APTA STANDARDS PROGRAM
RECOMMENDED PRACTICE

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PRESS Electrical Working Group

Normal Lighting System Design for Passenger Cars

Abstract: This recommended practice provides both qualitative and quantitative factors for normal lighting design for passenger cars. It encompasses general performance parameters and the means for measurement and verification of performance.

Keywords: emergency lighting, normal lighting, rail passenger equipment lighting, standby lighting

Summary: This document provides guidance regarding the performance requirements for normal lighting systems. It addresses issues affecting the design of new-vehicle installations, as well as considerations for retrofitting existing passenger equipment.

Foreword

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

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

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

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

This document supersedes APTA PR-E-RP-012-99, Rev. 1, which has been revised. Below is a summary of changes from the previous document version:

- Reformatted to latest template which caused numbering changes to sections.
- Added keywords: emergency lighting, normal lighting, standby lighting.
- Added summary.
- Added Foreword.
- Updated Participants.
- Added PRESS applicability language to Introduction.
- Combined former Section 1.1, Scope, and Section 1.2, Purpose, into new section Scope and purpose. Deleted former Section 1, Overview.
- Renumbered former Section 4 to Section 1.
- Section 1.1.1, Normal lighting: Added requirement for conformance with flame and smoke requirements of 49 CFR §238.103, Fire Safety. Added requirement for conformance with APTA PR-E-S-010-98, "Development of an Electromagnetic Compatibility Plan."
- Added new Section 1.1.2, Lighting technology for new vehicles and retrofits.
- Section 1.1.3, Standby lighting: added more explanation regarding purpose and prevalence of standby lighting.
- Section 1.1.4, Emergency Lighting: Added brief explanation of emergency lighting with standby lighting caveat as described within APTA PR-E-S-013-99, "Emergency Lighting System Design for Equipment."
- Added new sections 1.1.5, Charging light for HPPL signs and markings, 1.1.6, Night lighting and quiet car, and 1.1.7, Light switches.

- Section 1.3, Reaction to loss of normal power: increased standby lighting function period from 15 minutes to up to 30 minutes. Added language for cars without standby lighting.
- Section 1.5, Amount of light: Added consideration of LED dimming due to age.
- Table 1: Added initial measurement conditions. Removed “Reference location” column. Incorporated more detail into “Where Measured” column. Added “Conditions Under Which Measured” column. Added new row “Door emergency exit controls/manual releases.” Added new row “Gangway.” Removed Phone booth measurement from Short-distance Intercity Coach. Added new rows Cab area of cab car: Console, Floor, Console where train orders read, and Windshields.
- Added new Section 1.9.1, Light color.
- Former Section 5, General Lighting, renumbered to Section 2.
- Section 2.1.2: Added car-borne lighting requirements for equipment serving unlit stations. Updated car-borne station lighting requirement distance from about 3ft to 4ft horizontally. Changed measurement location for the vestibule floor from directly beneath fixture to geometric center of vestibule; for long vestibule (gallery cars), readings along vestibule centerline.
- Section 2.2, Inter-car passageways, formerly Diaphragm area: Split requirements into conventional and gangway. Added gangway lighting measurement point and value.
- Added new Section 2.7, Reading lights.
- Added new Section 2.10, Passenger information displays.
- Added new section 2.11, Exterior Lighting.
- Former Section 5, Coach lighting renumbered to Section 3.
- Former Section 6, Dining car lighting, renumber to Section 4.
- Section 4.3.1, Dining area: Changed measurement point for tables from 45^{O} up facing plane to on the table surface.
- Renumbered former Section 7, Short distance snack car (light food service) lighting, to Section 5.
- Added new Section 5.3.4, Vending Machines.
- Renumbered former Section 8, Sleeping car lighting, to Section 6.
- Section 6.3.1, Room: Added note regarding lighting needs for the charging of HPPL material.
- Section 6.3.2, General Areas: Added night light measurement for charging of HPPL material.
- Renumbered former Section 9, Long-distance lounge and observation car lighting to Section 7.
- Renumbered/renamed former Section 10, Baggage car or bag area of combination cars to Section 8, Baggage car or bag compartment of combination cars.
- Added new Section 9, Cab area of cab car.
- Added new Section 10, Exterior lighting.
- Renamed Section 11, Fixture design to Design of interior fixtures.
- Added new Section 11.5, LED Fixtures.
- Moved former Section 11.7, Reading lights, to Section 11.9.
- Added new Section 11.11, Design of exterior fixtures.
- Added new Section 13.1.1, Qualification testing (initial verification).
- Added new Section 13.2, Preparation for tests.
- Added new Section 13.3, Data collection.
- Added new Section 13.4, Procedures for measuring illuminance of normal lighting systems.
- Moved former Section 13.1.2, Battery source tests, to Section 13.4.3.
- Moved former Section 13.2, Measurements – passenger cars, to Section 13.5: Added detail on measurements.
- Moved former Section 2, References, to References.

- Moved former Section 3.1, Definitions, to Definitions: Added definitions for color rendering index, color temperature, diaphragm, conventional, gangway, luminaire (light fixture), main level, main car battery, power, standby, representative car/area, stairway, stanchion, and threshold. Removed definitions for existing equipment and rebuilt/remanufactured vehicle.
- Moved former Section 3.2, Abbreviations and Acronyms, to Abbreviations and acronyms.
- Removed former Section 3, Definitions, abbreviations and acronyms.
- Added new Section, document history.
- Added new Appendix A (informative): Data collection guidance.
- Added new Appendix B (informative): Alternatives to increase illumination levels.
- Added new Appendix C (informative): Sample data sheet.

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Introduction

This introduction is not part of APTA PR-E-RP-012-99, "Normal Lighting System Design for Passenger Cars."

This recommended practice applies to all:

railroads that operate intercity or commuter passenger train service on the general railroad system of transportation; and

railroads that provide commuter or other short-haul rail passenger train service in a metropolitan or suburban area, including public authorities operating passenger train service.

This recommended practice does not apply to:

rapid transit operations in an urban area that are not connected to the general railroad system of transportation;

tourist, scenic, historic or excursion operations off the general railroad system of transportation;

operation of private cars, including business/office cars and circus trains unless otherwise required by other standards or regulations;

railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

Scope and purpose

This recommended practice provides both qualitative and quantitative factors for normal lighting design for passenger cars. It identifies minimum recommended performance criteria for the design of the normal lighting system for passenger rail cars that operates when normal car power is available. It includes minimum interior illumination levels at specified locations, both for new equipment as well as retrofits of existing rolling stock. It encompasses general performance parameters as well as methods for testing to validate the design. Emergency lighting requirements are covered in APTA PR-E-S-013-99.

The purpose of any illumination system is to provide sufficient amounts of light in such a manner as to make a particular seeing task or group of such tasks possible, safe and comfortable. In achieving a desirable result, many physical and psychological factors must be integrated, and it is very difficult to determine which has the greater weight in the overall evaluation of a lighting system. This recommended practice attempts to provide a minimum level for normal lighting.

Normal Lighting System Design for Passenger Cars

1. Lighting system types and operation

1.1 Lighting types

1.1.1 Normal lighting

Car lighting is powered by a combination of voltages derived from the car auxiliary or head end power (HEP) system and battery charger/low-voltage power supply. While the bulk of the lighting load is generally AC powered, trends in recent years have been to place a growing portion of the lighting load on the low-voltage DC and battery supply. This has allowed higher car interior light intensity when the auxiliary/HEP power source is not available, during momentary power losses, or even for longer intervals, such as during a locomotive change.

Typical lighting voltages are 240, 120 and 28 VAC, the latter primarily for reading lights, and 74, 37 and 28.5 VDC.

Materials used in the manufacture of interior lighting fixtures must conform to the flame and smoke requirements of 49 CFR §238.103, Fire Safety.

Electronics and associated wiring employed in the lighting system may produce radio frequency emissions. In order to not interfere with other car equipment as well as crew radios, the lighting system must conform to the requirements of APTA PR-E-S-010-98, "Development of an Electromagnetic Compatibility Plan."

1.1.2 Lighting technology for new vehicles and retrofits

Fluorescent systems remain in service across many fleets, but the main lighting technology currently selected for new car or refurbishment projects is LED-based. The types of LED lighting used in the rail industry are discussed in this section.

1.1.2.1 New vehicles

LED technology is now widely used in most new car applications, largely replacing fluorescents and almost completely replacing incandescent lamps.

The development of LED technology in the early 21st century has brought about major changes in passenger car lighting. This technology offers a much longer life expectancy and low heat output, and uses much less power to produce the same light generated by traditional fluorescent and incandescent lamps. The small size of the LED chips allows fixtures to have a very low profile. With LEDs, it is easy to provide variable light intensity and even variable color.

Unlike the older omnidirectional lamps, LEDs are very directional; the way they are used to provide suitable lighting is quite different and needs to be considered in the system design. LEDs slowly degrade and produce lower light levels as they age. Typically they should be replaced when they reach about 70% of the original value. End-of-life for LEDs is thus harder to identify, since they "fail" by dimming and generally not by simply failing to light. Since LED applications do not employ traditional industry-standard envelopes, they typically are not multisource components but are available only from the fixture manufacturer. It must be recognized that maintenance practices as well as spare part sourcing for LED lighting are quite different from those of more traditional lighting.

1.1.2.2 Retrofitting existing vehicles

A considerable amount of rolling stock was built before the widespread development of LED lighting, employing largely fluorescent with some incandescent lighting. There are many opportunities to upgrade older applications with new technology in these vehicles. The approach taken to retrofit these cars may well differ from that for brand-new fleets. The intent of the potential retrofit, as well as life cycle costs, should be considered in the evaluation. Replacement of incandescent is very appealing; fluorescent needs more consideration.

Retrofits generally fall into four categories, as follows:

General lighting, such as cove lights

Fluorescent systems remain in service across many fleets, but it may well be possible to retain the existing fixtures and merely replace the fluorescent tubes with LED technology. Several approaches are possible:

- **LED Type A:** This type of LED system directly replaces only the traditional fluorescent lamp with no electrical modification required to the existing light fixtures. It is sometimes referred to as "plug and play." The LED lamp is driven by the existing fluorescent ballast. Not all ballasts are compatible with Type A LED lamps. Type A LED lamps are typically employed on retrofit applications and are associated with a shorter service life compared with type B and C systems. A label inside the light fixture (not visible to passengers) should be applied to alert maintenance personnel that LED Type A lamps are in use. The label should also identify which transit authority–approved lamp is in use. The lens material shall be either glass or transit grade polycarbonate. Care needs to be taken regarding the orientation of the lamps with regard to the lamp holders so that the light is emitted in the desired direction. This has the potential of requiring different lamps in various locations, even though they are the same length. Special labeling or lamps with rotatable end caps may be necessary.
- **LED Type B:** This type of LED system directly replaces the traditional fluorescent lamp and eliminates the ballast. It is sometimes referred to as "direct wire." Electrical modification to the light fixture is required. The light fixture is rewired to drive the LED lamp directly by the mains. The lamp holders may be required to be replaced in accordance with the lamp manufacturer specifications. Type B LED lamps are typically employed on retrofit or overhaul applications and are associated with medium service life compared with type A or C systems. A label inside the light fixture (not visible to passengers) should be applied to alert maintenance personnel that LED Type B lamps are in use. The label should also specify which transit authority–approved lamp is in use. The lens material shall be either glass or transit grade polycarbonate.
- **LED Type C:** This type of LED system is printed circuit board based. The PCBs can be supplied either integrated into complete fixtures or separately without enclosures for both new car equipment or refurbishment applications. This type is typically supplied on most new car projects and is associated with the longest service life currently available. Since it is more labor and material intensive, this approach is likely most appropriate for midlife overhaul type applications.

Local fixtures, such as vestibule lights

Often incandescent, these fixtures can often be easily replaced in kind with LED equivalent.

Marker lights

LED form–fit–function replacements are available for the traditional 60 W PAR-type marker lights. They offer very long life and greatly reduced electrical load. Since incandescent lamps generally employ a dropping resistor, this may need to be bypassed if an LED lamp is used. Suitable labeling should be used and care must be exercised to ensure that maintenance personnel are aware of which type lamp is to be used. One caution: In climates where there is snow, LEDs may not be suitable, as they do not generate enough heat to melt the snow that might accumulate on the lens.

Exterior indicator lights (door open, brake status, etc.)

Usually incandescent, these small fixtures are often easily replaced in kind with an LED equivalent. This works very well since LEDs are very directional. Use care that the light is not so bright that it is "blinding" at night.

1.1.3 Standby lighting

Standby lighting (if provided) is powered from the main car battery and is activated in response to loss of main power, or is already on as part of the low voltage power supply load. A load shed relay, sensing battery voltage and/or time, is often used to deactivate the standby load after approximately 30 minutes (or other period, as desired). The emergency lighting load should remain powered after standby lighting has gone off.

This mode is intended to keep a substantial number of the normal lighting fixtures, including those normal lighting fixtures also used as emergency lighting fixtures, operating for a period (90 seconds to 30 minutes or more) so that short-term power outages, such as those encountered from phase gaps in catenary or third rail supply or 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. The customer should include performance requirements in the purchase specification for cars it may wish to have incorporating standby lighting.

1.1.4 Emergency lighting

Emergency lighting is that which is activated or remains illuminated upon loss of normal power, and standby power (as applicable). Emergency lighting is listed herein for completeness of types; however, requirements are given in APTA PR-E-S-013-99, "Emergency Lighting System Design for Equipment."

1.1.5 Charging light for HPPL signs and markings

The normal lighting system is generally used to charge HPPL signs and markings, as an auxiliary function. This function and the performance requirements are defined in APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment."

1.1.6 Night lighting and quiet car

Some intercity equipment may be used in overnight operations in which the lighting on cars is dimmed and/or portions of it are extinguished to create a restful environment for passengers to doze or sleep. Likewise, one method to designate a quiet car is to dim car lighting. Path lighting, such as along aisles and similar areas, needs to remain illuminated to provide safe passage, yet must also be designed to avoid shining into the eyes of passengers who wish to rest. Sleeping car rooms are equipped with a small passenger-activated night light.

1.1.7 Light switches

Sleeper rooms need a method by which the occupant can locate the switch in the dark, such as back-illuminated or glow-in-the-dark toggles. Care is required in developing this function so as to not interfere with HPPL charging requirements during night lighting mode.

1.2 Combination of normal and emergency light functions

The overall car lighting system combines the functions of main and battery-powered lighting. A variety of approaches are available, but they normally include some combination of the following:

- separate fixtures for emergency light function only
- fixtures powered from the low-voltage power supply, which are illuminated for normal and emergency functions

Standby lighting (when available) normally continues the operation of much of the normal lighting system. Since the power demand is fairly high, the length of time the battery system supports the load is limited. The load is significantly reduced when standby mode changes over to emergency mode, which allows the remaining load to be supported for a longer time.

1.3 Reaction to loss of normal power

With the initial condition of normal power available, all normal lighting is available.

Upon loss of normal power:

- **If equipped with standby lighting,** this function remains on approximately up to 30 minutes. At the end of standby lighting mode, emergency lighting is immediately illuminated. If the main battery fails, emergency lighting is activated immediately.
- **If not equipped with standby lighting,** emergency lighting is illuminated immediately for the time duration defined in APTA PR-E-S-013-99.

1.4 Lighting theory

All the general requirements of good lighting, such as reduced direct and reflected glare and elimination of deep shadows and excessive brightness ratios that will interfere with good vision, apply to railroad cars. Lighting engineers, designers and carbuilders should work together to create an attractive, comfortable and efficient lighting system with due regard to the economic factors involved. A railroad passenger car has certain fundamental limitations that affect the proper design of an illumination method. The length, height and width of the car are fixed by operational envelope. The inherent physical characteristics of the car with its maximum utilization of space, air ducts, conduit, structural members and limitations of power supply pose challenges for the lighting design.

