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Emergency Lighting System Design for Passenger Cars

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

Keywords: emergency lighting, independent power source (IPS), normal lighting, standby lighting

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

Scope and purpose: This standard applies to all passenger rail cars that operate on the general railroad system in the United States. This standard specifies minimum performance criteria for the design of the emergency lighting system for passenger rail cars that operates when the normal lighting system is unavailable, including minimum interior illumination levels at specified locations and the minimum duration this lighting system must remain on. This standard also requires tests to validate the design.

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Introduction

This introduction is not part of APTA PR-E-S-013-99, Rev. 2, "Emergency Lighting System Design for Passenger Cars."

This standard applies to all:

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

This standard may not apply to:

1. Rapid transit operations in an urban area that are not connected to the general railroad system of transportation;
2. Tourist, scenic, historic or excursion operations, whether on or off the general railroad system of transportation;
3. Operation of private cars, including business/office cars and circus trains; or
4. Railroads that operate only on track inside an installation that is not part of the general railroad system of transportation.

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

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

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

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

This APTA standard was originally developed to provide guidance for meeting the FRA regulations and to specify the design of emergency lighting systems for passenger rail equipment, as well as minimum illumination levels, that will facilitate the ability of passengers and train crew members and/or emergency responders to see and orient themselves, to identify obstacles, and to move safely through a passenger rail car. APTA designed this standard to offer flexibility in application, as well as to achieve the desired goal of facilitating passenger and crew egress from potentially life-threatening situations on passenger rail cars.

This standard is an integral component of a systems approach for locating, reaching and operating emergency exits to facilitate the safe evacuation of passengers and train crew members in an emergency. The other required components of this systems approach include emergency signage and low location exit path marking (LLEPM), which are described in APTA PR-PS-S-006-18, "Emergency Signage for Egress/Access and Low-Location Exit Path Marking of Passenger Rail Equipment."

Each railroad has the responsibility to ensure that the design, installation and maintenance of the emergency lighting system is compatible with its internal safety policies of emergency evacuation, while complying with the performance criteria specified in this standard. Railroads and car builders should carefully consider the options available to meet emergency evacuation requirements presented in the aforementioned standard.

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

Emergency Lighting System Design for Passenger Cars

1. Types of lighting and power sources

1.1 Normal

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

Typical lighting power voltages for lighting are 240 and 120 VAC and 74, 37.5 and 24 VDC.

1.2 Emergency

Emergency power is activated when there is a loss of HEP or primary power to a passenger rail car that does not constitute a standby power activation scenario (see Section 1.3 for standby power). Emergency lighting systems shall comply with the illumination levels and duration required in **Table 1**, **Table 2,** and Section 3 and shall be powered by one or more means of an independent power source located in or within one half a car length of each light fixture it powers.

For cars ordered on or after January 1, 2024 or placed into service for the first time on or after January 1, 2028, the independent power source shall either be within each emergency light fixture or, if remote, not directly adjacent to the independent power source for the other half of the car.

> **NOTE:** Emergency lighting systems installed on passenger cars ordered prior to April 7, 2008, or placed in service for the first time before Jan. 1, 2012, may use the main car battery in lieu of independent power sources, regardless of whether or not the main car battery is within half a car length of each fixture.

Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests (see Appendix B). After a discharge test is conducted, time shall be provided to recharge the system before placing the equipment back into revenue service. Supercapacitors used as independent power sources shall have a means of identifying a faulty unit, such as a status light, manual testing, etc. These independent sources shall be charged from the normal power sources and shall be capable of operating in any orientation.

1.3 Standby

Standby lighting is powered from the car main battery system and provides near-normal lighting levels when the car has lost main power (typically HEP, third rail or catenary). Standby lighting is intended to keep lighting operational for a period as determined by the purchaser so that a short-term loss of main power will not affect the passengers' and crew's ability to safely move throughout the train. Minimum illumination levels for Standby mode shall be no less than the minimum illumination levels for Emergency mode. Equipment ordered before April 7, 2008, and placed into service for the first time before Jan. 1, 2012, may use standby lighting to fulfill the duration requirement of **Table 1**. Equipment order after this date may not use standby lighting to fulfill the duration requirement of **Table 1** and must use independent power sources separate from the car main battery.

On cars equipped with standby power, emergency power shall be activated if either of the following conditions occurs:

- Standby power is unavailable (such as from system failure or damage).
- Main car battery is depleted from operation of standby mode.

> **NOTE:** Other methods to transition from Standby to Emergency mode may be considered, provided that a hazard analysis is conducted to ensure that emergency scenarios are covered.

Standby lighting systems installed on each passenger car ordered on or after April 7, 2008, or placed in service for the first time on or after Jan. 1, 2012, shall be designed so that if there is a loss of voltage from the main car battery, the emergency lighting system is automatically activated.

> **NOTE:** Although the term is more commonly applied to dedicated systems performing as described above, "standby" as an operational situation can occur under any normal operating scenario in which HEP or auxiliary power can be expected to undergo interruptions as a normal part of operations, e.g., brief ones for phase breaks and third rail gaps, as well as longer ones for locomotive changes, etc. Typically, the extended operating requirements given above are not applicable, but either a portion of the normal lighting does remain active for the short periods of time associated with these expected interruptions, or the emergency lighting system may be activated.

2. Emergency lighting system requirements

The emergency lighting system shall be designed to facilitate the ability of passengers, train crew members and emergency responders to see, orient themselves and identify obstacles in order to enable safe movement within, through and out of a passenger car when normal lighting is not available.

The light sources utilized to comply with the criteria required in Section 2.2 shall be electrically powered (e.g., fluorescent, electroluminescent, incandescent or LED).

2.1 Location

Emergency lighting shall, at a minimum, illuminate the following areas:

- door emergency exit controls/manual releases
- passenger car aisles, passageways, interior stairways
- vestibule floor, passageway and vestibule door thresholds
- exterior side door thresholds, vestibule steps (to facilitate safe entrance/exit from the door)
- end frame door threshold
- diaphragm/inter-car passageway
- restrooms

- crew area of MU/cab car
- galley/cafe
- sleeping car rooms
- other coach/specialty car areas

2.2 Illuminance criteria

Table 1 contains minimum performance criteria for the emergency lighting system for the various areas of the passenger rail car. The values are the minimum values at the end of 90 minutes and 60 minutes, as applicable (see **Table 2**).

Emergency light illumination levels shall be tested in accordance with Section 3 (also see Appendix C). Emergency lighting systems shall be maintained in accordance with Section 6, including periodic retesting.

TABLE 1
Emergency Lighting Performance Criteria, Locations

Area	Where Measured	Conditions Under Which Measured
Initial conditions	N/A	1. The car is to be darkened, either by placing in a dark room without lighting, or by covering the car with opaque materials 2. All exterior doors (exterior side, end frame, etc.) closed 3. All interior doors (vestibule, passageway, toilet, crew office, cab, passenger accommodation, etc.) closed 4. All curtains/drapes to be closed over all windows and doorways where so equipped 5. Upper and lower berths deployed in sleeper accommodations
Door emergency exit controls/ manual releases	At location of emergency/manual door control release and associated instructions[1]	1. Door closed
Aisle (path bordered by seating on both sides)	25 in. (64 cm) above floor at centerline[1], including any steps and/or ramps included along aisle path	1. Doors closed 2. For galley cars, the aisle of the gallery level is considered an aisle
Passageway (path bordered by walls)	25 in. (64 cm) above floor at centerline[1]	1. Door closed 2. On sleepers, all room doors closed
Stairway (interior)	Center of step tread of top landing, middle step, and bottom landing. If there are landings or corner steps where direction of travel changes, center of that step/landing also.	1. Doors closed
Passageway door threshold	Adjacent door, both sides of door	1. Door closed
Vestibule door threshold	Adjacent door, both sides of door	1. Door closed

