passageway			
Interior stair (if any)			
Top Landing			
Middle step			
Bottom Landing			
Toilet 1 (if any)			
Toilet 2 (if any)			
Crew area			
Other special area			

Annex D (informative)

Alternatives to increase illumination levels

If, during the interior verification tests or periodic inspections, the level of the illuminance of normal or emergency light fixtures fails to meet the minimum illuminance criteria, as measured directly on the floor or other action point surface, there are several actions that can be taken to increase the illumination levels:

- Check the battery voltage
- Check the light fixtures near the test areas to ensure proper working order.
- Clean light fixtures and check to ensure that the diffusers not yellowed with age. Old, dirty fixtures have been measured with less than half the light output of clean ones with new diffusers.
- Check fluorescent lamps to ensure they are not near the ends of their service lives, where light output drops significantly.
- Replace warm –white fluorescent lamps with cool-white fluorescent lamps.
- Replace incandescent luminaires with fluorescent lamps or LED luminaires.
- Replace existing fluorescent lamps with those of recent design that provide 10-15% more light for the same wattage rating and double the service life.

Annex E (informative)

Representative sample sizes – Periodic maintenance

E.1 ANSI and ASQ

The American National Standards Institute (ANSI) and the American Society for Quality (ASQ) have developed detailed procedures for calculating the size of a representative sample depending on population size, variance, and required levels of statistical confidence. These may be found in Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming *(ANSI/ASQC Z1.9-1993).* The ANSI / ASQC minimum sample size for a population of up to 8 units is 3 units. Specification of minimum sample sizes for more than 8 cars / areas requires previous knowledge of the variance in the test parameter of interest. In the absence of such knowledge, a common rule of thumb is to plan to test 15 units and conduct a running analysis of variance as the test proceeds. If the variance among samples is small, it is usually possible to establish 95% confidence by testing 5-10 samples total.

If the total car fleet is smaller than the number of samples required by ANSI/ASQC Z1.9-1993, then the sample size is equal to the car fleet size.

E.2 Simplified sampling method

A simplified method of conducting the tests consists of the following:

1) Select five (5) cars / areas at random from each car/area:
   - Inspect cars / areas to ensure that there are no defects, such as burned out lamps, weak batteries, etc., and
   - Follow the test preparation procedures described in Section 6.
2) Take all of the measurements described in Section 6 and Annex C.
3) If all of the measurements in all of the cars / areas comply with all minimum criteria required by Table 1 and Sections 6 and 9, no further action is required.
4) If one or more cars / areas fail to meet minimum criteria:
   - Determine and document the extent and cause of the failure and perform repairs to car(s) / area(s).
   - Continue take measurements on cars / areas randomly selected without replacement (not previously tested) until at least ten (10) successive cars / areas or all cars / areas comply with all minimum criteria in Table 1 and Sections 6 and 9.
   - If a pattern of failures becomes apparent, (i.e., occurs repeatedly), determine the cause, document, and implement a fleet-wide redesign / repair to correct the defect.
     - Inspection and testing may be interrupted until this repair has been completed.
     - Confirm correction of failure / defect by inspecting / testing a sample of ten (10) repaired cars / areas (or all cars / areas) to verify compliance with all minimum criteria in Table 1 and Sections 6 and 9.
5) Retain records for possible FRA inspection.