Lighting is important for the passengers from the time they board the train, beginning with the vestibule and platform, which must be designed so passengers can board and detrain safely. While on the train, the visual activity of the passengers ranges from casual reading, glancing around the car and looking out the windows, to eating, concentrated reading or working on a laptop computer. In some cases, particularly in bedroom or roomette accommodations, paperwork and writing are done for extended periods of time.

For additional lighting information, refer to *The Lighting Handbook: Reference and Application*.

The goal is to provide lighting (from one or more systems) that is satisfactory for the varied activities of the passengers. In designing this lighting, consideration should be given to the following:

- amount of light
- direct and reflected glare
- brightness patterns in the field of view
- brightness ratios
- color

1.5 Amount of light

To ensure an adequate amount of light, the lighting design should make allowance for the decrease in light output caused by dirt accumulation in the light fixtures. Also, degradation of other interior surfaces, such as walls, ceilings, floors and upholstery, and the degradation in light source output will affect the amount of light output. In the case of LED lighting, this technology dims slowly with age, a factor that needs to be taken into account.

Older cars were generally built equipped with fluorescent lighting for most situations, with incandescent lighting in specialized or local applications, such as vestibules. Retrofits to LED lighting may be appropriate in some situations. Reading lights are another place where retrofits may prove attractive.

The minimum amount of light for the various areas is covered in **Table 1**. Measurements are to be spatial averages, but in some cases a point reading may be appropriate. The action point is to be considered the position where the light level is needed. Examples are an aisle, door release location or work surface. For further explanation, see References and Section 13.5.

> **NOTE:** General lighting readings are taken with any reading lights off. Reading light readings are taken with the car darkened in either nighttime or quiet car mode, as specified by the customer.

TABLE 1
Normal Lighting Minimum Performance Criteria

Foot-Candles, All Equipment	Where Measured (Action Point)[1]	Conditions Under Which Measured
Initial measurement conditions		
n/a		• The car is to be darkened, either by placing in a dark room without lighting or by covering the car with opaque materials. • All exterior doors (exterior side, end frame, etc.) should be closed. • All interior doors (vestibule, passageway, restroom, crew office, cab, passenger accommodation, etc.) should be closed. • All curtains/drapes to be closed over all exterior and interior windows and doorways where so equipped. • Upper and lower berths deployed in sleeper accommodations.
Door emergency exit controls/manual releases		
n/a	• At location of emergency/manual door control release and associated instructions. • Refer to APTA PR-PS-S-006-23.	• Door closed. • Refer to APTA PR-PS-S-006-23.

TABLE 1

Normal Lighting Minimum Performance Criteria

Foot-Candles, All Equipment	Where Measured (Action Point)[1]	Conditions Under Which Measured
Vestibule floor (Section 2.1)		
5	• Geometric center of vestibule. • Geometric center of each trap door, (if equipped). If not equipped, halfway between center of car and exterior door interior threshold. or • For cars with long longitudinal vestibule (gallery cars), three readings spaced equally along car centerline between vestibule bulkheads.	• Exterior side doors closed, vestibule door(s) closed, end frame door closed, if equipped
5	**Exterior side door threshold** • At floor, at center of threshold	• Exterior side door open only at that site • For cars equipped with traps, both with trap open and closed
5	**Vestibule steps** • At geometric center of each tread • If stairway is divided by stanchions, each section is a separate vestibule stairway • For cars with steps external to the carbody, these steps are included	• Exterior side door open only at that site
2	**Outside platform (required on intercity cars)** • Area same width as door threshold extending perpendicularly 3 ft outward	• Exterior side door open only at that site • High platform level, low platform level or both if car has traps
Inter-car passageways (Section 2.2)		
5	**Conventional diaphragm area** • At floor, center of path side-to-side, in plane even with collision posts	• End-frame/collision post door open, if there is a door • Light from adjacent car area is allowed to contribute • Open face of diaphragm is covered, or open to dark outside
5	**Gangway** • 25 in. above floor at centerline, midway through gangway	• End-frame/collision post door open, if there is a door • Light from adjacent car areas is allowed to contribute
Stairway (interior) (Section 2.3)		
5	• At geometric center of each stair tread, landing and adjacent floor • If there are landings or corner steps where direction of travel changes, center of that step/landing also	• Any adjacent door closed
Passageway (Section 2.4)		
5	• At floor	• End-frame, vestibule doors closed • Any doors opening onto passageway closed

TABLE 1

Normal Lighting Minimum Performance Criteria

Foot-Candles, All Equipment	Where Measured (Action Point)[1]	Conditions Under Which Measured
Aisle (Section 2.5)		
5	• At floor on centerline • This includes any steps and/or ramps included along aisle path	• End-frame, vestibule doors closed • For galley cars, the aisle of the galley level is considered an aisle
5	• 33 in. above floor for seat selection	
Restroom (Section 2.6)		
30	**Mirror** • 16 in. from mirror, 62 in. above floor	• Door closed
15	**Area** • 33 in. above floor • For non-ADA restrooms, approximate center of room • For ADA restrooms, three readings approximately evenly spaced	
Electric/switch locker (Section 2.8)		
No value specified; see text		• Door to locker or service area open
Service lighting and equipment room (Section 2.9)		
No value specified, see text		
Commuter coach (Section 3.1)		
20	• 33 in. above floor, at center front edge of seats	
Short-distance intercity coach (Section 3.2)		
20	**Seating area, general** • 33 in. above floor, at center front edge of seats	
20	**Seating, reading lights only** • 45 deg. reading plane, 33 in. above floor	• With only reading lights on
Long-distance intercity coach (Section 3.3)		
20	**Seating area, general** • 33 in. above floor, at center front edge of seats	
20	**Seating, reading lights only** • 45 deg. reading plane, 33 in. above floor	• With only reading lights on
Dining car (Section 4.3)		
10	**Diner, general dining area** • 33 in. above floor, at center front edge of seats	
15	**Table** • On table, 8 in. from front edge of table for each seat	
10	**Diner/galley food storage area** • Vertical plane, on cabinet doors	• With car configured to serve passengers, crew doors and any movable panels, screens, etc. so positioned

TABLE 1

Normal Lighting Minimum Performance Criteria

Foot-Candles, All Equipment	Where Measured (Action Point)[1]	Conditions Under Which Measured
20	**Food preparation area** • On work counter	
50	**Food preparation area (cutting, handling food directly)** • On work counter	
20	**Food serving and maître d' area** • On work counter	
20	**Hand sink, dish washing area** • 30 inches above the floor	
Short-distance snack car (Section 5.3)		
20	**Seating area, general** • 33 in. above floor, at center front edge of seats	
20	**Seating area, reading lights only** • 45 deg. reading plane, 33 in. above floor	• With only reading lights on
15	**Tables** • On table at each seat location	
10 20 20	**Food storage area** • Vertical plane, on cabinet doors **Food preparation area** • On work counter **Food serving area, hand sink** • On work counter	• With car configured to serve passengers, crew doors and any movable panels, screens, etc. so positioned.
Sleeping Car (Section 6.3)		
20	**Reading** • 45 deg. reading plane, 33 in. above floor	• Room doors closed • With only reading lights on
20	**Berth** • 45 deg. reading plane	• Room doors closed • With only reading lights on
20	**Table** • On center of table	• Room doors closed • With only reading lights on
20	**General room** • Horizontal plane, 33 in. above floor; approximate center of room	• Room doors closed • Berth(s) retracted
30	**Mirror** • 16 in. from mirror, 62 in. above floor	• Room doors closed
15	**Private toilet** • 33 in. above floor	• Room doors closed • Door closed
20	**Coffee station (in hallway)** • On counter	• Room doors closed

TABLE 1

Normal Lighting Minimum Performance Criteria

Foot-Candles, All Equipment	Where Measured (Action Point)[1]	Conditions Under Which Measured
Long-distance lounge (Section 7.3)		
20	**Lounge area seats general** • 33 in. above floor, at center front edge of seats	
20	**Lounge area seats, reading lights only** • 45 deg. reading plane, 33 in. above floor	• With only reading lights on
15	**Table area** • On table at each seat location	
10	**Food storage area** • Vertical plane, on cabinet doors	• With car configured to serve passengers, crew doors and any movable panels, screens, etc. so positioned.
20	**Food service preparation area** • On work counter	
20	**Food serving area, hand sink** • On work counter	
Baggage car/baggage compartment (Section 8.3)		
5	**Floor** • At floor, center of aisle	• All car doors closed
5	**Open area for luggage, etc.** • Approximate geometric center of each area on floor • If longer areas, at least every 6 ft	
5	**Baggage shelves/towers** • Approximate geometric center of lowest shelf	
5	**Loading door threshold** • Center of threshold	
2	**Outside platform** • Area same width as door threshold extending perpendicularly 3 ft outward	• Associated loading door open • Exterior side door open only at that site • High platform level, low platform level or both if car will be used outside high platform territory
Cab area of cab car (Section 9.3)		
15	**Console** • 33 in. above floor	• Active cab configuration; if convertible cab, that mode only. Cab door closed • Except reading light, lights off in cab as they would be during nighttime operation
15	**Floor** • Floor representative areas	
25	**Console where train orders read** • On surface where train orders read, perpendicular to that surface • Both locations if two-person cab	
No glare	**Windshield(s)**	• With cab activated (screens, gage lights, instruments etc. on for normal operation)

1. LEDs slowly decline in light output over time; the light level requirements for new installations should take this into account.

1.6 Glare

To avoid discomfort from high light levels that reach the eyes directly or indirectly through reflections from shiny surfaces or from improperly shielded light sources, lighting equipment should be located as far from line of sight as possible.

1.6.1 Direct

Direct glare is caused by light source brightness directly shining into the passengers' eyes. All sources should be shielded to eliminate direct glare.

1.6.2 Reflected

Reflected glare is caused by light source brightness reflected from shiny material, such as magazines or book pages, mirrors, or other reflective surfaces. The location of lighting apparatus, particularly with high-brightness sources, should be such that reflected glare does not occur from the work (books, etc.) or mirrors placed at usual locations with respect to the passengers' eyes. Glossy reflecting surfaces should be covered or modified to reduce glare.

1.7 Brightness patterns

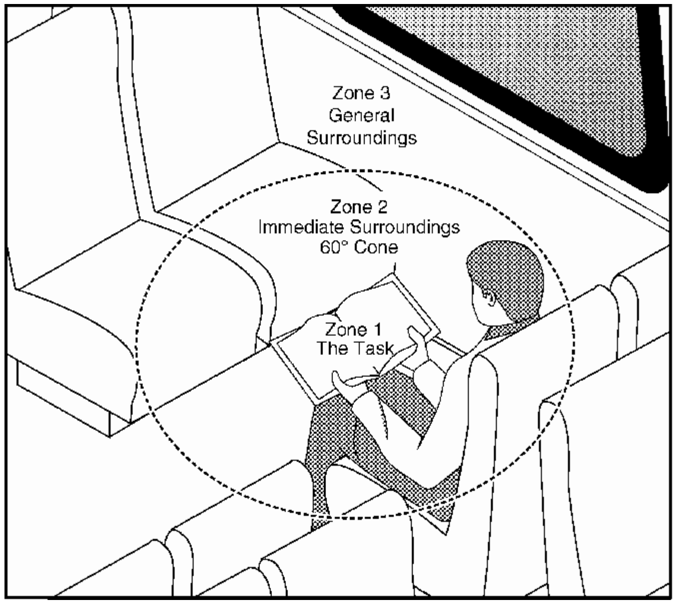
High brightness of lamps and windows and high brightness ratios will produce uncomfortable seeing conditions, and prolonged exposure will generally result in eye fatigue. The subject of brightness patterns and how they provide visual comfort and visual effectiveness is of primary importance to lighting designers in all fields of application. At present, it is considered that the most satisfactory and comfortable lighting results are attained for periods of close visual activity when the following brightness relationships within the field of view guide the lighting plan.

The task brightness is considered the basis for recommended brightness within the surroundings. In car lighting, brightness in the area immediately surrounding the task (a 60 deg. cone whose axis coincides with the line of sight; see **Figure 1** and **Figure 2**), which are two times greater than task brightness, or less than one-fifth the task brightness, contribute to discomfort, and are, in general, distracting. As the task brightness increases or as the duration of the task lengthens, a lower ratio becomes desirable. Refer to Section 1.8 for the recommended brightness ratios.

> **NOTE:** These brightness ratios can best be obtained by proper shielding of the light sources, as well as the use of light ceilings, side walls, window frames and upholstery.

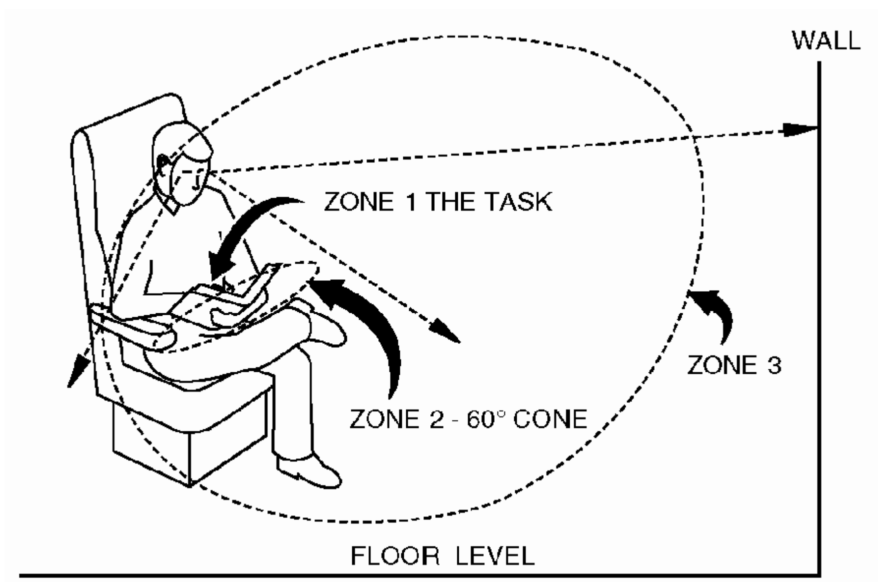
Figure 1 shows the general magnitude of the visual zones for reading a book. The reflectance of major interior surfaces, as well as lighting design, determine the brightness ratios between zones. **Figure 2** shows the approximate limits of the visual field and the relative size of the three zones when the head is bent forward and the eyes are fixed on a small task. As the eyes or head move, the gaze shifts from zone to zone.

FIGURE 1
Brightness Visual Zones (Over-the-Shoulder Perspective)



General magnitude of the visual zones for reading a book

FIGURE 2
Brightness Visual Zones (Facing Perspective)



Approximate limits of the visual field and the relative size of the three zones when the head is bent forward and the eyes are fixed on a small task

1.8 Brightness ratios

To achieve a comfortable balance of brightness, it is recommended to limit brightness ratios between areas of appreciable size from normal viewing points, as described in **Table 2**.

TABLE 2
Recommended Brightness Ratio Limits by Area

Areas Involved	Acceptable Limit
Between task and adjacent surroundings	1 to ⅕
Between task and more remote darker surfaces	1 to 1⁄10
Between task and more remote lighter surfaces	1 to 10
Between lamp or windows and surfaces adjacent to them	20 to 1
Anywhere within the normal visual field	40 to 1

1.9 Color/reflectance

1.9.1 Light color

Light color has an important impact on passengers and crew. This is more of an issue with LED lamps, as they are available in a wider range of colors than the older traditional lamps, such as incandescent and fluorescent.