TABLE 1

Emergency Lighting Performance Criteria, Locations

Area	Where Measured	Conditions Under Which Measured
Vestibule floor	On floor[2]; three readings: 1. Center of vestibule. 2. Center of each trap door, if equipped. If not equipped, halfway between center of car and exterior door interior threshold. 3. For cars with long longitudinal vestibule (gallery cars), three readings spaced equally along car centerline between vestibule bulkheads.	1. Exterior side doors closed 2. Vestibule door(s) closed
Exterior side door threshold	At doors, at floor inside car. Point of doing with door closed and open is to verify that a passenger can locate the door from inside when it is closed and, once open, identify the edge of the car so as to aid in egress without falling.	Test conducted one side at a time. **For cars without traps:** 1. Door closed 2. Door open **For cars equipped with traps:** 1. Trap closed, door closed 2. Trap closed, door open 3. Trap open, door open 4. Trap open, door closed
Vestibule steps	Take reading at center of step tread of bottom and top steps and average readings. If stairway is divided by stanchions, each section is a separate vestibule stairway. For steps that extend outside the envelope of the car, each step must be measured individually.	1. Exterior side door open
End frame door (blind end door and collision post door) threshold	Adjacent door, inside car, and adjacent door, outside car	1. End frame door closed 2. Exterior side doors closed
Diaphragm[2]	At the center of the floor, even with the collision posts	1. Collision post door open, if there is a door 2. Light from adjacent area is allowed to contribute
Gangway[2]	25 in. (64 cm) above floor at geometric center[2]	1. Light from adjacent area is allowed to contribute
Restroom area	25 in. (64 cm) above floor[1] **Non-ADA room:** Approximate center of room (this also includes sleeper room toilets when separate room) **ADA toilet:** Average of three readings approximately evenly spaced	1. Door closed
Crew area of MU/ cab car	On floor: • Exit path to each exit door • On each stair step enroute to exit door • On each door threshold higher than 1 in.	1. Cab door closed to passenger area

TABLE 1

Emergency Lighting Performance Criteria, Locations

Area	Where Measured	Conditions Under Which Measured
Galley/cafe behind counter	25 in. (64 cm) above floor[1] Path along centerline of serving area and/or food preparation area. Several readings, evenly spaced, minimum three.	1. As set up for serving passengers 2. For diner galley, serving door open, but crew access door closed
Sleeping car passenger rooms	25 in. (64 cm) above floor, but not less than 1 in. above surface of lower berth, approximate center of the open floor area of the room remaining with berths down. (This may need to be customized slightly based on the actual floor plan. The intent is to verify that there is sufficient light for the passenger to orient themselves and locate the door to the hallway.)	1. Room access door closed.
Other coach/ specialty car areas	25 in. (64 cm) above floor[1], approximately in center of open area	1. Door closed

1. Values for these areas are averages of all the measurements made. For equipment ordered on or after Sept. 8, 2000, or placed in service for the first time on or after Sept. 9, 2002, no single measurement shall be less than one-tenth of the values in **Table 2** (i.e., 0.1 fc (1 lx) initially and 0.06 fc (0.6 lx)) after 90 minutes. For equipment ordered before Sept. 8, 2000, and placed in service before Sept. 9, 2002, no single measurement shall be less than one-tenth of the values in **Table 2** (i.e., 0.05 fc (0.5 lx) initially, and 0.03 fc (0.3 lx) after 60 minutes. See Section 3.3.3.3.

2. Applies only to new equipment ordered after January 1, 2024, or placed into service for the first time after January 1, 2028.

Note: Cars built and tested before new requirements went in effect do not need to be retested unless specifically identified.

TABLE 2

Minimum Emergency Lighting Performance Criteria, Light Levels

Effective Dates	Intensity Required (fc [lx])		Duration Required (minutes)	Power Source	Power Source Placement
	T=0	T=Duration			
Ordered before 9/8/2000, placed in service before 9/9/2002	0.5 (5.4)	0.3 (3.2)	60	Can be car battery	
Ordered on or after 9/8/2000, or placed in service for the first time after 9/9/2002	1.0 (10.8)	0.6 (6.5)	90	Can be car battery	
Ordered after 4/7/2008 or placed in service for the first time after 1/1/2012[1]	1.0 (10.8)	0.6 (6.5)	90 (standby power no longer counts toward emergency lighting requirement)	Backup power sources must meet the performance requirements for independent power sources	Independent power source(s) within one-half car length of each fixture
Placed in service for the first time after 1/1/2017	1.0 (10.8)	0.6 (6.5)	90	Must use *only* independent power sources	Independent power sources within one-half car length of each fixture

TABLE 2
Minimum Emergency Lighting Performance Criteria, Light Levels

Effective Dates	Intensity Required (fc [lx])		Duration Required (minutes)	Power Source	Power Source Placement
	T=0	T=Duration			
Ordered on or after 1/1/2024 or placed in service for the first time after 01/01/2028	1.0 (10.8)[2]	0.6 (6.5)[2]	90	Must use *only* independent power sources	Independent power sources must not be adjacent to each other

1. Standard cited in 49 CFR 238.115 on November 29, 2013.
2. Includes diaphragm and inter-car areas.

2.3 Duration

Emergency lighting systems shall operate all emergency lighting for a period of at least 90 minutes without a loss of more than 40% of the minimum illumination levels specified or 60 minutes without a loss of more than 40% of the minimum illumination levels specified for cars ordered before Sept. 8, 2000, placed into service prior to Sept. 9, 2002.

Emergency lighting systems installed on passenger cars ordered prior to April 7, 2008, or placed in service for the first time before Jan. 1, 2012, may use the main car battery in lieu of independent power sources, regardless of whether or not the main car battery is within half a car length of each fixture, and shall comply with the former definition of emergency lighting. This means that these cars may utilize standby power to fulfill the illumination duration and intensity requirements in part or in total.

All cars ordered on or after April 7, 2008, or placed into service for the first time on or after Jan. 1, 2012, shall be equipped with independent power sources that fulfill the illumination duration and intensity requirements without aid from the main car battery and shall comply with the current definition for emergency lighting.

The time at which the clock is started for timing the lighting duration is as specified in **Table 3**.

TABLE 3
Clock Starting Times

Lighting Mode	When Clock Starts	When Clock Stops
Standby power	When HEP or auxiliary power is shut off.	At fully elapsed test duration time, or when any light goes out, whichever comes first. Note: Since standby lighting is optional, there is no formal requirement in this document for duration; intensity is quantified, however.
Emergency, car equipped with standby power	When standby lighting goes off (i.e., main battery is fully discharged or timeout occurs).	At fully elapsed test duration time, or when any light goes out, whichever comes first.
Emergency, car without standby power	When HEP or auxiliary power is shut off.	At fully elapsed test duration time, or when any light goes out, whichever comes first.

3. Evaluation measurements and tests

To verify design and compliance with the minimum emergency light level requirements in **Table 1** and **Table 2**, railroads shall ensure that a qualification test is conducted on at least one representative car/area for each emergency lighting system layout, in accordance with this section and Appendix C.

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

3.1 Qualification test (initial verification)

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

- a brand-new car before it is placed into service
- an existing car that has had the power source and/or the standby/emergency light fixtures modified or replaced (see Section 3.6), different from that when the car last had a qualification test (refer to **Table 4** for an explanation of required retesting.

This test is typically done on one new car. If several similar car types are part of the same order, one complete car from the order must be tested for light intensity as well as the areas unique to each of the other car types such that light measurements of all locations in **Table 1** are taken. Each car type shall be tested for duration.

> **NOTE:** 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 shall be conducted to demonstrate the system performance of emergency lighting system from each power source, including main battery and/or independent power sources as applicable.