Warm colors are more soothing and relaxing, whereas cold colors can be harsh. The lamp color also impacts appearance, which is important for locations such as mirror lighting and the lighting in around food service and eating areas.

Light color is generally considered as follows:

- **Warm white:** 2700–3000 °K
- **Cool white:** 3500–4100 °K
- **Daylight:** 5000–6500 °K

Lighting color has a surprisingly strong impact on passenger mood. Warm colors are soothing, while cool colors are harsher. For example, cool white may be appropriate for brightly lighted commuter car applications, while warmer colors would be more appropriate for longer-distance equipment, especially long-distance rolling stock. Colors with a high Color Rendering Index value (specifically greater than 80) and a high R9 value (60+) are particularly critical for food service applications (especially dining cars), as they enhance the appeal of food. Having a greater abundance of red wavelength light can be beneficial to encourage sleep.

Different colors will also affect the intensity needed to charge HPPL material present in emergency signs and markings.

1.9.2 Interaction with car interior surfaces

Proper color of upholstery, walls and ceiling is necessary to utilize any lighting system to its greatest advantage. Colors of objects appear to change with the surface finish of the object. It should be noted that matte finishes will reflect diffused light and give an object a more consistent color appearance, while glossy surfaces may lose their color when viewed in a direction near the specular angle. Finishes such as velvet and deep-pile carpeting appear darker than smooth-surface materials such as vinyl or plastic laminate of the same color.

Relatively light colors with a high reflection factor should be used. The wall colors or finishes should have a reflection factor of 35% to 60% at the bottom and a reflection factor of 35% to 90% at the top. Glossy finishes are to be avoided. Ceilings should have a reflection factor of 60% to 90%. Matte finishes are recommended to avoid so-called "hot spots" and reflection of light sources. Upholstery should have a reflective factor of 15% to 35%.

2. General lighting

This and the following sections describe typical lighting features on a wide variety of car configurations. Since there are so many situations, it is difficult to discuss them all adequately. Accordingly, typical activities and lighting methods are provided for each general situation, followed by a discussion.

This section describes lighting applications that apply to most car types. Throughout this section, the basic lighting task for most areas is to provide adequate general illumination for orientation and safe passage by passengers and crew during the day and night.

> **NOTE:** All applications must incorporate emergency lighting per APTA PR-E-S-013-99.

2.1 Vestibule

2.1.1 Activities

- Safe boarding and detraining
- Safe passage
- Reading tickets to determine assigned seats or accommodations (except on commuter equipment)
- Reading signage

2.1.2 Typical lighting methods

- Ceiling lighting
- Boarding light to illuminate the platform outside

The areas of interest are on the platform, steps (if any) and vestibule floor near the entrance/exit. The lighting for these areas is all horizontal at floor level. The viewing angle is practically vertical for the person to observe the condition of the tread surface and platform alignment with the car floor. The area of special concern is that the edge of the car, whether high or low platform, be well-illuminated to help passengers avoid tripping at these transition points.

The entrance/exit and vestibule areas should be lighted to allow safe and rapid boarding and detraining of passengers and luggage.

Ceiling mounted LED or fluorescent lighting should be arranged to provide good general lighting levels within the entrance/vestibule area, as well as the step area (if equipped). For cars that have steps extending outside the carbody envelope, these should also be well-lighted. ADA requirements for threshold, whether high or low platform, and exterior platform light levels are identified in 49 CFR §38.101 and §38.119.

Per these same regulations, car-borne platform lighting is required for equipment operating at non-lighted station platforms. Car lighting is required to provide light out onto the station platform for 3 ft horizontally: on high platforms to identify the gap between the platform and vehicle, and on low platforms, the area in front of the step(s). This can be accomplished with ceiling fixture location or by providing one or more separate spotlight fixtures. An alternative for low-level applications is to provide separate light fixtures low on the outside of the car that shine downward onto the station platform.

The minimum illumination should be as follows:

- 5 fc (54 lx) on the platform of the car, geometric center of vestibule; for long vestibule (gallery cars), readings along vestibule centerline
- 5 fc (54 lx) at center of the threshold with the door open
- 5 fc (54 lx) on the geometric center of each step (if equipped)
- 2 fc (22 lx) on the exterior platform at all points perpendicular to the door threshold for a distance of 3 ft (91 cm), high and/or low platform, consistent with territory where car will operate

2.2 Inter-car passageways

There are two basic types of inter-car passage that require lighting:

- **Conventional:** Walkway enclosed by two diaphragms, one on the end of each car. These accommodate relative angular, lateral and vertical displacement between the ends of cars by means of sliding buffers at the floor level and by sliding diaphragm faceplates or tubular sliding diaphragms at the sides and top.
- **"Gangway":** Walkway enclosed by a continuous bellows/diaphragm that is sufficiently flexible to accommodate relative angular, lateral and vertical displacement between carbodies. This is typically employed on semipermanently coupled or articulated (angular motion only) cars.

Gangways generally are sealed from weather and have a wide path, while conventional diaphragms are narrower and less fully enclosed. These paths allow passenger/crew to safely move between coupled cars.

On car ends without vestibules with conventional diaphragms, one or more small light fixtures mounted overhead or on the sides, can be used to provide illumination within the diaphragm and adjacent area to allow safe passage.

The light level on the conventional type is measured at floor level, as there is a potential trip hazard. The minimum illumination is a spatial average of 5 fc (54 lx). Cars employing a gangway can be lighted in a similar way. The minimum illumination is a spatial average of 5 fc (54 lx) at 25 in. above the floor, as the area functions more as a passageway.

2.3 Stairway (interior)

2.3.1 Activities

- Safe passage

2.3.2 Typical lighting methods

- Small light on each step and landing
- Overhead and/or side wall supplement

Interior stairways require illumination for safe passage. These are areas where many injuries occur. Lighting should include a small fixture in the side wall for each step and landing or equivalent. This lighting is often supplemented by ceiling- or wall-mounted fixtures. It is desirable to optically highlight the edge wrap of the top and bottom steps so they are easily identified by passengers with visual impairments.

The minimum spatial average illumination is 5 fc (54 lx), measured along the center of each tread and each landing, as well as the floor level immediately adjacent to the top and bottom step.

2.4 Passageway

2.4.1 Activities

- Safe passage

2.4.2 Typical lighting method

- Ceiling lights
- Recessed lighting in side wall near floor (optional)

Passageway lighting requires considerable care in day/night operation to balance the need for passenger movement with the need for subdued light levels that don't interfere with sleep. Care should be taken in fixture placement so light does not shine into the eyes of seated passengers at night. Highly directional lighting is often required, with particular care taken to avoid bright edges on the lens. The side wall surface material and flooring reflectivity are important considerations. Uniformity of lighting throughout the length of the passageway is desired.

The minimum spatial average illumination is 5 fc (54 lx) measured along the centerline of the passageway at the floor.

2.5 Aisle

2.5.1 Activities

- Safe passage
- Seat selection

2.5.2 Typical lighting method

- One or more rows of lights along the center or side of ceiling

The areas of interest are the ability to observe the floor area for obstacles and the seat area for accommodations. The plane of the area for walking is at floor level and at 33 in. (84 cm) above the floor for seat selection. When seat numbers are provided, such as along the edge of the luggage rack, this should be coordinated with the lighting to make the seat numbers easy to read.

In day/night operation, aisle lighting requires considerable care to balance the need for passenger orientation with the need for subdued light levels. One method to achieve this is to employ the high directionality of LEDs to illuminate only the aisle, with essentially no spillover to passenger seating. Another approach is a dual lamp fixture, which employs colored lamps (or lenses) for night and clear lamps for the normal (and emergency) function. Other alternatives include staged light circuits or dimming selected circuits.

The minimum spatial average illumination is 5 fc (54 lx), measured along the centerline of the aisle at the floor.

For seat selection, the minimum spatial average illumination is 5 fc (54 lx) measured on a horizontal plane at 33 in. (84 cm) above the floor along the centerline of the aisle.

2.6 Restroom area

2.6.1 Activities

- Restroom use
- Hand/face washing
- Changing clothes
- Grooming, including shaving and application of makeup
- Baby diaper changing and related activities

2.6.2 Typical lighting methods

- Single fixture over mirror
- General ceiling-mounted fixture

The most visually demanding tasks usually are shaving and applying makeup. This is because the apparent distance of the face or figure as viewed in the mirror is twice its actual distance from the mirror, and the details to be seen in shaving and critical inspection are usually small and of low contrast with the background.

Since most restrooms are rather small, a single LED or fluorescent fixture over the mirror works well.

For the use of mirrors, the minimum illumination value is 30 fc (323 lx) on the face, measured in a vertical plane at a distance of 16 in. (41 cm) from the plane of the mirror, 62 in. (1.57 m) above the floor. Supplementary mirror fixtures or careful planning of the overall lighting may achieve this.

Large rooms, such as those that are ADA accessible, may require an additional general lighting fixture.

The minimum spatial average illumination is 15 fc (162 lx) measured on a horizontal plane 33 in. (84 cm) above the floor.

2.7 Reading lights

2.7.1 Activities

- Reading books, magazines, etc.
- Reading/studying detailed work on documents
- Various activities where the user does not want to disturb the neighboring seat or berth when car general lighting is reduced for nighttime

2.7.2 Typical lighting methods

Intercity passenger cars are often equipped with dedicated individual reading lights to provide very localized lighting for each seat occupant, as well as those in upper and lower berths. Typically, they are mounted on the underside of overhead luggage racks, or possibly the seatback area, though other situations may call for other mounting. Under the control of the passenger, the light provides relatively bright lighting for tasks such as reading.

Fully-gimbled fixtures are very useful in allowing the light to be aimed for the task, taking into account that the passenger seat may be upright or reclining. If the seats can be rotated, the site of the light and its movement should take this into account. The beam path of the light should be such that it does not interfere with the seat neighbor’s space. Currently, nearly all new installations employ LED lamps, replacing older incandescent technologies. The high directionality, long life, small size and lower heat output of LEDs makes them particularly well-suited here.

2.8 Electric/switch locker

Switch and electric lockers include a great many variations in their shape and arrangement within the car interior. Generally, the switch locker encloses devices widely used by the operating crew in daily activities, such as temperature controls, monitor panels, lighting controls, etc. Electric lockers tend to enclose electrical devices less frequently accessed by crew, such as power circuit breakers, relays and contactors, etc.

2.8.1 Activities

- Read instructions, labels on switches, and other controls and indicators
- Inspect, maintain and service electrical and mechanical equipment

2.8.2 Typical lighting methods

- Single fixtures on or near ceiling of walk-in type lockers
- General ceiling car lighting fixtures may provide sufficient lighting for shallow lockers

The light level should be sufficient and located so as to allow service personnel to work in the space without requiring additional light, such as a flashlight.

The deep or walk-in style electric locker should be provided with one or more interior lights controlled by a door-operated switch. These lights should be powered so that they are available under all conditions when main battery power is available. Likewise, a shallow switch or electric locker should be lighted in a similar fashion, unless it receives good light from an adjacent battery-supported source that is always illuminated when main battery power is available.

2.9 Service lighting

2.9.1 Activities

- Read labels on switches, other controls and indicators
- Inspect, maintain and service electrical and mechanical equipment

2.9.2 Typical lighting methods

- Single fixture(s)

Service lighting should be located in equipment rooms, lockers and closets, storage spaces, overhead equipment spaces, etc., to allow maintenance personnel to perform routine work on car equipment without the need to use portable lighting such as a flashlight. This tends to require omnidirectional fixtures.

The lighting should be turned off automatically when the door or access panel is closed. The fixtures should be moisture resistant and be provided with guards to protect the lamps from breakage and to avoid personnel injury from burns.

2.10 Passenger information displays

Because these displays can take almost an unlimited variety of forms, this document can speak only in generalizations. Light intensity needs to be considered so that the displays are not intrusive and distracting to passengers. Also, since they may give off considerable light, consideration should be given to possibly dimming them during night mode/quiet car mode so as to not interfere with passengers trying to sleep.

2.11 Exterior lighting

2.11.1 Marker lights

Marker lights are required per 49 CFR §221 on the rear of the last car of the train. This is generally achieved by using a pair of lights mounted high on the car end sheet, one on each side. Usually, the lights are activated by use of a toggle or rotary switch. However, other methods are used, such as via use of the looping jumper, which is often employed end-of-train. For cab cars, the control of marker lights on the cab end may be associated with the headlight switch.

Historically, PAR-46 incandescent lamps have been used, connected via a dropping resistor for each lamp. Recently, matrix-type LED lamps have been used, and have been retrofitted on many cars. LEDs offer the advantage of much lower power consumption, no requirement for dropping resistor, and much longer lamp life. The one drawback is that since LED units do not produce much heat, they are unable to melt snow/ice that may accumulate on the lens in cold weather, unlike incandescent lamps.

2.11.2 Platform/ground lights

Platform/ground lights are used to illuminate the platform below vestibule steps, the area on and below retractable steps, or the ground below a ladder (such as from cab car cab or baggage car). Platform lights provide light onto low-level platforms, which are often poorly lighted (if at all). Ground lights are often employed below ladders of cab car crew access doors to provide light onto the platform, ground or track ballast. Since these lights are outside the protective envelope of the carbody, they need to be located to the extent possible to protect them from debris damage as well as weather.

Historically, this lighting was provided via incandescent lamps, though LEDs are now the norm. LEDs offer advantages in small size, great directionality, low power consumption and long life. It is also easy to configure the lighting into strips, which may be useful to provide light along the lower edge of vestibule steps.

2.11.3 Indicators (door open, brake status, etc.)

Indicator lights are provided on most modern passenger cars to indicate to the operating crew the status of the passenger doors, application/release of air brakes (and possibly handbrake), and possibly other railroad-specific functions. Required by 49 CFR §238.131, Exterior Side Door Safety Systems, and defined by APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars," a minimum of one door status light is required on each side of the car. It is common to have a light at each passenger side loading door.

Generally, door status lights are mounted high up the side of the car. Brake status lights are typically mounted one fixture high up on each side of the car, diagonally opposite from each other. Indicator lights are normally low-profile to ensure that they do not violate the car dynamic clearance envelope. The lights are oriented to shine fore and aft along the train, so the crew can check system status by sighting along the length of the train. Historically, the lamp was incandescent, but LEDs are now universal, including many applications of retrofits. LEDs offer the advantage of small size, high brightness, very directional light pattern, low power consumption and long life.

3. Coach lighting

General lighting functions for these car types are described in Section 2.

There are two main coach types: commuter and intercity coach cars. Intercity coaches may be of the short- or long-distance type. These are the most common car types. Short-distance coaches have moderate seat densities and operate primarily in regional services, with trip times of up to 12 hours. Long-distance coaches offer low seat densities and trip times up to three days. Both types of intercity coaches include luggage racks, which significantly affect overhead lighting operation.

An intercity coach provides more kinds of service than any other passenger car. It may be in use 24 hours per day and combine all the varying functions of the specialized cars. In addition to the coach's daytime use by passengers who wish to view scenery, read or relax in comfort, it also provides service during the evening and night hours when its utility and comfort depend in large measure on the design of the lighting system. In the early evening hours, the passengers may wish to talk, read, eat, drink or just relax. Later, while the majority would wish to sleep, there may be some who would like to continue reading. The lighting system or operating procedure should provide for this, as well as safe movement through the car by both passengers and crew when lighting is dimmed for the night operation.

3.1 Commuter coach

3.1.1 Activities

- Looking out the window
- Reading/writing
- Ticket collection and related transactions
- Car cleaning and maintenance
- Using a laptop computer or other electronic device

3.1.2 Typical lighting method

- The general lighting is required; refer to Section 2.
- General ceiling lighting, center or cover

3.1.3 Discussion

The interior should be illuminated to provide adequate light for the typical activities done in this type of car.

Commuter coach lighting is generally fairly basic, with either lighting running down the center of the ceiling or cove lighting. Fairly high general light levels are provided to allow comfortable passenger reading and crew fare collection.

The minimum spatial average illumination in the reading area should be 20 fc (215 lx) with all lights "on," measured 33 in. (84 cm) above the floor at the center front edge of the seats.

> **NOTE:** The minimum spatial average illumination of the seating area immediately behind the cab area may have to be reduced below the 20 fc (215 lx) recommended value in order to reduce glare reflections upsetting operator night vision out of the cab windows.

3.2 Short-distance intercity coach

3.2.1 Activities

Same as Section 3.1.1, plus:

- Looking out window (lighting should only minimally interfere with looking out during daytime, dusk and nighttime lighting scenarios)
- Reading and extended or detailed work on documents
- Using a laptop computer or other electronic device
- Playing games
- Eating snacks
- Napping

3.2.2 Typical lighting methods

- General lighting, per Section 2
- General ceiling lighting, center or cove
- Reading lights

3.2.3 Discussion

Normal lighting is provided from fixtures located in the ceiling and/or adjacent to or in the luggage rack or cove where the side wall meets the ceiling.

The lighting system should also provide general illumination of the ceiling and throughout the coach area in order to ensure an attractive and comfortable atmosphere. For night occupancy, a low level of illumination is necessary for safe movement through the car, and for the comfort of sleeping passengers. This may be accomplished by use of night lights in fixtures located below seat level or included in the overhead fixtures, dual lamp fixtures, staged lighting or dimming selected circuits.

Illumination for reading and writing can be accomplished by individually controlled reading lights mounted either in the aisle edge of the luggage rack or at the line of the luggage rack and the outer wall of the car. In case of the closed type luggage rack, these lights are mounted directly above the seats. Many reading light types allow the passenger to aim the light beam to suit their individual need. The beam width should not interfere with the adjacent seat of a pair. Location and aim of the reading lights must take into account seat rotation as well as seat recline (if equipped with either or both).

The minimum spatial average illumination on the reading area should be 20 fc (215 lx) with only reading lights “on,” all other car lighting off, measured on a 45 deg. plane 33 in. (84 cm) above the floor at the center front edge of the seats.

3.3 Long-distance intercity coach

3.3.1 Activities

Same as Section 3.2.1 plus the following:

- Sleeping

3.3.2 Typical lighting method

Same as Section 3.2.2.

3.3.3 Discussion

Generally, long-distance intercity coach lighting is similar to that of the short-distance car (Section 3.2.3). However more care is required in producing an attractive, restful atmosphere since passengers occupy the car for much longer periods.

Normal lighting is generally provided by fixtures located along both sides of the car at the ceiling cove, supplemented by aisle lights down the center of the ceiling.

Since these cars carry many passengers on overnight trips, considerable care is required to provide night lighting that does not interfere with restful sleep, while still providing enough light for safe movement.

The minimum spatial average illumination on the reading area should be 20 fc (215 lx) with only reading lights "on," all other car lighting off, measured on a 45 deg. plane 33 in. (84 cm) above the floor at the center front edge of the seats.

4. Dining car lighting

General lighting functions for this car type are described in Section 2.

The functions of a lighting system in dining cars are to enhance the appeal of the interior decorations, table settings and food, and to assist in creating a comfortable, pleasant atmosphere for the diners. Quality and color of light under these circumstances are of more importance than quantity, which should, however, be adequate for safety and convenience.

4.1 Activities

Passenger area:

- Read menu, waiter take order
- Present food in an appealing way (good color and light quality)
- Dine
- Looking out window (lighting should only minimally interfere with looking outside during daytime, dusk and nighttime lighting scenarios)
- Money/credit card transactions
- Sanitation activities, car cleaning and maintenance

Galley and service area:

- Read orders
- Food preparation, presentation and serving (good color and light quality)
- Money transactions
- Stocking/removing stock from car, including paperwork (often this is done during emergency lighting operation, thus requiring good light levels)
- Sanitation activities, dish washing, car cleaning and maintenance

4.2 Typical lighting method

- General lighting, per Section 2

Passenger area:

- Cove lighting
- Aisle light
- Table lighting (incident)
- Maître d' area counter

Galley area:

- General lighting, ceiling
- Counter lighting
- Refrigerator lighting (large units only)

4.3 Discussion

4.3.1 Dining area

Dining areas can be adequately illuminated by means of two continuous rows of lamps, one on each side of the car. As dictated by interior design, the rows may be recessed in the ceiling with a diffusing medium below the lamps or mounted in coves on each side of the car. The coves may be modified to obtain some direct "down" light in addition to that on the ceilings, or small LED lights recessed in the cove or along wall above windows may be added over each table. Where indirect cove lighting is used, some additional light to accent the tables is generally necessary, and if not provided by direct "down" lighting, may be obtained by the use of wall-mounted sconces or LED table lamps on the wall side of each table.

The selection of the system should be governed by the overall décor of the car and the effects desired. Direct "down" lighting on a table results in sparkle to the silverware and glassware that cannot be obtained from diffuse illumination, and is an important aid in the stimulation of eye appeal. The proper color characteristics of the light sources are important if the source is LED or fluorescent. The presently designated warm white lamps provide overall color rendition that is complimentary to the appearance of people, food and interior furnishings.

The minimum spatial average general illumination for the dining area should be 10 fc (108 lx) at 33 in. (84 cm) above the floor.

Passengers need light for eating and drinking and for reading menus and checks.

The minimum spatial average illumination should be 15 fc (162 lx), provided on the table at each seated diner, 8 in. (21 cm) in from the front edge of the table.

4.3.2 Galley

High levels of quality illumination are required in the galley for the utmost efficiency of operating personnel. Good illumination also ensures good appearance of food and its proper inspection. FDA lighting level requirements are identified in U.S. Public Health Service Food Code, 2017, 6-303.11, Lighting Intensity.

Quality of lighting is important, especially in regard to color. In addition to general lighting, usually supplied by ceiling-mounted lamps, counter lighting should be provided over all work areas generally by fixtures mounted on the underside of overhead cabinets.

High levels of lighting are required where food is handled directly, such as cutting boards, etc. The work performed is preparing foods and beverages and cleaning the area. The task plane is horizontal on work counter surface. Illumination should be provided on the work counters from the front to the back edge.

The area from which food is served, whether between the kitchen and pantry or separated, such as on a bi-level car, should be well lighted to facilitate food inspection. Large refrigeration cabinets should have at least one lamp per compartment, operated by automatic door switches. Good light levels are needed for dish washing and general galley sanitation.

Galley and serving area minimum spatial average illumination should be:

- **Food storage area:** 10 fc (108 lx), measured on a vertical plane, measured at geometric center of each cabinet door
- **Food preparation area:** 20 fc (215 lx), measured on counter
- **Food handling, cutting use of utensils, preparation:** 50 fc (538 lx) on counter

- **Food serving area:** 20 fc (215 lx) on counter
- **Hand dish washing:** 20 fc (215 lx), 30 in. above the floor

Since stocking the car is often done with main power off, high levels of standby light are necessary. With fluorescent lighting, this is usually done by equipping a number of ceiling and/or counter fixtures with inverter ballasts and powering them from the car main battery system. In a similar way, LED lighting is powered from the car main battery system.

5. Short distance snack car (light food service) lighting

General lighting functions for this car type are described in Section 2.

Short distance snack cars generally include some combination of coach seating, table seating and a food service area, though all cars do not necessarily include all three. A common floor plan includes the food service area in the center, with a passenger area on both ends of the car. Coach seating could be provided at both ends of the car, table seating provided at both ends of the car, or coach seating on one end and table seating at the other.

The function of the lighting, especially in the food service area, is to provide an appealing atmosphere in which to select, purchase and consume snacks and light meals.

5.1 Activities

Passenger area:

- Looking out window (lighting should only minimally interfere with looking out during daytime, dusk and nighttime lighting scenarios)
- Reading and extended or detailed work on documents
- Using a laptop computer or other electronic device
- Playing games
- Eating snacks or light meals at seats or tables
- Napping
- Ticket collection and related transactions
- Car cleaning and maintenance

Food service area:

- Present menu and items for sale in an appealing way
- Food preparation, presentation and serving (good color and light quality)
- Money transactions (checking ID)
- Stocking/removing stock from car, including paperwork (often this is done during standby lighting operation, thus requiring good light levels)
- Sanitation activities, car cleaning and maintenance

5.2 Typical lighting method

- General lighting, per Section 2
- Ceiling lighting, center or cove
- Aisle lighting
- Reading lighting at seats, but generally not tables unless they are under luggage racks
- Table lighting
- Food service general lighting (ceiling)
- Food service counter lighting

5.3 Discussion

Though there are a wide variety of car arrangements in use, most can be divided into four functional areas: coach seating, table seating, food service areas and vending machines.

5.3.1 Coach seating area

The use of this section of the car is very similar to that of a typical short-distance coach, as described in Section 3.2. Likewise, the lighting arrangement is similar, generally including ceiling, reading and possibly aisle lighting. Luggage racks are normally provided in this portion of the car.

5.3.2 Table seating area

Tables are provided, usually with bench-type seating, in this area of the car. These tables are generally used for eating light meals and also see frequent use in a business environment, either as a desk or a place to have a meeting. Lighting generally includes ceiling and possibly aisle lighting. Reading lights are not normally provided. Luggage racks are not normally installed in this portion of the car; if they are, reading lights should be considered.

5.3.3 Food service area

This staffed area normally includes a food preparation and serving counter where passengers come to select and purchase drinks, snacks and light meals. Food is served, generally in a prepackaged form, with preparation usually limited to heating and dispensing. These items are either consumed within the car or taken elsewhere in the train. Selection is made from wall-mounted menus. Good color rendition is essential to provide appealing offerings to the passengers.

High light levels must be provided to meet FDA requirements, as identified in U.S. Public Health Service Food Code, 2017, 6-303.11, Lighting Intensity.

Ceiling lighting is typically provided directly over the serving counter, with counter lighting provided over all work areas, from front to back, generally by fixtures mounted on the underside of overhead cabinets. Effective lighting of the menus needs to be included in the overall lighting design.

If the food service area can be closed off when not in service, such as by roll-down curtains, this has the potential of affecting the lighting levels in the passageway around the area. This must be addressed in the lighting system design so that required light levels are met both with counter open as well as shut down and shuttered.

5.3.4 Vending machines

In recent times, some cars have been equipped with vending machines rather than having staffed counter service. This may be arranged in a variety of ways, but typically the vending machines are placed side-by-side along the car exterior side wall.

Since lighting is provided primarily by the car lighting system, this would typically be achieved through overhead fixtures, similar to that provided by passageway lighting. The light levels should be fairly high to allow customers to easily make their choices. In addition, the lighting must be sufficient to comply with FDA required light levels to allow easy restocking of product and proper sanitation in cleaning the area around and inside the machines. Due to the wide variety of possible configurations and that the lighting must work in conjunction with that of the machines, no specific light levels are provided here.

Lighting in the area should take into account scenarios of both passengers passing through the area as well as those using the machines. In addition, lighting should be located so the customer does not cast shadows onto the machines.

5.3.5 Illumination

Minimum spatial average illumination should be as follows:

- **Coach area:** The minimum spatial average illumination on the reading area should be 20 fc with only reading lights "on," all other car lighting off, measured on a 45 deg. plane 33 in. above the floor at the center front edge of the seats.
- **Table area:** 15 fc (162 lx) on the table at each seat position.
- **Food storage area:** 10 fc (108 lx), measured on a vertical plane at the geometric center of each cabinet door.
- **Food preparation area:** 20 fc (215 lx) on the counter.
- **Food serving area:** 20 fc (215 lx) on the counter.
- **Hand dish washing:** 20 fc (215 lx), 30 in. above the floor.
- **Vending machine area:** Not defined here; refer to customer specification.

Since stocking the car is often done with main power off, high levels of standby lighting are necessary. With fluorescent lighting, this is usually done by equipping a number of ceiling and/or counter fixtures with inverter ballasts and powering them from the car main battery system. In a similar way, LED lighting is powered from the car main battery system.

6. Sleeping car lighting

General lighting functions for this car type are described in Section 2.

The lighting design of the sleeping car should add to the comfort, convenience and beauty of the accommodations. Creating a relaxed environment is especially important since passengers occupy the room for up to three days. As in any good lighting installation, the ability to perform the visual task is the primary consideration. Lighting design is difficult due to the many seeing activities and severely limited wall and ceiling area available for mounting fixtures. Ergonomic issues are very important, since not only must the lighting be oriented correctly, but also the controls must be located logically and be easy to use, especially those for the upper berth.

6.1 Activities

Passenger area:

- Looking out window (lighting should only minimally interfere with looking out during daytime, dusk and nighttime lighting scenarios)
- Reading, writing, studying documents, illustrations, etc., both in seat and in bed, without disturbing other room occupants
- Using a laptop computer or other electronic device

- Playing games
- Dining or eating snacks
- Sleeping in bed
- Ticket collection and related transactions
- Car cleaning and maintenance
- Childcare, baby diaper changing and related activities
- Changing linen and making up beds
- Toilet use (some car type and accommodation types only; toilet may be in room itself, or a small room within the accommodation; some cars also have public restrooms and showers)
- Hand and face washing, grooming, including shaving and application of makeup
- Changing clothes
- Taking a shower

6.2 Typical lighting method

- General lighting, per Section 2
- General room lighting (ceiling with night light and wall light)
- Reading lighting
- Berth light
- Mirror/sink lighting
- Private or public toilet/shower lighting
- Passageway (with room numbers) lighting
- Closet lighting
- Night light

6.3 Discussion

6.3.1 Room

Room lighting and control should take into account that most rooms are occupied by two passengers, who may wish to do different activities. For example, one person could be asleep in the upper berth while the second is using one of the seats and small folding table to write a letter. Another example is for the upper berth occupant to be reading while the lower berth passenger sleeps. Thus lighting requirements in different parts of the room can be very different at the same time.

Lighting control should allow control of the main room light and night light from upper and lower berth positions. Controls must be easy to find and use in a dark room, especially since a passenger may be unfamiliar with the room layout and its features. Backlighted switches have been successfully used for this purpose, but care must be taken to avoid this light being too bright. A night light should be provided, enabled by the passenger.

> **NOTE:** In cases where lighting control is provided and/or general lighting levels may be below the charging level for HPPL materials, consideration needs to be taken for the proper charging on HPPL signs and markings, or active exit path lighting should be considered.

General illumination can be provided from a combination of ceiling and mirror fixtures with possible supplement from wall-mounted luminaries. A small LED or fluorescent fixture, mounted over the room mirror, generally provides good lighting for sink use and grooming.

The general illumination should meet the requirements for lounging and to provide sufficient component of illumination to the upper walls and ceilings for the elimination of unpleasant contrasts. Supplementary lighting sources may be required to furnish the higher level of illumination required for prolonged reading and business work. Lamps should be arranged not to shine into eyes of other occupants. Berth lamps are furnished and placed to provide a suitable source for reading in bed. Bed lamps should be designed to provide a concentrated beam of light for the reading task and a component for general illumination to relieve excessive contrasts.

Private toilet rooms are usually illuminated with a ceiling-mounted fixture. When the toilet room is also used as a shower, the fixture must be water-resistant and grounded. A night light should be provided, enabled by the passenger, for nighttime visits so as to not expose the user to the bright daytime light levels.

6.3.2 General areas

Passageway lighting should generally conform to the requirements of Section 2.4 and is usually provided by small ceiling-mounted fixtures. They often include a lens, which indicates the room number. They may also incorporate features for the attendant call system, such as a light indicating that service is desired.

Public restrooms should generally conform to the requirements given in Section 2.6. Likewise, public showers have similar requirements, with the additional requirement of water-resistant fixtures that are grounded.