3.1.1 Test procedure

A detailed step-by-step test procedure is required to conduct the lighting test. It shall 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 drawings, etc. (lighting arrangement drawing)
4. Prerequisites for the test (identifying the state of the car to be tested: light fixture lenses clean, new lamps, battery condition, 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 **Figure 3** in Appendix C.4)
7. Step-by-step procedure for taking the measurements
8. Data sheet to record readings (refer to **Figure 3**)
9. Final conclusion with signatures of those conducting/witnessing the test

For an example test procedure, see Appendix F.

3.2 Battery emulation

> **NOTE:** A regulated DC power supply may be substituted for the main battery to conduct the test if done in accordance with the following procedure:

3.2.1 Battery discharge

Voltage drop in car wiring must be taken into account when establishing the DC bus voltage measurement site. This is to ensure that the voltage actually feeding the lighting loads is the same whether the battery or DC power supply is powering the loads.

If the power supply will feed the entire car DC load, the measurement point can be at the battery leads at the battery or charger, or at the DC circuit breaker panel.

If the DC power supply will be feeding only the lighting loads (not the full DC load), the measurement site must be the DC bus (such as the line side of the DC main circuit breaker on the DC power distribution circuit breaker panel).

1. Connect a digital voltmeter with accuracy of 0.1% or better to this exact site. Record the location on the data sheet.
2. Activate all DC loads that are active when the car is in revenue service. In the case of a cab car, this includes all cab loads, including headlight, auxiliary lights (continuously on, not flashing), event recorder, alerter, PTC, etc. For non-cab cars, activate any end-of-train functions, such as marker lights, looping relays, etc.
3. Fully charge the power source(s) to a full state of charge as per OEM instructions.
4. Shut off all auxiliary power (HEP) to the car; immediately start a timer set for the duration specified in **Table 2**.
5. Allow the car emergency lighting and all other DC loads to function. Load shed should function as per design over the duration required in **Table 2**. At the end of that duration, read and record the voltage from the meter on the data sheet.
6. Remove battery power from the car and isolate the leads. Connect the regulated power supply to replace the battery feed. Keep the same meter used earlier connected to the same point.

   NOTE: If the power supply is unable to provide the full load battery current, it is acceptable to disconnect the nonemergency lighting loads by opening the respective circuit breakers. Note this in the test report, as applicable.

7. Power up the power supply and adjust the output voltage to exactly match that measured on the digital meter in step 5.
8. Continue with intensity test procedure, step 3.4.

   NOTE: The light intensity of the lighting fixtures fed from the main car battery is dependent on the voltage at the fixture. Since there is voltage drop in the car wiring from battery to the distribution point (typically DC circuit breaker panel), this must be taken into account when the regulated power supply is substituted for the battery.

   NOTE: The voltage drop in car is dependent on load current, as long as the voltage feeding the DC lighting loads is the same at the distribution point as it would be with the full load borne by the battery.

3.3 Preparation for tests

3.3.1 Car preparations

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

3.3.1.1 Light fixtures

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

3.3.1.2 Car interior

1. Car shall be configured and equipped as it would be in ready for revenue service, but can be free of consumable items.

3.3.1.3 Battery system

Information shall be recorded identifying date of manufacture and time in service of main and independent power source batteries.

Main battery

1. Main battery shall be clean, with fluid levels topped up as required.
2. Battery shall be fully charged, as identified by the manufacturer

Independent power sources

1. These shall be fully charged, as identified by the manufacturer

3.3.1.4 Temperature

1. Temperature shall be within the range of normal operating temperatures as recommended by the test equipment manufacturer.
2. In addition, the car lighting system shall 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.

3.3.2 Initial conditions

1. The car shall be configured as indicated before beginning the light level measurements. The intent is to configure the car in test to simulate it being disabled in a dark area, on a clear, moonless night. The car should be arranged to depict it as it would be in typical revenue service. In addition, the individual reading locations are intended to be areas of interest to a passenger attempting to exit the area. For example, finding the emergency release instructions are relevant only if the door is closed.
2. All extraneous light shall be excluded to the extent practicable. Meaningful data can be collected only if ambient light can be eliminated almost completely from the areas being measured. Any approach is acceptable as long as ambient light is reduced below 0.01 fc (0.1 lx) in the areas being measured.
3. If the ambient light cannot be reduced to 0.01 fc (0.1 lx), there are two alternative measurements that can be used to meet the requirements in **Table 1** and **Table 2**:
    - Measure the ambient light at each location and subtract that value from the value measured with the emergency lighting operating.
    - If the emergency lighting is at least twice the required levels in **Table 1** and **Table 2** plus the ambient light reading, consider the required levels to be met.

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 (climate room, paint booth, carwash, test area, etc.).
2. Secure the car to be tested so it does not move; parking brake applied, chocks at wheels. Blue flag as required.

3. Place car in an area where it will not be disturbed. Cover all car exterior windows with opaque coverings, such as a 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 car body such as vestibule windows.
5. For any cars equipped with drapes/curtains over side windows, these shall be closed fully throughout the car.

Requirements for doors:

1. All exterior-facing doors shall be closed: exterior side doors, end frame doors, stock loading doors/hatches, etc.
2. All interior doors shall be closed: vestibule, passageway, toilet, galley access, cab, etc. For cars equipped with individual rooms, such as sleeping cars, these doors shall be closed. Any curtains/drapes on windows of these rooms shall be fully closed.
3. Unless allowed during a particular measurement or required to access a reading location, all doors shall be closed for the duration of the test.

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 nonreflective masking tape or stickers. It is helpful to number each site.
2. For the 25 in. height, a small stand should be created upon which to place the light sensor.
3. For semi-permanently coupled trainsets, the testing of the semi-permanently connected areas must be addressed in the test plan.

Configure car power system for test:

1. All the battery loads that may be applied under emergency conditions shall be identified. Circuit breakers shall be set so that those loads (door operators, PA system, controls, headlights or marker lights, etc.) that are normally present in revenue service are energized during the emergency lighting tests.
2. The tests shall be conducted with battery power only; any feeds from HEP, auxiliary or wayside sources shall be disconnected.

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

3.4 Data collection

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

1. Number of car
2. Car type (e.g., Superliner-1 Sleeper)
3. Location where test is conducted: geographic location and where (e.g., in car wash building in Amtrak 14th Street shops, Chicago)
4. Date of original manufacturer or date car is placed in service
5. Identification of individual(s) conducting test
6. Dates 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:
    - Manufacturer and model number
    - Serial number of instrument
    - date of last calibration
    - whether or not equipped with color correction filter
13. Identification of area tested (e.g., entire car, vestibule, aisle, passageway)
14. Type of lighting fixtures and record of which fixtures were lighted
15. Location of readings (need an illustration to show this; could be lighting arrangement drawing)
16. Individual illumination level measurements taken

NOTE: It is recommended that the following information be recorded:

- Condition of fixtures
- New or old
- Type of reflector and condition
- Cleanliness
- Wattage and rated voltage of lamp
- Color temperature or manufacturer's model number of lamps
- Battery voltage

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

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

Appendix D describes steps to follow if the illumination levels do not meet the criteria specified in sections 2 and 3.4.

3.5 Procedures for measuring illuminance of emergency lighting systems

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

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

3.5.1 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 (0.1 lx) 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 (2 m) 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. (Appendix C contains a sample data collection form that includes all necessary data items.)

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

3.5.2 Data collection timing

The car emergency lighting illuminance performance readings shall be taken at the start of the test after the emergency lighting is activated, and again at the end of the final applicable time duration. All data shall be recorded. For cars with standby lighting as well as emergency lighting, separate tests must be conducted on each system. Note that standby lighting, since it is not a requirement, does not have a duration requirement, only intensity.