A coffee station is provided on some equipment, which includes features such as a coffee maker, fruit juice dispenser, etc. Light must meet FDA requirements for sanitation in the area.

Miscellaneous closets and other larger storage spaces, such as linen lockers, may be equipped with small door-activated lights. Care needs to be taken to protect the lamps and fixtures from overheating should they stay on and be exposed to the contents of the locker.

Minimum spatial average illumination shall be as follows:

- **Reading:** 20 fc (215 lx), with only reading light on, measured on a 45 deg. plane, 33 in. (84 cm) above the floor at the front edge of each seat
- **Berth:** 20 fc (215 lx), with only reading light on, measured on a 45 deg. plane, with the height determined by comfortable passenger reclining position
- **Table:** 20 fc (215 lx), on the center of the table
- **General room:** 20 fc (215 lx), measured 33 in. (84 cm) above the floor
- **Mirror:** 30 fc (323 lux), measured in a vertical plane, 16 in. (41 cm) from the mirror, 62 in. (1.57 m) above the floor
- **Private toilet:** 15 fc (162 lux), 33 in. (84 cm) above the floor
- **Night light (in room):** at least enough light to charge any HPPL markings or signs in room as measured in APTA PR-PS-S-006-23.
- **Coffee station:** 20 fc (215 lux) on the counter

7. Long-distance lounge and observation car lighting

General lighting functions for this car type are described in Section 2.

Modern lounge and observation cars are used to furnish extra convenience and comfort for railroad passengers, and because of the different types of service they provide their lighting needs are many and varied. The problems involved in the lighting of these cars are a combination of those encountered in the lighting of the various areas of the other type cars as previously enumerated. Each of the areas listed has some lighting tasks that are not common to the other areas and should be treated separately and distinctly. Cars typically have three basic areas: lounge seating with clusters of seats surrounding small tables; table area with larger tables for light meals and playing games; and food service areas, where snacks, drinks, and pre-packaged meals are prepared and served.

The function of the lighting in the lounge area is to provide a relaxing atmosphere for passengers. In the food service area it should provide an appealing atmosphere in which to select, purchase and consume drinks, snacks and light meals.

Many of these cars are designed specifically for sightseeing and have vast areas of glass. Accordingly, considerable care is required in the lighting design to avoid reflections or glare from the lighting that would interfere with the view, especially at night but also at dusk and during the day.

7.1 Activities

Passenger area:

- Sightseeing (lighting should only minimally interfere with looking out during daytime, dusk and nighttime lighting scenarios)
- Reading and extended or detailed work on documents
- Using a laptop computer or other personal electronic device
- Playing games
- Eating snacks in the lounge area
- Napping
- Ticket collection and related transactions
- Car cleaning and maintenance

Food service area:

- Present menu and items for sale in an appealing way
- Food preparation, presentation and serving (good color and light quality)
- Dishwashing, sanitation activities
- Money transactions and checking ID
- Stocking/removing stock from car, including paperwork (often this is done during standby lighting operation, requiring good light levels)
- Car cleaning and maintenance

7.2 Typical lighting method

- Basic lighting, per Section 2
- Cove lighting
- Aisle lighting
- Reading lighting
- Table lighting
- Food service general lighting (ceiling)
- Food service counter lighting

7.3 Discussion

Though there are a wide variety of car arrangements in use, most can be divided into three functional areas: lounge seating, table seating and food service areas.

7.3.1 Lounge seating area

The lighting tasks consist mostly of seeing requirements for reading and lounging. This area generally includes cove and aisle lighting, with the cove lighting switched off at night on sightseeing type equipment. Spot or reading lights, individually controlled, may be provided over the small tables and/or seats in the area.

In the dead-end, observation type car, the fixtures preferably are extended to meet at the rear of the car, conforming to its curvature. Special lighting may be added, such as table fixtures or mirror or picture illumination to add lighting interest and also suitable dimming or night light features.

7.3.2 Table seating area

Tables are provided, usually with bench-type seating, in this area of the car. These tables are generally used for eating light meals and card playing and also see some use in a business environment, being used as a desk. Lighting generally includes ceiling and possibly aisle lighting.

7.3.3 Food service area

This area normally includes a food preparation and serving counter where passengers come to select and purchase drinks, snacks and light meals. It may take two forms:

- Serving counter where customers make selections from wall-mounted menus
- Area equipped with glass display cases from which customers make their own selections.

Food is served, generally in a prepackaged form, with preparation usually limited to heating and dispensing. These items are either consumed within the car or taken elsewhere in the train. Good color rendition is essential to provide appealing offerings to the passengers.

High light levels must be provided in the food service area to meet FDA requirements, as identified in U.S. Public Health Service Food Code, 2017, 6-303.11, Lighting Intensity.

Ceiling lighting is typically provided directly over the serving counter, with counter lighting provided over all work areas, from front to back, generally by fixtures mounted on the underside of overhead cabinets. Additional accent lighting may be installed on the front of the counter area for visual interest. Effective lighting of the menus needs to be included in the overall lighting design.

Minimum spatial average illumination should be:

- **Lounge area:** 20 fc (215 lux), with only reading (or spot) light on, measured on a 45 deg. plane, 33 in. (84 cm) above the floor at the front edge of each seat
- **Table area:** 15 fc (162 lux) on the table at each seat position
- **Food storage area:** 10 fc (108 lux), measured on a vertical plane, at the geometric center of each cabinet door
- **Food preparation area:** 20 fc (215 lux) on the counter
- **Food serving area:** 20 fc (215 lux) on the counter
- **Hand dish washing:** 20 fc (215 lux), 30 in. above the floor

Since stocking the car is often done with the main power off, high levels of standby lighting are necessary. With fluorescent lighting, this is usually done by equipping a number of ceiling and/or counter fixtures with inverter ballasts and powering them from the car main battery system. In a similar way, LED lighting is powered from the car main battery system.

8. Baggage car or bag compartment of combination cars

General lighting functions for this car type are described in Section 2.

8.1 Activities

- Read labels attached to baggage/packages
- Safely handle baggage, bicycles and other articles into and out of the car in dark station areas, from both high- and low-level platforms
- Car cleaning and maintenance

8.2 Typical lighting method

- General lighting, per Section 2 (limited areas apply)
- General ceiling lighting
- Loading door lighting

8.3 Discussion

LED or fluorescent weather-resistant fixtures should be provided along the ceiling of the car. A fixture should be provided over each side loading door of the car to provide sufficient light both inside and outside the car to allow safe and efficient baggage handling to and from an unlighted station platform. All car lighting should be battery supported, because it is common practice to be loading/unloading baggage while HEP is not available.

Minimum light levels:

- **Floor:** 5 fc (54 lux)
- **Loading door threshold:** 5 fc (54 lux)
- **Baggage shelves, if provided:** 5 fc (54 lux) at aisle on floor

9. Cab area of cab car

Several cab configurations are possible, dedicated and various forms of convertible (dual-mode). The dedicated form functions solely as a cab, while the dual-mode cab can be configured as an operating cab and, when not functioning in that role, can be configured for passenger seating or pass-through to the body end frame door. Lighting requirements are as follows.

9.1 Convertible cab: passenger seating mode

When the cab is configured in this mode, the passenger seating and aisle/passage light requirements are defined by sections 2.4 and 2.5. For the passenger seating mode, aisle/passageway measurements need be done only once, with the cab area configured for passenger seating. A separate aisle/passageway test conducted with the cab isolated is not required.

9.2 Convertible cab: pass-through mode

When the cab is configured in this mode, aisle/passage light requirements are defined by sections 2.4 and 2.5. For the pass-through mode, aisle/passageway measurements need be done only once, with the cab area configured for pass-through. A separate aisle/passageway test conducted with the cab isolated is not required.

9.3 Active cab (crew operating train)

This is defined to be either:

- dedicated cab, used only by operating crew; or
- convertible cab, the operating mode when the cab is set up to control the train and is closed off to passengers.

The material following applies only to the active cab configuration.

9.4 Activities

- Orientation in the cab, such as when moving around as well as to avoid tripping
- Setting up/shutting down operating controls when activating/deactivating the cab
- Operating the train
- Reading train orders
- Reading instruments, such as air brake gauges, etc.
- Reading screens
- Cleaning

9.5 Typical lighting methods

- ceiling lights
- reading lights
- red reading lights

9.6 Discussion

This recommended practice addresses only general lighting requirements for cab areas. Specific details concerning other lighting aspects are best addressed by the authority since they are very specific to a given cab design.

9.6.1 Internal cab lighting

Cab lighting typically includes the following:

- General lighting
- Reading lights, white with dimmer
- Reading light, red (for night vision)
- Floor lights, (to identify differences in floor level, as required)
- Console and gauge lights

General requirements for cab lighting are identified in 49 CFR §229.127, Cab Lights.

9.6.1.1 General lighting

For half-carbody-width cabs, common in commuter vehicles, typically a single overhead fixture is provided for general lighting. For full-width cabs, a second similar overhead fixture is provided on the non-operator side. In convertible cabs, where passenger access is provided to part of the area when the cab is not in use, the lighting design should include features to configure the lighting operation according to when the cab is in use and when it is not. The cab area should incorporate one or more conveniently located switches to control general lights. General lighting should have power available from the car main battery system since it may be necessary to work in the cab when HEP or normal power is not available.

- **Engineer's (and assistant's) console:** 15 fc, 33 in. above the floor
- **Floor, for movement within the cab area:** 15 fc

9.6.1.2 Reading light-white

An aimable spotlight is generally provided to allow the operator (and assistant, as applicable) reading train orders, etc. while the general lighting is extinguished. The light must not reflect onto the windshield or otherwise interfere with seeing outside during nighttime operation. Control for each should include an on/off switch as well as a dimmer.

- **Console where train orders would be read:** 25 fc, perpendicular to the reading surface

9.6.1.3 Red reading light

A red aimable spotlight may also be provided to allow the operator to read train orders, etc., during nighttime operation; red light is employed so as to not affect the operator's night vision.

9.6.1.4 Floor lights

These lights, if employed, may be useful in identifying any changes in floor level, and might remain illuminated when the cab is darkened for nighttime operation. They must not affect the crew's ability to see ahead at night.

9.6.1.5 Emergency lights

While this document does not generally address emergency lighting, the cab area is of special concern. It is very possible for the train to operate under conditions when the emergency lighting system is illuminated. Emergency lighting in the cab must not interfere with the operator's view ahead, cause glare onto the windshields or otherwise interfere with the safe operation of the cab. Refer to APTA PR-E-S-013, "Emergency Lighting," for details regarding this lighting.

9.6.1.6 Console, gauge and instrument lights

Console lighting may be provided integrally. Gauge and instrument lighting is normally provided internal to those units. Since these issues are very specific to a given cab design, they are best addressed by the authority having jurisdiction.

9.6.1.7 Lighting controls

Conveniently located to the seated operator, clearly labeled switches should be provided to the operator for all cab lighting.

9.6.2 Exterior cab lighting

Specific details of these lighting systems are best addressed by the authority having jurisdiction, since they are vehicle-specific. This includes the following:

- **Headlights and auxiliary (conspicuity) lights:** Requirements for headlights and auxiliary lights, as well as conspicuity lights, are called out in 49 CFR §229.125 and §229.133 respectively. AAR S-5516, "LED Headlights and Auxiliary Lighting for Locomotives," has details regarding LED headlights and auxiliary lights. Switches to control these lights, as well as the conspicuity light flashing functions, should be consistent with other existing equipment of that authority, to avoid operator confusion.
- **Road number sign lights:** Lighting of road number signs should also be included. These signs need to be clearly readable by personnel on the ground as well as at higher elevations to verify the identity of a passing train by its road number. This must be possible during daylight as well as at night.
- **Marker lights:** Marker lights requirements are identified in 49 CFR §221.

10. Exterior lighting

10.1 Marker lights

Most passenger equipment is equipped on each end with a pair of red marker lights, to conform with 49 CFR §221 color and intensity requirements. Historically, they are round, employing either a 60 W PAR-64 incandescent lamp, with associated dropping resistor, or an FRA-approved LED array of similar size. The LED approach uses considerably less power and has a much longer life. One potential drawback, though, is that the LED does not generate much heat and may be unable to successfully melt snow/ice from the fixture in cold weather.

10.2 Door and brake status lights

Most passenger equipment is now equipped on both sides with door as well as brake status indicators, mounted on the sides of the cars. Other indicators are also sometimes provided. These provide information to operating crews to indicate on that car when a door is open and/or not latched closed, and brakes applied/released.

These bidirectional fixtures usually take the form of a small cylinder approximately 1.5 in. in diameter oriented longitudinally along the car. Typically, door status lights use red lamps or lenses, while brake applied is usually amber and brake released green, though the color and indications are usually determined by the authority having jurisdiction. The door status lights are normally mounted in the proximity of each side door used by passengers. The indicators are normally viewed fore and aft along the train, and to the extent practical, it is desirable to be able to read the color in both daylight and darkness over the train length. Newer installations normally employ LEDs.

The requirements for the door indicators are identified in APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars."

10.3 Ground lights

Some passenger cars are equipped with ground lights to illuminate the platform/ground beneath the side steps and/or onto and below retractable steps, to aid in loading/unloading passenger and crew. They may also be used in conjunction with crew ladders, such as might be used on cab car cabs or baggage car loading doors.

The fixtures take a variety of forms, with most employing LEDs. Care should be taken in locating these fixtures to protect them to the extent practical from mechanical damage, such as ice and snow, branches, and debris that might be thrown by train motion. Car-borne platform lighting is required for equipment operating at non-lighted station platforms per 49 CFR §38.101 and §38.119. This may be provided by various methods, such as ground lights.

11. Design for interior fixtures

The light distribution and the lighting fixtures form an important part of the interior furnishings and must meet the specified requirements for appearance, color schemes, and blending with the interior design concepts.

Materials used in the manufacture of interior lighting fixtures must conform to the flame and smoke requirements of 49 CFR §238.103, Fire Safety.

Electronics and associated wiring employed in the lighting system may produce radio frequency emissions. In order to not interfere with other car equipment as well as crew radios, the lighting system must conform to the requirements of APTA PR-E-S-010-98, "Development of an Electromagnetic Compatibility Plan."

Lighting in each car type should be designed by the contractor to meet the illumination requirements specified in sections 1 through 10. The lighting arrangement for each car type should be designed to minimize the load during battery operation. Common fixtures and fixture components should be used to the greatest extent possible between car types.

The lighting fixtures should be designed to produce a uniform brightness of evenly distributed light, free from glare, high-intensity spots, beams, beam holes, edge scatter or patterns of light. The fixture should not deteriorate rapidly in effectiveness through the collection of dirt and should permit easy cleaning and easy lamp renewal. Interior fixtures should be dust-resistant. Those in wet areas, such as equipment areas, food service areas, showers and restrooms, should be moisture-proof.

Design of the lighting fixtures and their deployment should minimize the number of lamp types required and unique fixtures used. To the extent possible, LED modules, drivers, lenses, sockets, ballasts and fasteners should be interchangeable among all fixtures. Likewise, sockets, lamp holders and switches should be readily available from multiple U.S. sources. If incandescent lamps are employed, to the extent possible, sockets and lamps should be selected so it is impossible to insert the wrong lamp into a socket (i.e., candelabra bases could be used for DC battery circuits, with bayonet bases used for AC circuits).

Fixtures should be either repairable in place (e.g., ballast change-out, socket replacement), or be easily removable for bench repair. In order to avoid dark spots, adjacent fluorescent fixtures should not be fed from the same ballast. Similarly, adjacent LED fixtures should not be fed by the same driver.