An acceptable alternative to using the main car battery for the 60- or 90-minute 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 (see Appendix E). The discharge curve of the battery in a particular car can be measured, and then an external power supply can be used to deliver a fixed voltage corresponding to a particular point in time on the discharge curve. Illumination measurements can be conducted using those voltage points at a later convenient 60 and 90 minutes (see **Table 1**). Refer to Section 3.2 for details of this technique.

Alternatively, there exists a limited case of an emergency light system design that utilizes constant power emergency lights with no dimmer circuit. The emergency light levels over the entire 60- or 90-minute test period remain static at the action points. For such designs with static emergency light levels at the applicable action points, only the initial light level measurements need be recorded, with the emergency lights permitted to discharge for the rated 60- or 90-minutes test period. The same initial measurements may also be used as the final set of measurements in lieu of recording a final set of measurement data in order to justify emergency light level compliance in accordance with **Table 1**.

3.5.3 Required measurement locations

To take the measurement readings, the sensor is placed on the locations listed in **Table 1**, using adhesives or supports if necessary. The observer simply records the reading(s) using a form similar to that contained in Appendix C.

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

3.5.3.1 Door exit control/manual release instructions

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

As an alternative, measurements may be taken with a meter with basic accuracy of 3% or better (but not necessarily with accurate cosine correction) with the sensor placed flat on the floor at any point within a horizontal distance of 3 ft (0.9 m) from the door control. The illumination value shall be at least five times greater than listed in **Table 1**.

3.5.3.2 Aisles and passageways

Because emergency lighting illumination levels may vary within a car, an average based on measurements taken no more than every 4 ft shall be taken for each aisle or passageway at equidistant intervals along the aisle centerline at a height of approximately 25 in. (64 cm) above the floor to represent the mean illuminance level throughout the car length. Measurements shall be taken with the vestibule, passage and end frame doors closed.

To ensure that each minimum illuminance level measurement used to determine the spatial average is at least 0.1 fc (1 lx) or 0.05 fc (0.5 lx), as applicable, at the beginning of the test and 0.06 fc (0.6 lx) or 0.03 fc (0.3 lx), as applicable, at the end of the test, the measurements shall be taken at each marked location equally spaced along the aisle in the spot that appears darkest to the observer. Whether measurements are recorded manually or by computer, they should be taken in a manner such that the observer's shadow does not affect the readings.

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

3.5.3.3 Interior stairway

For interior stairways, a measurement shall be taken on the tread near the geometric center at the top landing, at a step in the middle of the stairway and at the bottom landing. An average of these three measurements shall be recorded. If there are landings or corner steps where direction of travel changes, each segment of the stairway between the changes and direction shall be treated as an individual stairway. Any nearby door shall be closed.

3.5.3.4 Passageway and vestibule door threshold

Measurements shall be taken on the floor at the center of each door threshold with the door closed, on both the inside and outside of the door.

3.5.3.5 Exterior side door threshold

The objective of taking readings with the door closed and then open is to verify that passengers can locate the door from inside when it is closed and, once the door is open, identify the edge of the car so as to aid in egress without falling.

The measurements shall be taken on the floor inside the car at the center of each exterior side door threshold. The measurements are to be conducted one side at a time, as follows:

For cars without traps:

- Door closed
- Door open

For cars equipped with traps:

- Trap closed, door closed
- Trap closed, door open
- Trap open, door open
- Trap open, door closed (if car so equipped)

3.5.3.6 Vestibule floor

The arrangement of the vestibule area of cars varies greatly among car types, including some with traps.

Readings shall be taken on the floor as follows with all doors closed:

- Geometric center of the vestibule (for cars with exterior doors within the seating areas, this reading may be the same one taken for the aisle/passageway)
- Approximately longitudinal center and 30 in. from the inside surface of the exterior side door, both sides of car

An alternative:

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

3.5.3.7 Vestibule steps

For cars with steps for non-level boarding, measurements shall be taken near the geometric center at the top step and threshold of the bottom step. An average of these two measurements shall be calculated. The measurement of the bottom step can be done with the adjacent exterior door open, but all extraneous light sources must be handled as per Section 3.3.

If a stanchion divides the side doorway entrance into two or more sections, each section shall be treated independently and measured separately. For example: A stanchion separates the doorway entrance into two sides. The measurements shall be taken on each side of the stanchion respectively. The measurements shall be taken at the center of each divided section.

For steps that extend outside the envelope of the car, each step must be measured individually.

3.5.3.8 End frame door threshold

Blind end doors are those providing access to the neighboring car when there is no intervening vestibule. Collision post doors are those used to close off the diaphragm area of a car when that end of that car is at the front or rear of the train.

For equipment ordered on or after January 1, 2024, or placed into service before January 1, 2028, the end frame door threshold measurement shall be taken on the floor at the center of each door on the inside.

For equipment ordered on or after January 1, 2024, or placed into service before January 1, 2028, the end frame door threshold measurement shall also be taken on the outside of the car at the door threshold with the door closed, but all extraneous light sources must be handled as per Section 3.3.

For collision post doors, the measurements shall be taken with the vestibule door closed and exterior side doors closed.

3.5.3.9 Inter-car passageways

There are three basic types of inter-car passage:

- **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 car bodies. This is typically employed on semipermanently coupled or articulated (angular motion only) cars.
- **Open:** Walkway unenclosed; relative lateral and vertical displacement of the floor between the ends of cars accommodated by means of sliding buffers and employing chains (or equal) on the sides between cars. This approach is used in scenarios such as facing cab end to cab end where passengers do not normally move inter-car.

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

Light levels shall be measured as follows:

- **Conventional diaphragm:** At the center of the floor, within the center of the longitudinal range of the collision posts, end frame door open if there is a door. Light from adjacent car area is allowed to contribute. The open face of the diaphragm is covered or open to the dark outside.
- **Gangway:** At 25 in. (64 cm) above floor at centerline, midway through the gangway.

For equipment ordered on or after January 1, 2024, or placed into service before January 1, 2028, the diaphragm light levels shall be measured on the floor in the geometric center of the diaphragm. The end frame door shall be closed, but illumination from the emergency lighting inside the car can contribute to the emergency lighting levels through the window in that door.

3.5.3.10 Restroom

Inside the restroom area, the measurements shall be taken at a height of approximately 25 in. (64 cm) above the floor with the door closed. For a non-ADA restroom, which is typically quite small, a single reading in the approximate center of the room is adequate. For an ADA restroom, an average of at least three or more measurements shall be measured and be used to determine a spatial average.

3.5.3.11 Crew area of MU/cab car

While there are a wide variety of cab area configurations within passenger cars, three activities are possible, depending on car configuration:

- Operating crew using cab
- Passengers occupying seat(s) in cab area of dual mode (convertible) cab
- Passengers and/or crew exiting car via cab area

A dual mode cab is defined as one that can be configured either 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.

For cars with cabs ordered on or after January 1, 2024, or placed into service before January 1, 2028, the measurement of the inside of the cab area shall be taken as follows:

Cab (crew operating train)
This is defined to be either of the following:

- Dedicated cab, used only by operating crew
- For convertible cabs, the operating mode when the cab is set up to control the train and is closed off to passengers

The cab emergency light levels are taken at floor level, as follows:

- The exit path from each seat to each exit door
- On each stair step to be negotiated to the exit door
- On each door threshold higher than 1 in.

> **NOTE:** The locations of requirements are traceable to AAR Standard S-580, "Locomotive Crashworthiness Requirements."

With a blind end cab, since there is no pass-through possible to the adjacent car, the only emergency lighting measurements are those required for Cab mode.

Convertible cab: passenger seating mode
When the cab is configured in this mode, the passenger seating and aisle/passage light requirements are defined by Section 3.5.3.2. For this 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.

Convertible cab: pass-through mode
When the cab is configured in this mode, aisle/passage light requirements are defined by Section 3.5.3.2. For this 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.

3.5.3.12 Galley/cafe behind counter

In the galley area, with the car configured to service passengers, the measurements shall be taken at a height of approximately 25 in. (63.5 cm) above the floor along the path of the approximate center line of the serving area or food preparation area, taken no more than every 4 ft (1.2 m). The crew door and any serving counter security gate/screens/panels, etc. shall be in the normal position when the galley is active.

3.5.3.13 Sleeping car passenger rooms

The measurement shall be taken at a height of approximately 25 in. above the floor, but not less than 1 in. above the surface of the lower berth, approximately in the center of the open floor area of the room remaining with berths down. (This may need to be customized slightly based on the actual room floor plan. The intent is to verify that there is sufficient light for the passengers to orient themselves and locate the door to the hallway.)

The door to the passageway shall be closed. If there is a toilet room within the accommodation, this door shall be closed. Curtains/drapery in the room shall be closed, covering all the windows. This applies to interior windows as well as windows to the exterior of the car.

3.5.3.14 Other coach/specialty areas

The measurement shall be taken at a height of approximately 25 in. above the floor, approximately in the center of the open floor area of the room. The door shall be closed.

3.5.3.15 Multilevel cars

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

3.6 Retesting emergency lighting

When portions of the car emergency lighting system are altered, overall system performance may change. Accordingly, some or all of the system may need reverification. Retesting requirements are as shown in **Table 4**:

TABLE 4
Retesting Requirements

System Change	Retesting Requirement	Rationale
Battery capacity increased, or electrical load on battery reduced	No tests required	
Battery capacity reduced from original	Duration test only	Intensity not changed, but duration may be affected
Battery charger changed for different model or rating	Duration test only	Intensity not changed, but duration may be affected
Battery load increased (e.g., new equipment added)	Duration test only	Intensity not changed, but duration may be shortened
Reconfiguration of car interior (e.g., replace restroom)	Intensity of affected areas test plus duration test	Since only a small area of the car is affected, only that portion needs intensity; battery load might change and reduce duration
Relocation of existing emergency lights, using same fixtures and quantity	Intensity of affected areas test only	Intensity may have changed, but duration has not been affected
Local replacement of existing lights with different light source (i.e., LED), or fixture (e.g., new vestibule lights)	Intensity of affected areas test plus duration test	Battery load may have changed
Whole-car replacement of existing lights with different light source (i.e., LED) or fixtures	Full retest: intensity plus duration	This is in effect a new installation and as such requires a full qualification retest

For the purposes of **Table 4**, “battery” refers to the battery and/or independent power source, including supercapacitors providing power to the emergency light(s) in question. Likewise, “battery charger” refers to the associated equipment used to charge the above battery or supercapacitors. Changes of any batteries on the car that are not associated with the emergency lighting system do not require any retest of emergency lighting equipment.

When duration testing is required, only a single car of each car type in which the change is applied need undergo duration testing.

When illumination testing is required, at least one example of all affected areas shall be tested. For example, if only the lavatory emergency lighting configuration is changed, 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.

> **NOTE:** If it can be proved through calculations and analysis using archival or measured battery load data that the added battery load does not result in the emergency battery capacity being within 10% of the 90-minute requirement, a duration test is not necessary. For example, if the added battery load results in a calculated battery capacity of 95 minutes, a duration test must be performed. If the calculated battery capacity after including the added battery load is greater than 99 minutes, a duration test is not necessary.

3.7 Recordkeeping

Railroads shall 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, and the results of such tests.

Railroads shall retain a copy of the test results until the next periodic test is conducted on a representative car/area, as required by Section 6, or until cars of that type are retired, or are transferred, leased, or conveyed to another railroad. A copy of such records shall be transferred to the accepting railroad along with any such car(s).

4. Operating conditions

The required illuminance criteria shall be met under normal operating conditions.

> **NOTE:** Operating practices should take into account that the frequent deep discharges of the battery, (e.g., “pulling the plug” on HEP at the end of each trip), whether from main and/or IPS, may have an adverse effect on their life expectancy.

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

1. Each main car battery and each independent power source shall be capable of operating in all equipment orientations within 45 deg. of vertical, and after the initial shock of a collision or derailment resulting in the following individually applied accelerations:
   - longitudinal: 8g
   - lateral: 4g
   - vertical: 4g
2. Emergency lighting system components shall be designed to operate without failure under the conditions typically found in passenger rail equipment including expected mechanical vibrations (as defined by IEC 61373-1) and shock, as well as comply with electromagnetic interference and other criteria in 49 CFR Part 238, Passenger Equipment Safety Standards, Sections 238.225, 238.425 and 238.725.

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

Tier III trainsets are subject to acceleration requirements contained in 49 CFR 238.743.

5. Maintenance

5.1 Maintenance requirements

After the initial qualification (verification) tests required by Section 3, railroads shall ensure that periodic tests to confirm the minimum illumination level and duration of the emergency lighting system are conducted no less frequently than once every eight years. A representative sample of cars or areas per ANSI/ASQC Z1.9-1993 shall be tested using the procedures in Appendix E.

Railroads shall ensure that periodic inspections at least every 184 days, including a functional test of the system, are conducted of the emergency lighting system, including all power sources. Deference of inspections are allowed for out-of-service rolling stock in accordance with 49 CFR 238.321.

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

5.1.1 Maintenance practices

Railroad maintenance shall ensure that all emergency lighting system components are kept in a state of good repair so that when called upon, the system will function with the intensity and duration expected.

> **NOTE:** Maintenance practices shall take into account that the frequent deep discharges of the battery (e.g., "pulling the plug" on HEP at the end of each trip), whether from main and/or IPS, may have an adverse effect on their life expectancy.

For light fixtures, this includes tasks such as:

- Replacing defective or end-of-life bulbs or luminaries
- Replacing defective drivers and/or ballasts
- Cleaning fixture lenses/diffusers
- Replacing missing, damaged or yellowed lenses/diffusers as required
- In the case of LEDs that also function as part of main lighting, this may require calendar-based or condition-based change-out

For systems that utilize independent power sources, the railroad shall implement the recommendations established by the emergency lighting system manufacturer for periodic maintenance

For the main battery, this includes maintaining proper electrolyte levels, keeping battery clean, checking terminals and proper battery charger functioning, etc. The railroad will need to periodically replace batteries that have reached the end of their manufacturer's recommended service life.

Independent power sources typically are "maintenance-free," requiring only check of the status lights. The railroad will need to periodically replace batteries and/or supercapacitors that have reached the end of their manufacturer's recommended service life.

Battery maintenance and replacement intervals shall take into consideration the effect on battery life of cyclic charging and discharging of batteries that occur during operation and maintenance, as well as other factors that will affect the battery life.

5.1.2 Performance over time

Emergency lighting system performance on well-maintained equipment may diminish over time, as a combination of deterioration of the light output of fixtures as well as the main battery and/or independent power sources. This may require the railroad to periodically renew aging components with new ones in order to continue to keep the required light levels and durations of **Table 1** and **Table 2**.

5.1.3 Issues regarding light fixture light levels

Light fixture output may vary over time due to lamp characteristics, even with good maintenance. This section contains a discussion of different lamp types.

Incandescent and fluorescent lamps have an easily determined end of life and as such are routinely replaced as needed. Since the light level of these lamps does not vary significantly over their life, it can be assumed that the light output of the fixture remains constant over the life of the fixture. Likewise, fluorescent lamp ballasts perform properly until they fail, which again is easy to identify.