11.1 Mechanical design features

The lighting fixture should be free from rattles and squeaks and designed to prevent resonance. The fixture's design should be available or supported for the life of the vehicle. The lighting fixture surfaces and parts with which the passengers or crew could possibly come into contact should not have surface temperatures in excess of 125 °F. (52 °C.). The fixtures should be fabricated in such a way that when mounted in the car, no hardware such as bolt heads, screw heads, or fasteners will show from the passengers' walking or seated fields of vision, except those that may be required for releasing the door assembly for relamping. Fasteners used to secure door assembly should be captive. All materials used in the manufacture of reflectors, components and housing should meet the flammability, smoke emission and toxicity requirements specified by the railroad. Lamps, fixtures, reflectors, diffusers and shades should meet interior color rendering and background effects requirements.

11.2 Reflectors

All fluorescent and incandescent fixtures should be equipped with reflectors of any suitable combination of white, matte silver chrome plate or aluminum finish. LED fixtures may or may not require or rely on reflectors of any kind. Fixtures should all be tarnish-, rust-, corrosion- and mark-resistant for the typical car interior environment. The fixtures should be easy to clean without susceptibility to scratching, pitting or loss of original color and surface texture.

11.3 Construction

The design of the lighting system, lighting fixtures and various components should ensure that adequate space is provided to prevent any wiring from being crushed by mechanical components or being sharply bent. It should not be located adjacent to surfaces where vibrations could create failure due to insulation abrasion. Adequate clearance should also be provided between all exposed electrical contacts and terminals and adjacent conductive components and surfaces. Such clearances should be in accordance with acceptable manufacturing practices. Each metal body fixture should employ ground wiring to bond it to the carbody.

Wiring should be stranded wire in accordance with APTA RP-E-009-98. General wiring should be in accordance with APTA RP-E-002-98. Wiring will be terminated using crimp-type pre-insulated ring-tongue lugs. Alternatively, car wiring may be connected to the fixtures through the use of railroad-approved connectors. Different connectors or keying should be employed if more than one connector is used on a fixture. Connectors should be selected for durability and very long-term availability.

Wiring should be adequately secured in position, using Ty-Raps, screw-down cable clamps, etc. Cable clamps secured to the panel by an adhesive are not acceptable for this purpose. All wires should be labeled on both ends. Wires 4 in. or less in length need only one label. LED driver or power supply, if separate, as well as ballast wiring internal to the fixture, may be color-coded as an alternative.

11.4 Identification

Each light fixture should have a permanent label and/or stamping, visible when the light cover is removed or swung down, that contains the following information:

- supplier part number
- build date
- railroad part number (optional)
- fixture voltage
- lamp identification (fluorescent and incandescent only), including fluorescent color, maximum wattage and required wattage

11.5 LED fixtures

LED lighting is a new technology that has developed rapidly in recent years, so that a large percentage of new lighting applications use it. This form of lighting offers many advantages over the older incandescent and fluorescent applications, such as much lower energy use, very long life and great flexibility for special applications. As a new technology, it is important to understand some of the differences from previous approaches. Following are some of the less obvious issues:

1. LEDs are generally “point source” and directional rather than omnidirectional, so the way the lighting is provided changes. This can affect the appearance of the area, even though intensity values are the same.

2. Unlike incandescent and fluorescent lamps, which have standardized shapes and output ratings and are available from multiple manufacturers, LED “lamps” are normally custom-designed for the application and available only from the OEM.
3. Unlike older lamp types, which have an obvious failure mode, LEDs slowly get dimmer over time and usually do not have an obvious end of life. Thus, maintenance changes, ranging from simply replacing lamps that do not light to an approach that changes out whole groups of lamps on a calendar or time basis.
4. LEDs can have a very long life compared with incandescent and fluorescent. However, the replacement parts are much more expensive and likely more difficult to change out. Thus the life-cycle cost, especially when energy costs are included, is lower. This requires a completely different maintenance philosophy and approach to stocking replacement parts.
5. Light colors from LEDs have evolved considerably since they were first introduced for lighting. The customer needs to understand the impacts of the light color specified.
6. Unlike incandescent and fluorescent lamps, which have not changed much in a long time, LED technology is still changing rapidly, so potential obsolescence of a particular product should be considered in maintenance planning. The fixture OEM should provide some guarantee to provide reverse-compatible components for the life of the fixture, upward to 40 years.

11.5.1 Expected service life

Unlike fluorescent and incandescent systems, LED-based systems will generally not just self-extinguish or fail outright when at end of life. LED systems will gradually dim in intensity beyond the L70 failure threshold, which means the light has decreased by more than 30% of its original intensity.

The standard should include a requirement that the lighting system shall provide compliant lighting levels throughout the effective service life of the light fixture or lamp. In other words, the light is considered at end of life when it can no longer provide the minimum light levels **Table 1**, as well as the Emergency Lighting Standard’s Table 1 (90-minute interval). This intensity degradation can be monitored or verified through periodic testing to determine when the components should be replaced.

11.5.2 Fixtures

LED fixtures, due to their longer life compared with fluorescent or incandescent sources, do not require frequent source change-outs. Therefore, fixtures may be either permanently sealed or be accessible (to their interior) for the purpose of repairing or replacing failed or compromised components.

Should the interior components be accessible for repair or replacement operations, then some type of deterrent should be in place, such as tamperproof hardware or inherent design features that prevent passengers or untrained personnel from gaining access to the fixture interior compartment components. All replaceable components should be easily removeable without disturbing other components or wiring.

LED fixtures can be designed to function at specific input nominal DC voltages with tolerances based on EN 50155:2021:

- 28.5 VDC (−30% +25%)
- 37 VDC (−30% +25%)
- 74 VDC (−30% +25%)
- 110 VDC (−30% +25%)

Additional information is provided in Section 11.5.6.

11.5.3 Lens/cover

LED fixture lens material should be UV stabilized and meet NFPA 130, as well as comply with 49 CFR §238, Section 103, Flammability and Smoke Generation Requirements.

At the time of this recommended practice's release, polycarbonate remains the only compliant resin currently available.

To increase passenger comfort, the lens material should provide a "diffused" appearance essentially blending the output of all LED sources visible at the surface rather than being individually identifiable through the lens.

11.5.4 LEDs

Due to the constant advancement of LED technology, it is likely that any LED selected at the beginning of a project could become obsolete over the life span of the project. Therefore, there should be some provisions made for replacing the original LEDs, providing that certain key design elements are in place to maintain consistency, including light intensity, light chromaticity and maximum power.

Two main topologies can be used for maintaining consistent color throughout the production and maintenance phases of any project: using a single LED with a nominal color (see Section 11.5.5), or mixing of two LED colors can be used to target a desired color temperature if a proper diffused lens is used in the fixture (see Section 11.5.3).

11.5.5 Color

Standard deviation color matching defines the terms of just-perceptible differences in color using MacAdam ellipses, as defined in the CIE 1964 color space. For passenger cars having fixed-color lighting, the range of correlated color temperatures for the lamps in a given part should not be greater than 3 SDCM; this includes both the individual fixture as well as all fixtures of a given type throughout the car.

Refer to the color mixing approach described in Section 11.5.4 as a good practice for maintaining consistent LED color throughout a project. The individual LEDs in each fixture should be within a 1 SDCM range.

11.5.6 Driver

The driver, whether part of the LED module or a separate device, as well as wiring must not be a source of electromagnetic interference; refer to APTA PR-E-S-010-98, "Development of an Electromagnetic Compatibility Plan."

Drivers can either be integrated on the same circuit board as the LEDs or be supplied as separate, standalone devices. Driver circuitry should integrate fuse and surge protection to alleviate any need for external system level fuses installed within or in the near vicinity of the LED fixtures.

In addition to the nominal voltages listed in Section 11.5.2, it is also possible to have LED drivers perform over the entire range of 20–137 VDC rather than operate only for specific nominal operating values.

11.6 Fluorescent fixtures

11.6.1 Fixtures

The fluorescent lighting fixtures should contain 37 or 74 VDC inverter ballasts and/or 240 or 120 VAC ballasts. If possible, all ballasts should be integral parts of the fixtures, conveniently located and easily removed from the fixtures without disturbing other components and wiring.

11.6.2 Fixture sockets

Fluorescent fixture lamp holder sockets should be designed to support the ends of the lamp, in addition to that obtained from the terminal pins. This feature should be achieved by an approved built-in locking device, such as in the lock sockets. Lamp holders should meet or exceed the requirements of UL 542.

11.6.3 Lens and covers

All fluorescent fixtures should have lenses of a UV stabilized polycarbonate. Alternatives will be considered, including designs incorporating louvers, provided that the issue of cleaning can be resolved, and subject to design review. The lenses should not have any edge gaps or holes enabling raw light to be directly visible from bulbs or reflectors. All reflectors should be designed to minimize dust accumulation and be easy to clean. All covers should be designed to minimize dust accumulation.

Overhead light assemblies should be designed for relamping from below by swinging down the lens door assembly. Fasteners securing the door should not be mounted directly in the polycarbonate to avoid cracks.

11.6.4 Ballast

Integral ballast designed for proper operation of lamps should be mounted for ease of maintenance within the fixture. This can take the form of surface-mount or a mounting on the back side of a hinged door secured with captive hardware. Accessibility to the ballast wiring must also be addressed. If the ballast includes an indicator light, this should be easily visible with the lens cover open.

In order to avoid large dark spots when a ballast fails, adjacent fixtures should not be powered from the same ballast. However, wiring runs of the ballast wiring should be kept under 10 ft.

All ballast should meet the requirements of UL 595 and ANSI C82.

11.6.4.1 AC ballast

All AC ballasts should be U.S. source, high-efficiency, high power factor, rapid start units. The ballast must not sustain damage from removing a lamp while in operation and must automatically restart when a new lamp is installed. The ballast and wiring must not be a source of EMI; refer to APTA PR-E-S-010-98, "Development of an Electromagnetic Compatibility Plan." Required features include the following:

- **Starting temperature:** 50 °F (ballast must be able to start when at 50 °F or above)
- **Sound rating:** A
- **Class:** P

11.6.5 DC (inverter) ballast

All inverter ballasts should be U.S. source, rapid start, high-efficiency, high-frequency units (20 kHz or above). The ballast must not sustain damage from removing a lamp while in operation and must automatically restart when a new lamp is installed. The ballast and wiring must not be a source of EMI; refer to APTA PR-E-S-010-98, "Development of an Electromagnetic Compatibility Plan." Required features include the following:

- **Starting temperature:** 50 °F (ballast must be able to start when at 50 °F or above)
- **Sound rating:** A
- **Input voltage range:** Designed to operate normally from the nominal supply voltage, with capability for continuous operation over full input range, self-protected against low, high and reversed polarity input

11.7 Incandescent light fixtures

All incandescent fixtures should have lenses of molded, UV stabilized, translucent or frosted white polycarbonate and should deliver light evenly, free from glare when viewed directly. Alternative materials will be considered, subject to design review. All lenses and/or door assemblies should swing down or be removable from the front for renewing bulbs. The cover/lenses should be designed to distribute the light evenly on the surface area. Reading and general incandescent lamps should have lenses that will aid in light distribution, prevent glare and facilitate easy bulb replacement.

11.8 Lamps

Lamps should be chosen that are suitable for the rough duty service found in the normal railroad environment. Without sacrificing lighting performance, the number of different types of lamps required should be kept to a minimum, preferably those already in use by the railroad. Only lamp types readily available in the U.S. marketplace should be used. Fluorescent lighting is preferred over incandescent, wherever it does not compromise lighting function.

Socket-mounted LEDs are available in a few types, typically for indicator-type applications.

Fluorescent lamps should be rapid start, energy-efficient, long-life types, such as T-8, and compact types such as PL-9, which meet EPACT standards. Lamp color should be determined by interior design considerations.

11.9 Reading lights

Reading lights on new equipment are almost universally now LED, superseding incandescent and especially halogen lamps. A switch is normally provided to allow individual control of each light by the passenger. Fixtures can usually be aimed by the passenger to suit their individual needs, in both a lateral and longitudinal direction.

If a reflector is used (not required for LEDs), it is highly desirable for it to be part of the fixture itself, rather than to be part of the bezel assembly. The reading light switch must be selected to be robust as well as for a very high cycle life, in excess of 300,000 cycles at rated load, due to the frequent use. Since reading light fixtures are normally quite compact and the lamp may get hot, care is necessary to ensure that the surfaces that can be touched by the user do not exceed 140 °F. (60 °C.). Since LEDs are somewhat temperature sensitive, care may be required to ensure that these high-output devices have sufficient cooling. The switch should be mounted in such a way that it is accessible for servicing and replacement without major effort.

11.10 Controls

Lighting controls should be obvious in use and convenient to the passenger or crew as appropriate. Switches must be of high quality, be robust, have a very high cycle life (300,000 cycles or more), and be dust-resistant. Switches in potentially wet locations should be waterproof. They should be mounted in such a way as to not work loose on the mounting. On ferrule-mounted switches, this includes providing keying in the keyway. Switches should be mounted in such a way as to make them available for servicing and replacement without major effort in disassembly of the car interior.

Accessible locations must be equipped with controls in compliance with ADA requirements, as identified in 49 CFR §38.127, (ADA-intercity rail cars) Sleeping Compartments. This includes at a minimum ADA seating areas as well as ADA sleeping car rooms. Switches, clearly labeled, should be provided for activating night light or quiet car lighting modes, etc. of main lighting, rather than relying on circuit breakers to act as primary control switches.

Lighting controls should be clearly labeled with permanent labels. Where functions are complicated, such as those in a sleeping car room, an instruction label may be appropriate.

11.11 Design for exterior fixtures

In addition to providing the required lighting performance, exterior fixtures have the additional requirement of being mechanically robust to remain reliable under demanding environmental conditions, such as weather, and potential impact damage. The fixtures must be inherently waterproof in addition to providing a waterproof seal to the carbody for the life of the fixture, including protection from solvents used in car washers. Mechanical damage may occur from car wash brushes, striking wayside debris, snow/ice buildup and impact, and accidental impact during routine servicing. The fixtures are also exposed to a very wide range of temperatures, from −40 to +130 °F, car motion, and wind-driven weather such as wind, dust, hail, sleet, rain, etc. Stainless steel or other corrosion-resistant materials are preferred for the housing.

A waterproof seal to the carbody is critical to avoid water leaking into the carbody where it is not seen and causing damage, such as wet insulation or potential corrosion inside the walls. This is a common problem that can be prevented through the use of a soft, compliant gasket of low durometer. The design should consider employing solid stops behind the mounting screws, which provide metal–metal contact. This allows appropriate compression of the gasket without overcompressing it and also provides indication of when the fastening screws are properly tightened.

The plastics used in most commercial exterior LED fixtures do not meet the flame, smoke and toxicity requirements of NFPA 130.

Electronics and associated wiring employed in the lighting system may produce radio frequency emissions; in order to not interfere with other car equipment as well as crew radios, the lighting system must conform to the requirements of APTA PR-E-S-010-98, “Development of an Electromagnetic Compatibility Plan.”

11.11.1 Marker light fixtures

The surface-mounted fixture is generally mounted on the car end sheet such that most of the fixture is inside the carbody. Serviced from the outside, it is typically equipped with a hinged door that is secured with one or more captive fasteners, which hold the lamp securely in the fixture. The lamp face, whether LED or incandescent, is normally exposed directly to the exterior, without a lens on the fixture. The lamp shall be keyed to provide directional orientation and to prevent rotation within the fixture. The fixture should be identified with a “This end up” label so it is oriented correctly when being installed.

11.11.2 Door and brake status fixtures

These fixtures are used either as solo or as two- or three-lamp clusters. The red door open indicators are required outside each passenger exterior door, on both sides of the car. The brake status indicators generally incorporate a pair of lamps, one green (all brakes released) and amber (all brakes applied). Since the brake status indicators are located diagonally on a car, it may be effective at some sites to combine the door status indicator into the assembly. Indicators of other colors, such as blue, may be used by some railroads for additional functions.