LEDs have a number of failure modes, making it more difficult to determine end of life:

1. LED fails to illuminate.
2. For matrix-type LEDs, some of the LEDs fail to light while others continue to perform properly. It is suggested that these be replaced when 70% or fewer of the matrix LEDs function.
3. LEDs dimming with age. This presents more of a problem, since it is difficult to judge the condition simply by looking at the device. LED technology is such that LEDs slowly get dimmer over time. The change in performance characteristic is identified by the LED chip manufacturer, generally stated as hours of service before the light intensity drops to 70% of original, say 50,000 hours. (A year is approximately 8,766 hours.) The use of LEDs in the car emergency light system varies greatly, such that in some applications these lamps are illuminated "all the time" and thus in perhaps 5½ years, light output of these LEDs will have dropped to the 70% value and it will be time to replace them. However, in some applications, the LEDs might come on only when normal power is lost and thus might never reach anywhere near 50,000 hours of service and would not need replacement over the life of the car lighting system.

The design of the car emergency lighting system employing LEDs needs to address how end of life will be addressed by the railroad in its maintenance practices. A variety of approaches may be taken, including but not limited to the following:

- Incorporate end-of-life function in the LED driver circuitry to annunciate when it is time to replace the unit.
- Routinely replace all car LED lamps on a calendar basis, based on anticipated hours of service. (Depending on the car design, perhaps a central timer could the clock hours the LEDs are illuminated.)
- Due to limited hours of illumination, the LED lamps may not reach the end of life.

For manual periodic regimes, analyze the duty cycle of the LED on and off times (LEDs that are minimally used, such as for emergency lighting, may never reach the end of lifetime replacement).

5.1.4 Issues regarding main battery deterioration

Typical nickel-cadmium and lead acid battery technology widely used today for car main batteries has the characteristic that the battery performance has a finite cycle life, resulting in the reduced ability to provide the rated ampere-hours as the battery ages. How rapidly this decline occurs is a complex subject, depending on many factors such as load, how often and how deeply the battery is discharged, as well as many other issues. The effect is that, as the battery ages, at some point in time it will no longer be able to support car emergency light loads for the required duration.

Railroads typically have a schedule for battery replacement for an entire fleet type (e.g., every 16 years), or possibly by conducting capacity tests to determine end of life. However, occasionally a battery fails or sustains damage requiring replacement at that time.

> **NOTE:** Section 6.1.4 applies only to cars in which the main battery is part of the standby/emergency light function.

5.1.5 Issues regarding IPS deterioration

The battery and/or supercapacitor technology typically used in independent power sources are subject to deterioration over time and cycling as follows.

5.1.5.1 Battery systems

The typical sealed-cell battery technology employed in an IPS has characteristics somewhat like that of the main battery, resulting in a loss of capacity over time. Often these IPS systems incorporate automatic or manually initiated self-discharge tests, which can be used to verify battery performance.

Railroads shall have a schedule for routine testing and replacement of these batteries, based on performance and/or on a calendar basis.

Batteries incorporating self-diagnostics or health monitoring can alert or confirm the authority of that battery's inability to perform compliantly. For any devices incorporating such active features, the replacement interval could be based upon the battery's diagnostic ability, a preventative maintenance test and/or the manufacturer's recommended replacement period.

For batteries without such active monitoring capabilities, the interval shall be based upon manufacturer-recommended testing and/or the manufacturer's recommended replacement period.

The battery-replacement interval shall be according to the IPS manufacturer's specifications, or if not specified, at least every five years.

5.1.5.2 Supercapacitor systems

The typical supercapacitor technology employed in independent power sources has characteristics somewhat like that of the main battery, resulting in loss of capacity over time.

Railroads shall conduct a functional test of the devices as part of the periodic inspection.

The replacement of these supercapacitors shall be based on their performance and/or on a calendar basis.

5.2 Periodic inspections and tests

5.2.1 Basic requirements

After the initial qualification test required by Section 3, railroads shall ensure that periodic tests to confirm the minimum illumination level and duration of the emergency lighting system are conducted no less frequently than once every eight years. This is a performance test conducted to verify that the car emergency lighting system has not deteriorated significantly below the initial performance. It is done on a statistical sample of cars. This test shall be conducted to demonstrate the system performance of the emergency lighting system from all applicable power sources.

If the emergency light system design does not change, and at the same time components are replaced with components with the same specifications, then the periodic testing of emergency lighting will not require reverification of minimum illumination levels. Refer to **Table 5** for details. If the emergency lighting system design does change, refer to **Table 4** for required testing.

For LED emergency lighting systems without end-of-life self-diagnostic functions, if the LED end of service life performance exceeds the minimum emergency lighting intensity requirements, then only a duration test need be performed as long as the OEM service life is maintained.

The railroad should provide justification for hours of service of LED emergency lighting operation used in developing the routine replacement of LED lamps. For fixtures incorporating end-of-life indicators, this is not required.

For LED emergency lighting systems with end-of-life diagnostic functions, illumination testing is not required.

TABLE 5

Measurements Required in Eight-Year Test if Car Has Not Been Modified Since Last Test

Light Source	Light Intensity Measurement	Duration Measurement
Incandescent	No	Yes
Fluorescent	No	Yes
LEDs "continuously on" replaced in kind at end of service life	No	Yes
LEDs used only for emergency lighting: still original	No	Yes
Original LEDs without end-of-life feature, if not replaced at end of service life	Yes	Yes
Original LEDs with end-of-life feature[1]	No	Yes

1. End-of-life feature indicates that it is time to replace the LED lamp at that fixture. It is assumed that the LED gets replaced when its life expectancy has been reached, and that the replacement has at least the light intensity as the original.

Incandescent and fluorescent lamps have an easily determined end of life and as such are routinely replaced as needed. LEDs dim with age, which makes it harder to determine end of life by simply looking to see if the lamp is illuminated.

5.2.2 Timing of tests

Table 6, **Table 7** and **Table 8** define the timing for conducting the eight-year cycle performance tests, as well as resets of the clock.

TABLE 6

Clock for Conducting Eight-Year Cycle Tests

Qualification Test Cycle	When Conducted
Initial full-car test	When car built, or new lighting system installed
First eight-year test	Eight years of in-service credit
Second eight-year test	Eight years from first test
Third eight-year test	Eight years from second test
Etc.	Eight years from previous test

TABLE 7
Conditions for Resetting the Eight-Year Clock

Category	Reset from Original Eight-Year Clock	Comments
No changes to car	No, continues eight years from last test	No changes to car
Changes made, partial car qualification test conducted for duration only	No, eight years from last eight-year test	No changes made affecting intensity
Changes made, partial car qualification test conducted for intensity	No, eight years from last eight-year test[1]	Changes made affected intensity
Full qualification test conducted	Yes, eight years from last qualification test	
Routine replacement of individual failed emergency light(s) as part of maintenance	No, continues eight years from last test	

1. If the unmodified portion of the car undergoes the eight-year test at the same time as the qualification testing on the modified portion of the car, then the clock is reset.

TABLE 8
Reset for Battery

Category	Reset from Original Eight-Year Clock	Comments
Original main battery	No, continues eight years from last test	Does not apply if main battery is not used for standby lighting
New[1] main battery	Yes, eight years from installation of new battery	Does not apply if main battery is not used for standby lighting
Original IPS power sources	No, continues eight years from last test	
New IPS power sources changed throughout car	Yes, eight years from installation of new IPS battery and/or capacitor(s)[2]	

1. "New" means new battery and/or IPS source was installed less than six months ago.
2. If the main battery is part of the emergency lighting system, the clock remains based on the original eight-year cycle.

5.3 Cars on which the testing is required

> **NOTE:** Often, the performance of the emergency light test is undertaken after maintenance is completed to the car such as after COT&S or after a car overhaul when the car is ready to leave the shop and is in good condition to do the test.

5.3.1 Cars tested for light intensity

For cars tested for light intensity, a representative sample of cars or areas per ANSI/ASQC Z1.9-1993 shall be tested using the procedures in Appendix E or other statistically valid documented sampling method. If the first two randomly selected sample cars or areas exceed the illumination levels specified in **Table 1** and **Table 2** of this standard by a factor of four or greater, no further testing is required for the car or area represented by the sample car/area tested for the periodic test cycle.

For cars/areas with steady-state emergency lighting systems—that is, systems that do not dim gradually over the duration of the required illumination period—if the illumination levels exceed the initial required minimum levels by 40%, no further testing of illumination levels is required for the car or area represented by the sample car/area tested for the periodic test cycle.

5.3.2 Dating individual samples

Each contributing test of an individual sample is valid for eight years after the test is performed.

It is recognized that for large, dispersed fleets, there may be logistical challenges to conducting the periodic eight-year tests on the representative cars at exactly eight-year intervals. For this reason, the following guidelines are provided:

1. The goal of the selection process is to identify representative cars approaching multiples of eight years of service, so as to not test cars prematurely nor exceed eight years of service from the last test.
2. Age of fleet is defined as the calendar year the first car of the fleet was put into service.
3. If the fleet was delivered over several years, the first sample representative cars should be taken from the oldest cars, to the extent possible, of that fleet.
4. For the next iteration of the eight-year cycle, the first sample for that cycle should be taken no more than eight years from the date of the previous iteration. (For example, for a fleet delivered over the years from the beginning of 2000 through 2003, the first car should be selected from those delivered during 2000 and would be tested before the end of 2008. The next cycle of the eight-year test would begin in 2016 and also be from the cars delivered in 2000.)

5.4 Defect reporting, repair and recordkeeping

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

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

Railroads shall 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 (if required), and the results of such tests.

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

It is desirable for the railroad to retain older test results to allow it to watch for developing trends. Test data should be maintained for analysis regarding detrition.

Related APTA standards

APTA PR-E-RP-007-98, "Storage Batteries and Battery Compartments"
APTA PR-E-RP-012-99, "Normal Lighting System Design for Passenger Rail Equipment"
APTA PR-IM-S-001-98, "Passenger Rail Equipment Battery System Periodic Inspection and Maintenance"
APTA PR-IM-S-005-98, "Passenger Compartment Periodic Inspection and Maintenance"
APTA PR-IM-S-008-98, "Electrical Periodic Inspection and Maintenance of Passenger Coaches"
APTA PR-IM-S-013-99, "Passenger Car Periodic Inspection and Maintenance"
APTA PR-M-S-018-10, "Powered Exterior Side Door System Design for New Passenger Cars
APTA PR-PS-S-006-23, "Emergency Egress/Access Signage and Low-Location Exit Path Markings for Passenger Rail Equipment"

References

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

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

49 CFR Part 238, Passenger Equipment Safety Standards.

49 CFR Part 239, Passenger Train Emergency Preparedness.

IEC 613373, Railway applications – Rolling stock equipment – Shock and vibration tests.

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.

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.

car: A passenger-carrying rail vehicle.

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.

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

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 car bodies. This is typically employed on semi-permanently 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 ft^2 of surface). English units are foot-candles (fc) or lumens per square foot (lm/ft^2). International units (SI) are lumens per square meter (lm/m^2) or lux (lx). One fc equals 10.76 lx.

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

lighting, emergency: Lighting mode that is activated when power for the normal lighting and standby lighting (if equipped) becomes unavailable in a car. Two or more independent power sources within the same car, aside from the main car battery, are used to supply the power to operate the fixtures that provide emergency lighting in each car.

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

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 (if so designed) when the car loses normal power, but the main car battery has not yet discharged to load shed (see also *load shed* and *power, standby*).

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).

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.

passageways: 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.

representative car/rea: 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. The area of a spatial average varies. For a stairway, it includes only the area of the stair step(s). For an aisle, the entire length of the aisle is included.

stairway: 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, that 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

CFR	Code of Federal Regulations
CIE	Commission Internationale de l'Eclairage (International Commission on Illumination)
cm	centimeters
COT&S	cleaned, oiled, tested and stenciled
EL	Electroluminescent
fc	foot-candle
FRA	Federal Railroad Administration
HEP	head-end power
IPS	independent power source
LAN	local area network
LED	light emitting diode
lm	lumen
lx	lux
m	meter
MU	multiple unit
OEM	original equipment manufacturer
PA	public address

PRESS Passenger Rail Equipment Safety Standards
NTSB National Transportation Safety Board
SI Système International
UL Underwriters' Laboratories

Summary of document changes

- Document formatted to the new APTA standard format.
- Sections have been moved and renumbered.
- Scope and summary moved to the front page.
- Definitions, abbreviations and acronyms moved to the rear of the document.
- Two new sections added: "Summary of document changes" and "Document history."
- Some global changes to section headings and numberings resulted when sections dealing with references and acronyms were moved to the end of the document, along with other cosmetic changes, such as capitalization, punctuation, spelling, grammar and general flow of text.
- Names of participants updated.
- Addition of independent power source (IPS), normal lighting, and standby lighting to keywords section.
- Summary and Scope and Purpose sections updated to provide succinct information regarding the contents of the standard. References to companion documents in these sections removed. Much of the removed material relocated to the Introduction section.
- Introduction updated. Added reference to APTA PR-E-RP-012-99, "Normal Lighting System Design for Passenger Rail Equipment."
- Section 1.1: Added the full spelling of head end power in addition to the already present acronym. The word "power" added after auxiliary in second sentence. Temporal clarifications regarding trends in power supplies for normal lighting systems. 28 VAC removed and 24 VDC added as typical normal lighting power voltages.
- Sections 1.2 and 1.3: order reversed.
- Section 1.2: Clarified the activation criteria for emergency power. Removed typical emergency lighting approaches. Added reference to minimum duration, location, and power source requirements for emergency lighting. Added new date requirement for location of independent power sources. Changed new requirement on power source location from previous revision into note. Added automatic testing requirement for supercapacitors used as independent power sources.
- Section 1.3: Removed functional description of standby power as it out of the scope of this document. Highlighted that only certain older equipment can use standby lighting to fulfill the duration requirement. Delineated the boundary between standby power and emergency power. Added note regarding standby power intended for use will during normal operations such as phase breaks and third rail gaps.
- Section 2.1: Term toilets replaced with restrooms.
- Tables 1 and 2: Table 1 from previous revision split into two separate tables, the new table 1 detailing the areas measured, where the measurement is taken and under what conditions the measurement is performed and the new table 2 detailing intensity, duration, power source, and power source placement requirements.
- Table 1: changes detailed individually in subsequent sections.
- Table 2: requirements affected by incorporation by reference in the CFR added. New Independent power source location requirements added for new equipment.
- Section 2.3: Section retitled. An application date is provided for equipment for which standby power was ambiguous as to whether it could fulfill emergency lighting requirements in previous revision. Starting point for emergency lighting duration requirement specified.
- Section 3.1: Qualification test (initial verification) section and subsections added.
- Section 3.3: Preparation for tests section split into subsections and clarified.

- Section 3.4: additional data collection information added to reflect current practices.
- Section 3.5.1: added rationale for floor measurement value exception.
- Section 3.5.2: added separate testing of standby power for certain equipment. Added final measurement exception for constant power emergency lights.
- Section 3.5.3.2: changed to individual measurement separation maximum from average of 20. Added door conditions. Added equal spacing requirement.
- Added sections detailing requirements for each location specified in table 1.
- Section 3.5.3.8: Changed requirements for end frame door measurement conditions and location.
- Section 3.5.3.9: added section on inter-car passageways (diaphragms and gangways).
- Section 3.5.3.11: New requirements for cab measurement conditions.
- Section 3.6: Retesting emergency lighting section added.
- Section 5: added note on deep discharge considerations.
- Section 6: removed references to Inspection and Maintenance standards.
- Section 6.1.1 through Section 6.2.2: added new sections replacing previous content.
- Section 6.3: New section on testing individual sample collection for representative sample cars.
- Section 6.4: added retention of test procedure and results requirements.
- Definitions: added definitions for diaphragm, conventional, gangway, main car battery, stanchion, and threshold. Added new definition for emergency lighting, labeling previous definition former. Removed entrance/exit.
- Added new acronyms.
- Added Appendix C.4.
- Replaced sample data sheet.
- Appendix E: created allowance for use of special inspection levels (S3) to be used in lieu of General II.
- Appendix E.1.2 added.
- Appendix F added.