The fixtures are low profile to not violate the car clearance envelope, with the lenses facing fore and aft along the carbody. LEDs are almost universal for this fixture, providing a convenient, narrow beam of colored light parallel to the carbody that can be easily seen by crew sighting along the consist, even in bright daylight. Care needs to be taken to ensure that the lamp is not excessively bright, as the crew member may be very close to the fixture on their car when sighting along the train. The lenses on these fixtures need to be easy to clean, as they tend to get quite dirty from dirt stirred up by the train, as well as diesel exhaust. Since these lamps see a high number of hours illuminated, they should be easily removed to replace the LEDs or incandescent lamp. The gasket sealing the fixture to the carbody should be replaced during such relamping to ensure that the waterproof seal is maintained.

11.11.3 Platform/ground light fixtures

These fixtures are particularly subject to environmental damage, since they are located quite low on the car or under it. Accordingly, they need to be designed to be robust in that demanding climate. LED-type strip lighting has been used successfully recently, especially for platform lighting, where the LED properties of small size and high directionality are well-suited. A fully hermetic fixture may be desirable.

12. Design reviews and first article inspection

12.1 Design reviews

Since engineering design for passenger car lighting is complex, design review at several stages is recommended.

Information should be provided to the customer for approval for each car type as part of the design review:

- Location of all fixtures.
- Identification of all fixture types.
- Location and type of all light switches.
- Lamp type(s) and quantity in each fixture.
- Plan showing what lighting is illuminated during normal, standby (if equipped), load shed (if equipped) and emergency lighting modes. If quiet car and/or night operational modes are intended, fixtures that are illuminated during these modes should also be identified.

12.2 First article inspection

The first article inspection should be conducted on all fixtures at the manufacturer's facility, as well as at the final inspection on the finished car to determine the functionality and effectiveness of the design. The samples should be evaluated for not only conformance to drawings, functionality, fit, etc., but also for maintainability. Any deficiencies noted should be corrected.

13. Evaluation measurements and tests

13.1 General

A qualification test should be conducted on each car type to determine whether the design meets the requirements. A report should be provided to the railroad showing the light levels measured and the procedure used to obtain the readings.

Since the primary considerations in railroad passenger car lighting vary with the accommodations and the task as described, evaluation measurements should be based on tasks or functions normally found in the full complement of railroad passenger cars. In evaluating the lighting system level for any particular car, the applicable combination of measurements will have to be employed. Testing is required for normal lighting and standby lighting (if so equipped) as well as any other operating modes, such as night lights and/or quiet car mode. It may also be convenient to conduct emergency lighting tests in conjunction with this test, per APTA PR-E-S-013.

The test plan should be submitted for railroad approval prior to conducting the test. It should include each component type and each car configuration. A report should be provided showing the light levels measured and the detailed procedure(s) used to obtain the readings.

This test should be completed before the equipment is released for operation in revenue service.

13.1.1 Qualification test (initial verification)

This is an engineering proof-of-design test conducted on the following:

- a brand-new car before it is placed into service
- an existing car that has had the normal lighting power source and/or the normal light fixtures modified or replaced, different from that when the car last had a qualification test (refer to **Table 3** for an explanation of required retesting)

This test is typically done on one new car. However, if several similar car types are part of the same order, one complete car should be tested for light intensity, and the areas unique to each of the other car types also tested for intensity, so that light measurements of all locations are taken. For example, if one car was a coach and another a food service car with the rest of the car having seating identical to the first coach car, only the food service area would need to be tested on the second car.

This test should be conducted to demonstrate the system performance of normal lighting system from the revenue service power source.

13.1.2 Test procedure

A detailed, step-by-step test procedure is required to conduct the lighting test. It should include the following, at a minimum:

1. Purpose (new car qualification, partial car qualification, etc.)
2. Equipment on which it will be conducted (typically car number series)
3. Any references required, such as lighting arrangement drawings, etc.
4. Prerequisites for the test (identifying the state of the car to be tested (light fixture lenses clean, new lamps, etc.)
5. Test equipment to be employed (light meter, multimeter, etc.)
6. Initial conditions required (include sketch identifying exact site of each measurement; refer to Appendix C)
7. Step-by-step procedure for taking the measurements
8. Data sheet to record readings (refer to Appendix C)
9. Test conclusion with signatures of those conducting/witnessing the test

13.2 Preparation for tests

13.2.1 Car preparations

The car to be tested is to be in condition suitable to conduct the test accurately under known, reproducible conditions.

13.2.1.1 Light fixtures

- Lenses must all be in place and clean.
- Incandescent and fluorescent lamps should be new. The latter should be aged for at least 100 hours before the test to ensure they achieve full light level.

13.2.1.2 Car interior

- Car should be configured and equipped as it would be in readiness for revenue service, but it can be free of consumable items.

13.2.1.3 Temperature

- Lighting is temperature-sensitive; car interior should be at normal operating temperature for revenue service.
- In addition, the car lighting system should be under power for at least 15 minutes before the test is started to warm up fixtures to the temperature they would experience in normal operation.

13.2.2 Initial conditions

- The car should be configured as indicated before beginning the light level measurements. The intent is to configure the car in test to simulate it being in a dark area, on a clear, moonless night. The car should be arranged as it would be in typical revenue service. In addition, the individual reading locations are intended to be areas of interest to passengers and/or crew.
- 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 one-tenth of the lowest applicable minimum required measurement.

The method of darkening the car can be one or a combination of the following:

1. Place car in a windowless shop facility where all shop lighting can be extinguished to make it completely dark, such as a climate room, paint booth, car wash, test area, etc.
2. Secure the car to be tested so it does not move by applying the handbrake and placing chocks at the wheels. Blue flag as required.
3. Place the car in area where it will not be disturbed. Cover all car exterior windows with opaque covering, such as tarpaulins, cardboard, etc. Use care when covering exterior lights such as headlights, auxiliary lights, marker lights, etc., as they can get very hot and melt coverings or even cause a fire.
4. Do not darken any windows within the carbody such as vestibule windows.
5. For any cars equipped with drapes/curtains over side windows, these should be closed fully throughout the car.

13.2.2.1 Doors

1. All exterior-facing doors should be closed (exterior side doors, end frame doors, stock loading doors/hatches, etc.)
2. All interior doors should be closed (vestibule, passageway, restroom, galley access, cab, etc.). For cars equipped with individual rooms, such as sleeping cars, these doors should be closed. Any curtains/drapes on windows, both interior as well as exterior, of these rooms should be fully closed.
3. Once a particular reading is taken, the door should be returned to the initial closed position.

13.2.2.2 Mark locations where readings will be taken

1. To expedite taking readings, the site of each required reading should be marked on the car, such as through the use of masking tape or stickers. It is helpful to number each site.
2. For the 25 and 33 in. heights, a small stand should be created upon which to place the light sensor.
3. For semipermanently coupled trainsets, the testing of the semipermanently connected areas must be addressed in the test plan.

13.2.2.3 Configure car power system for test

- The cars under test should be connected to the power sources they would experience in normal revenue service (HEP, catenary, third rail, etc.).
- All the AC and DC electrical loads that are normally present in revenue service should be energized during the normal lighting tests. Circuit breakers should be set so that those loads (door operators, PA system, controls, headlights or marker lights, etc.) are powered.
- The tests for standby lighting (if equipped) should be conducted with battery power only; any feeds from HEP, auxiliary or wayside power should be disconnected.

13.3 Data collection

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

1. Number of car
2. Car type (e.g., Superliner-1 Sleeper)
3. Location where test is conducted (geographic location and building; for example "In car wash building in Amtrak 14th Street shops, Chicago")
4. Year car was put into service
5. Identification of individual(s) conducting test
6. Date(s) test conducted
7. Time of day
8. Car interior air temperature
9. Outside ambient temperature
10. Start and end times
11. Method of darkening car (photos may be attached as reference)
12. Instruments used:
    a. Manufacturer and model number
    b. Serial number of instrument
    c. Date of last calibration
    d. Whether equipped with color-correction filter
13. Identification of area tested (e.g., entire car, vestibule, aisle, passageway)
14. Lighting fixture characteristics:
    a. Type of lighting fixtures and record of which fixtures were lighted (this could be shown on a lighting arrangement drawing)
    b. Condition of fixtures
        - New or old
        - Type of reflector and condition (if equipped)
        - Cleanliness
15. Wattage and rated voltage of lamp (only incandescent)
16. Color temperature or manufacturer's model number of lamps (especially important for fluorescent lamps)
17. Location of readings (need an illustration to show this; could be lighting arrangement drawing)
18. AC and DC bus voltage of all systems powering lighting at start of test
19. Individual illumination level measurements taken.

This information must be included with the test procedure documentation. A copy of such documentation is an acceptable record.

Appendix B describes steps to follow if the illumination levels do not meet the criteria specified in **Table 1**.

Appendix C contains a data sheet form suitable for recording all the above information.

13.4 Procedures for measuring illuminance of normal lighting systems

13.4.1 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 the following:

- **Basic accuracy:** ±3% of reading ±1 digit or better
- **Resolution:** 0.01 fc or better
- **Cosine error:** No more than 6%, measured at 50 deg.
- **Color correction:** To CIE photopic curve

To ensure that the close proximity of the person taking the measurements does not affect the readings, unless the floor measurement value is known to be at least five times the value in **Table 1**, a 6.5 ft (2 m) separation between the sensor head and the display must be used. If the measuring apparatus is unlit or if there is no light emitted from the apparatus, the 6.5 ft requirement need not apply.

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

Appendix C contains a sample data collection form that includes all necessary data items.

13.4.2 Battery source

Tests conducted to measure lighting performance when operating from a battery source, such as standby and emergency lighting, should include the following:

- The state of the battery system must be identified, including previous history.
- The battery should have been fully charged before the test, for a minimum of eight hours.
- Car loads should be identified so the test is conducted on a battery that is supporting all its normal loads, including items such as door operators, PA system, control systems, headlight or marker lights, etc.
- Battery terminal voltage should be measured at the beginning of the test, and at least every 5 minutes during the test.
- Continuous recording using a “strip chart,” recording digital voltmeter or data acquisition system is recommended.
- The test interval will start at the loss of HEP/auxiliary power.
- The “end” of the test is defined either to be the time when the overall battery terminal voltage equals 1.0 V per cell times the number of cells in the battery or that specified by controlling standards.

13.4.3 Data collection timing

The car normal lighting illuminance performance readings should be taken at the start of the test after the normal lighting is activated. All data should be recorded. For cars equipped with standby lighting as well as normal lighting, separate tests must be conducted on each system.

For cars equipped with standby lighting, an acceptable alternative to using the main car battery for the measurements is to characterize battery voltage performance as a function of battery discharge time, as long as the other factors that affect the performance of lighting systems are considered. 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.

13.5 Required location measurements

These measurements are intended to be used to provide verification of design in accordance with **Table 1**. The measurement readings are taken with the sensor placed on the locations identified in that table, using stands, adhesives or supports as necessary. The observer simply records the readings using a form similar to that contained in Appendix C. This section provides details as to the techniques used in taking the readings, as well as the reasoning behind them.

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.

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

There may be instances where stanchions, windscreens or other interior features are introduced following the original design or installation of the main lighting system. In the event that these features create "shadow zones" that negatively affect the target lighting measurement locations summarized within **Table 1**, it is acceptable to move the light meter away from the situational shadow area in a horizontal plane. The intent is to adjust the measurement position by as small a distance as possible, not exceeding 3 in. in any direction. Stair tread, door threshold and door handle measurements are exempt from such consideration.

13.5.1 Door exit control/manual release instructions

The normal lighting system is generally used to charge HPPL signage and exit path markings. There are no specific requirements in this document regarding required values; they are defined in APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Level Path Markings for Passenger Rail Equipment."

13.5.2 Vestibules

Readings should be taken at the floor on a horizontal plane.

The arrangement of the vestibule area of cars varies greatly among car types, including some with traps, some without. Readings should be taken on the floor as described below.

13.5.2.1 Floor

Readings should be taken at the following locations:

- geometric center of the vestibule
- geometric center of each trap (if car so equipped)
- halfway between centerline of car and exterior door on both sides of car (if car lacks traps)

Or, for cars that have long vestibules, with fixed stairs and no traps on both sides (such as gallery cars), three readings may be taken along the centerline of the car, evenly spaced between the vestibule bulkheads.

13.5.2.2 Exterior side door threshold

- Readings should be taken at the center of the threshold.
- For cars equipped with traps, readings are to be taken both with the trap closed and open. For the open condition, the reading is at the bottom step leading edge.

13.5.2.3 Vestibule steps

- Readings should be taken at the geometric center of each step. If stairway is divided by stanchions, each section is its own stairway.

13.5.2.4 Outside platform (intercity cars, commuter cars operating at unlit platforms)

- Readings should be taken at the corners and within the area defined by an area the width of the threshold, 3 ft extending outside the car. This is to be taken at platform levels with which the car is compatible: high level, low level or both.

13.5.3 Diaphragms and gangways

There are two scenarios of car-to-car diaphragms: semipermanently coupled car trainsets (gangway) and the conventional where cars can be uncoupled. Trainsets generally have wide diaphragm paths, with the area fully enclosed. Traditional diaphragms are narrower and less fully enclosed. This path allows passenger/crew to safely move between coupled cars.

The conventional type is measured at floor level, as there is a potential trip hazard there, while the trainset is measured at 25 in. because it functions more like a passageway.

13.5.4 Interior stairways

For interior stairways, a measurement should be taken on the tread near the geometric center of each step and landing. If there are landings or corner steps where direction of travel changes, measurements at the center of that step/landing are also required.

13.5.5 Passageways and aisles

Here the task calls for most horizontal measurements at the floor level for both passageways and aisles. Seat selection measurements are above floor level. One reading at selected intervals on the longitudinal centerline of the passageway or aisle should be taken. If no other selected interval is stated, 4 ft (1.22 m) should be used.

For gallery cars, the aisles of the gallery level should also be measured in addition to the aisle of the main level.

For bilevel and multilevel cars, the aisle and/or passageways should be measured on each of the levels: lower and upper level, as well as intermediate (as applicable).

13.5.6 General seating lighting

Measurements should be taken 33 in. (84 cm) throughout the seating area, with a sufficient number taken to be representative of the area. Unless otherwise specified, these readings should be taken at least every 6 ft. An average should be taken of all the readings. If the car is equipped with reading lights, they should be turned off for these readings.

13.5.7 Reading plane measurements

Measurements of foot-candle values should be made at the center front edge of each seat on a 45 deg. plane, 33 in. (84 cm) above the floor with the meter or test plate turned toward the seat (approximate reading plane). Where seats are reversible, measurements should be taken with the seat in the forward and reverse positions. Where seats are double or triple, as in a coach, readings should be taken at both the aisle, center (if equipped), and window seats. Sufficient readings should be taken throughout the space to determine any variations between center, sides and ends of the area being measured.

13.5.8 Dining or other table measurements

Readings should be taken with the paddle or meter on the table, 8 in. (21 cm) in from the edge of the table at each seat location. For small tables, such as in lounge areas, take the reading at the center of the table.

13.5.9 Food service areas

Measurements will be made on a horizontal plane at all work surfaces. Sufficient readings should be taken to obtain an average for the whole surface. Reading spacing should not exceed 3 ft.

Measurements will be made on a vertical plane at all food storage areas. Sufficient readings should be taken to obtain an average for the whole area. Generally, a reading at the geometric center of each door of storage areas is sufficient.

13.5.10 Baggage cars and baggage compartment

Measurements for most areas are defined in the above sections. The requirements unique to this section are those of the baggage areas themselves. For open areas other than the aisle and doorways, the reading should be taken at floor level at the approximate geometric center of the area. For longer open areas, a reading should be taken at least every 6 ft.

For areas with baggage shelves, readings should be taken at the approximate geometric center of the lowest shelf. For areas with bike racks, the reading should be taken at the floor, in the approximate geometric center of the bike area. Since there may be shadowing from any upper racks, the light sensor may be moved as necessary to avoid the shadows. Since it is impossible to identify all possible arrangements of baggage compartments, the measurement sites may need to be adjusted to make them appropriate to the situation. The point is to ensure there is sufficient light to safely and conveniently conduct the activity.

13.5.11 Cab area of cab car

Measurements for most areas in the cab area of cab cars are already identified in the above sections. The requirements unique to the cab area are those centered around the engineer and other crew members as applicable. It is critical that the cab lighting not interfere with the operator's view of the track ahead during nighttime operation.

With cab lighting set up for nighttime operation—ceiling light off, screens, gauge and instrument lights at normal levels, reading light off—verify that there is no glare on the windshield. If this is a full-width cab, also verify that the second windshield is free from glare.

With the cab set up as above for nighttime, turn on the white reading light at full brightness and read the light level perpendicular to the surface where train orders, etc. would be read. For full-width cabs, also take this reading for the second seat position.

For the general lighting measurement, one or more locations should be selected by the authority having jurisdiction; the point is to have the reading show that the cab lighting is adequate to safely and conveniently conduct the necessary activities. As a default location, use the center of the operator's seat (and any other crew seat), with cab seat roughly centered in its various modes of adjustment.

13.6 Retesting normal lighting

When portions of the car normal lighting system are altered, overall system performance may change. Accordingly, it is recommended that modified areas be retested as shown in **Table 3**.

TABLE 3
Recommended Retesting

System Change	Retesting Requirement	Rationale
Reconfiguration of car interior (e.g., replace restroom)	Intensity of affected areas test	Since only a small area of the car is affected, only that portion needs retesting.
Relocation of existing normal lights, using same fixtures and quantity	Intensity of affected areas test	
Local replacement of existing lights with different light source (e.g., LED), or fixture. (e.g., new vestibule lights)	Intensity of affected areas test	
Whole-car replacement of existing lights with different light source (e.g., LED), or fixtures	Full retest of intensity	This is in effect a new installation and as such requires a full qualification retest.

When testing is required, at least one example of all affected areas should be tested. For example, if only the lavatory normal lighting configuration has changed, then only the lavatory need undergo illumination testing, as the rest of the car is unaffected. The areas tested need not be from a single car.

13.7 Recordkeeping

Railroads should retain a copy of the test procedure describing the method used to obtain the measurement readings and a copy of the test data showing the illumination levels measured at the required locations, as well as the results of such tests.

Railroads should retain a copy of the test results until cars of that type are retired, or are transferred, leased or conveyed to another railroad. If the lighting system is modified and/or retested, these test reports should also be retained. Having subsequent test results is useful in determining how light level deteriorates (if at all) over time, which impacts light source replacement intervals. A copy of such records should be transferred to the accepting railroad along with any such cars.

Related APTA standards

APTA PR-E-RP-002-98, “Wiring of Passenger Equipment”
APTA PR-E-RP-009-98, “Wire Used on Passenger Equipment”
APTA PR-E-S-010-98, “Development of an Electromagnetic Compatibility Plan”
APTA PR-E-S-013-99, “Emergency Lighting System Design for Passenger Cars”
APTA PR-PS-S-006-23, “Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment”
APTA PR-M-S-018-10, “Powered Exterior Side Door System Design for New Passenger Cars”

References

Code of Federal Regulations:
49 CFR §38.101, (ADA-Commuter Cars) Lighting
49 CFR §38.119, (ADA-Intercity Rail Cars) Lighting
49 CFR §38.127, (ADA-Intercity Rail Cars) Sleeping Compartments
49 CFR §238.103, Fire Safety
49 CFR §238.131, Exterior Side Door Safety Systems
49 CFR §221, Rear End Marking Device
49 CFR §229.127, Cab Lights

Food and Drug Administration, U.S. Public Health Service Food Code, 2017, 6-303.11.

IES Lighting Handbook Reference and Application, 8th edition.

UL 542 Underwriters Laboratory, Lampholders, Starters, and Starter Holders for Fluorescent Lamps.

International Commission on Illumination, CIE 1964, “Color Space.”
https://en.wikipedia.org/wiki/International_Commission_on_Illumination

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, which is not bordered by walls, such as down the center of a coach car that has a row of seats on each side (may include a ramp or single step).

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, air conditioning, etc.

brightness ratio: The ratio of the light level in one area with respect to the light level in another area.

car: For this recommended practice, a unit of passenger rolling stock, including baggage cars.

color rendering index: A quantitative measure of the ability of a light source to reveal the colors of various objects faithfully in comparison with a natural or standard light source. The higher the number, the more accurate the color. 100% is the maximum value. The value is composed of the averages of 14 different color wavelengths (known as R1, R2, R3, etc.).

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.

diaphragm, conventional: A flexible enclosed walkway for the passage of passengers and crew between two adjacent cars, having two pieces, one located on the adjoining end of each car. These accommodate relative angular, lateral and vertical displacement between the ends of cars by means of sliding buffers at the floor level and by sliding faceplates with bellows or tubes sliding at the sides and top. This is typically employed on cars that get uncoupled.

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

gangway: A flexible enclosed walkway for the passage of passengers and crew between two adjacent cars, employing a continuous bellows that is sufficiently flexible to accommodate relative angular, lateral and vertical displacement between carbodies. This is typically employed on semipermanently coupled or articulated (angular motion only) cars.

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, 60 Hz three-phase systems are most common.

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) (1 fc = 10.76 lux).

lighting, emergency: A lighting mode that is activated when power for the normal lighting and standby lighting (if equipped) becomes unavailable in a car.

lighting, night: Low-intensity lighting provided on a car to allow passengers to sleep without annoyance, while still allowing sufficient light for orientation and safe passage throughout the car. Colored lamps or fixtures having colored lenses are often used.

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

lighting, standby: Lighting mode that is available (on some cars) when the car loses HEP or the auxiliary power system but the battery has not yet discharged to load shed. This mode is intended to keep the majority of the lighting operating for a short period (15 to 30 minutes or more) so that short-term power outages, such as those that occur during third rail gaps or catenary phase breaks, as well as when adding cars or changing locomotives at the station, will have only a minor effect on passengers. This type of light is used primarily on newer intercity passenger cars.

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 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.

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 typically consists 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).

luminance: Amount of light (luminous flux) falling on a specific area or surface. English units are foot-candles (fc) or lumens per square foot (lm/sq ft). International units are lumens per square meter (lm/m^2) or lux (lx).

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.

main car battery: A battery or set of batteries used to provide power to a car or trainset in case of loss of normal power during normal operations.

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

power, standby: Power mode that is available (if so designed) 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 those normal lighting fixtures also used as emergency lighting fixtures, operating for a short period (90 seconds to 30 minutes or more) so that short-term power outages, such as those that 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.

reflection factor: The amount of incident light returned from a particular surface.

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).

room/compartment: A space that can be occupied by passengers or crew, which is 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.

stairway: A continuous set of steps not interrupted by a landing.

stanchion: An upright bar, post or support.

threshold: A raised metal strip, located below and parallel to a door when in the closed position, which marks the boundary between the areas the door divides.

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.

Abbreviations and acronyms

ADA	Americans with Disabilities Act
CIE	International Commission on Illumination
CFR	Code of Federal Regulations
EMI	electromagnetic interference
fc	foot-candle
FDA	Federal Food and Drug Administration
FRA	Federal Railroad Administration
HEP	head end power
HPPL	high performance photoluminescent
LED	light-emitting diode
lx	lux
SDCM	standard deviation color matching
PA	public address
PAR	parabolic aluminized reflector
PCB	printed circuit board
UL	formerly Underwriters Laboratories
V	volts
VAC	volts alternating current
VDC	volts direct current
W	watt

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First published	—	—	—	March 4, 1999	March 17, 1999
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The passenger rail industry phased this recommended practice into practice over the six-month period from July 1 to December 31, 1999. The recommended practice took effect January 1, 2000.

Appendix A (informative): Data collection guidance

Equipment

There are at least three handheld meters on the market with adequate accuracy and sensitivity for this application. These meters are listed below and illustrated in **Figure 3**:

- 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 13 are also acceptable.

FIGURE 3
Typical Meters for Illuminance Measurements

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 forgo 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, Class II (which permits unlimited errors for angles of incidence greater than 60 deg.), 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.

> **NOTE:** CNS 5119 is a standard developed in Taiwan. It is available for viewing in English at https://cns-standards.org/CNS_standard.asp?CODE=CNS%205119.

Other considerations: The Minolta can be set to read out in foot-candles or lux; the Gigahertz-Optik meter may be ordered with either foot-candles or lux displayed; while the Hagner meters read out in lux only. The Minolta 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 that the optional A20 and A21 adapters are purchased. The other meters have 6.5 ft (2 m) cables permanently attached to the sensor.

Computer data collection

The measurements required by Section 13 must be performed by manually placing the light sensor at the designated locations. As an alternative, aisle measurement readings to determine the illumination levels required in **Table 1** can be taken much more quickly and 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.

FIGURE 4
Apparatus for Measuring Average Illuminance Levels

Consists of a handheld 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.

To collect data representative of illumination levels at armrest height, an apparatus must be constructed to support the sensor at a height of 25 in. (64 cm) above the floor and to carry the meter's electronics and computer/data logger. **Figure 4** 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 6 ft (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 an appropriate number of samples (e.g., 60 or more samples), so the data collector should walk at the rate of about 1 ft 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.

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 per Section 13.

Appendix B (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 are 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 that 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 (such as T12) with those of recent design (such as T8) that provide 10% to 15% more light for the same wattage rating and double the service life.
- Replace existing fluorescent lamps with LED types. (Note that this may have directional impact on lighting.)

Appendix C (informative): Sample data sheet

The following is a generic sample of a data sheet to be used to record the results of normal light performance tests. If the car is equipped with standby lighting, additional similar sheets will be required to record data in both normal as well as standby lighting. Likewise, cars equipped with night lighting and/or quiet car mode lighting will also require additional data sheets. Each railroad will need to review the content and adjust it according to the specific needs of their rolling stock.

Sample Data Sheet, Normal Light Performance

Test Type	☐ Qualification ☐ Periodic ☐ Other (explain)
Date of Test	
Car Number	
Carbuilder	
Car Series (M1, M2, etc.)	
Car Type (coach, cab car, etc.)	
Facility where conducted Geographic location and where: e.g., “in car wash building in Amtrak 14th Street shop, Chicago”	
Test Conducted By	
Test Witnessed By	
Time of Day Test Started	
Car Interior Temperature (Estimated)	
Car Exterior Temperature (Estimated)	
Main Battery Capacity A-H (If Applicable)	
Main Battery Installation Date (If Applicable)	
Renewal of LED Fixtures Date (As Applicable)	
Renewal of Fluorescent Lamps (If Applicable)	
Other Comments	
Starting Time for Series of Measurements: (HH:MM)	

Instruments Used				
#	Test Instrument	MFG Model	Serial #	Calibration Due Date

Light Intensity Readings				
#	Text Reference	Location of Reading	Reading	
			Left or A-End	Right or B-End
	13.5.1	**Door emergency exit controls/manual releases (see APTA PR-PS-S-006)**		
		1		
		2		
		3		
		Vestibule (each vestibule)		
	13.5.2.1	Vestibule floor, center		
		Center of trap, left side		
		Center of trap, right side		
	13.5.2.2	**Exterior side door threshold (each vestibule)**		
		Trap closed, door open, left		
		Trap open, door open, left		
		Trap closed, door open, right		
		Trap open, door open, right		
	13.5.2.3	**Vestibule steps (each vestibule)**		
		Top step		
		Second step		
		Third step		
		Fourth step		
		Top outside step		
		Second outside step		

Light Intensity Readings				
#	Text Reference	Location of Reading	Reading	
			Left or A-End	Right or B-End
	13.5.2.4	**Outside on platform (each vestibule)**		
		Trap closed, left corner		
		Trap closed, right corner		
		Trap open, left corner		
		Trap open, right corner		
	13.5.3	**Conventional diaphragm**		
	13.5.3	**Gangway**		
	13.5.4	**Stairway, interior (each stairway)**		
		Top step		
		Second step		
		Third step		
		Fourth step		
		Landing, upper		
		Fifth step		
		Sixth step		
		Seventh step		
		Landing, lower		
	13.3.5	**Passageway**		
		1		
		2		
		3		
		4		
	13.5.5	**Aisle (each aisle: gallery car, bilevel or multilevel)**		
		1		
		2		
		3		
		4		
		5		
		6		

Light Intensity Readings				
#	Text Reference	Location of Reading	Reading	
			Left or A-End	Right or B-End
		7		
		8		
		9		
		10		
		11		
		12		
		13		
		14		
		15		
		16		
		17		
		18		
		19		
		20		
		Restroom (each)		
		mirror		
		area		
		restroom: ADA		
		mirror		
		area (maybe more than one reading)		
		Switch locker/electric locker		
		Service lighting/equipment room (each)		
		1		
		2		
		3		
		Commuter coach, general lighting- (without reading lights)		

Light Intensity Readings				
#	**Text Reference**	**Location of Reading**	**Reading**	
			Left or A-End	**Right or B-End**
		Short-distance coach, general lighting		
		Seating area, general (throughout car)		
	13.5.6	Seating area, reading lights only (representative sampling)		
		Long-distance coach, general lighting		
		Seating area-general (throughout car)		
	13.5.6	Seating area, reading lights only (representative sampling)		
		Diner passenger area, general lighting		
		Seating area, general (throughout car)		
	13.5.7	Table (representative)		
	13.5.8	**Diner galley lighting**		
		Food storage area (each)		
		Food preparation area (multiple readings)		
		Food serving area and maître d' area (multiple readings)		
		Hand sink and dishwashing area (multiple readings)		
		Short-distance snack car		
		Seating area, general (throughout car)		
	13.5.6	Seating area, reading lights only (representative sampling)		
	13.5.7	Tables (multiple readings)		
	13.5.8	Food storage area (each)		
		Food preparation area (multiple readings)		
		Food serving area (multiple readings)		
		Hand sink and dishwashing area (multiple readings)		
		Sleeping car		
	13.5.6	Reading lights; only reading light on (each location within representative rooms)		
	13.5.6	Berth light; only reading light on (each location within representative rooms)		
	13.5.7	Table (each location within representative rooms)		

Light Intensity Readings				
#	Text Reference	Location of Reading	Reading	
			Left or A-End	Right or B-End
		General room lighting (each location within representative rooms)		
		Mirror (each location within representative rooms)		
		Private toilet room (representative rooms)		
	13.5.8	Coffee station (in hallway)		
		Long-distance lounge		
		Lounge area seating, general (throughout area)		
	13.5.6	Lounge area seating, reading lights only		
	13.5.7	Table area (multiple readings)		
	13.5.8	Food storage area (each)		
		Food preparation area (multiple reads)		
		Food serving area (multiple readings)		
		Hand sink and dishwashing area (multiple readings)		
	13.5.9	**Baggage car/baggage compartment**		
		Floor (multiple readings through area)		
		Open area for luggage (each area)		
		Baggage shelves/towers (each area)		
		Loading door threshold (each door)		
		Outside platform (each door)		
	13.5.10	**Crew area of MU or cab car**		
		Console		
		Floor, representative areas		
		Console where train orders read (each location)		
		Windshield (each)		
		Other specialty areas		
		Add additional areas as needed		