Document history

Document Version	Working Group Vote	Public Comment/ Technical Oversight	Rail CEO Approval	Policy & Planning Approval	Publish Date
First published	—	—	—	March 4, 1999	March 17, 1999
First revision	—	—	Sept. 11, 2007	Oct. 7, 2007	Oct. 22, 2007
Second revision	Sept 8, 2022	Nov. 30, 2022	March 6, 2023	June 6, 2023	June 6, 2023

Appendix A (informative): Bibliography

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

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

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

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

[B5] FAA Advisory Circular 20-38A. Measurement of Cabin Interior Emergency Illumination, February 1966.

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

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

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

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

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

[B11] National Transportation Safety Board (NTSB). Collision and Derailment of a Maryland Rail Commuter MARC Train 286 and National Railroad Passenger Railroad (Amtrak) Train 29 Near Silver Spring, Maryland on Feb. 16, 1996. Report No. NTSB/RAR-97/02. Adopted July 3, 1997.

Appendix B (informative): Automatic testing of electrically powered lighting systems that use batteries as independent power sources

Emergency lighting systems using independent power sources have important advantages since they are not vulnerable to loss of the main car battery power supply and/or damage to the main car battery power supply wiring. However, for the independent power supply to the emergency lighting system to be reliable and operate when necessary, multiple individual batteries must be periodically tested for each rail car (for cars with only two such batteries, each one must be tested). Batteries that are used as independent power sources shall have automatic self-diagnostic modules designed to perform discharge tests upon demand by maintenance personnel.

Manual testing requires that a worker first determine that all independent power sources using batteries have been connected to a source of charging power for the necessary amount of time to reach full charge. Then, car by car, the charging power must be disconnected and the emergency lighting system switched into emergency mode. After the prescribed 60- or 90-minute time period for discharge, the worker must then revisit each car and note which emergency light fixtures are working properly and which are not. While such tests are in progress, some kinds of maintenance work are effectively precluded by the lack of light inside the car.

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

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

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

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

Appendix C (informative): Data collection guidance

C.1 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 1**:

- Minolta T-10A Illuminance meter and cable
- Gigahertz-Optik X1 with VL 3704 illuminance detector
- Hagner E4-X digital luxmeter

Other meters that meet the performance specifications listed in Section 3 are also acceptable.

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

Railroads with fleets consisting entirely of brightly illuminated cars may 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 armrest 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 Mandarin at: http://www.cnsonline.com.tw/en/.

Other considerations: The Minolta can be set to readout in foot-candles or lux; the Gigahertz-Optik meter may be ordered with either foot-candle or lux displayed; while the Hagner meters read out in lux only. The Minolta and Gigahertz-Optik meters have USB data outputs. 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.

C.2 Timing of readings

Readings should be taken at least 15 minutes after the normal illumination charging light is placed in operation to allow the lamps to reach full output and per Section 3.

FIGURE 1
Typical Meters for Illuminance Measurements

C.3 Computer data collection

The measurements required by Section 3 must be performed by manually placing the light sensor at the designated locations. However, the numerous aisle measurement readings to determine the minimum average illumination levels required in **Table 1** can be taken much faster and more accurately using a computer. The computer data collection technique is based on moving/dragging a sensor down the aisle at a slow, steady pace while readings are captured to a notebook computer or data logger at the rate of at least one reading per second.

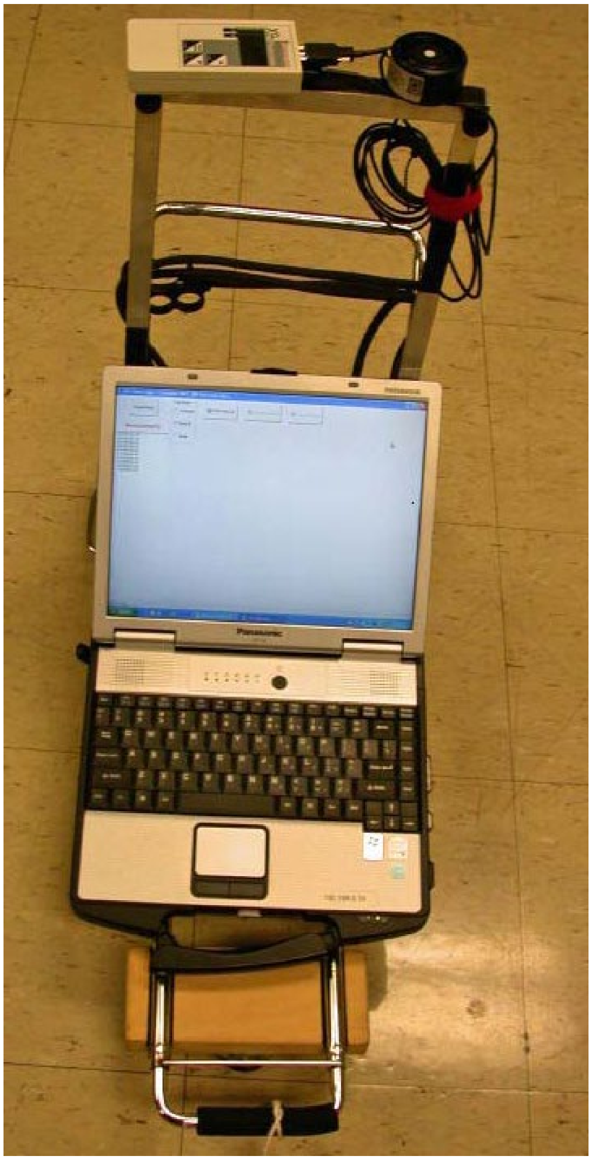
To collect data representative of illumination levels at armrest height, an apparatus must be constructed to support the sensor at a height of 25 in. (64 cm) above the floor and to carry the meter electronics and computer/data logger. **Figure 2** shows such an apparatus, built from an ordinary luggage 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 60 or more samples—i.e., the data collector should walk at the rate of about one foot per second. The software will also find the minimum value in each set of readings and may be used to generate a graphic profile of illuminance levels along the length of the car.

The minimum test period duration is either 90 or 60 minutes, per Section 3. All illuminance light levels are measured and recorded immediately at the start of the test and again at the end of the final time duration.

FIGURE 2

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.

C.4 Sample data recording sheet

Figure 3 is a generic sample of a data sheet to be used to record the results of emergency light performance tests. Each railroad will need to review the content and adjust it according to the specific needs of their rolling stock.

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

Test Type	☐ Qualification ☐ Periodic ☐ Other (explain)
Date of Test	
Car Number	
Car Builder	
Car Series (M1, M2, etc.)	
Car Type (coach, cab car, etc.)	
Facility Where Conducted (Geographic location and facility)	
Test Conducted By	
Test Witnessed By	
Time of Day Test Started	
Car Interior Temperature (est.)	
Car Exterior Temperature (est.)	
Main Battery Capacity A-H (if applicable)	
Main Battery Installation Date (if applicable)	
Renewal of LED Fixtures Date (as applicable)	
Renewal of IPS Power Sources Date (as applicable)	
Renewal of Fluorescent Lamps (if applicable)	
Other comments	

Instruments Used				
#	**Test Instrument**	**MFG Model**	**Serial #**	**Calibration Due Date**
1.				
2.				
3.				
4.				
5.				
6.				
7.				

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

Duration-Only Test				
	Start	**Finish**	**Duration**	**Comments**
Standby Lighting				
Emergency Lighting				

Light Intensity Readings						
Start Time for Series of Measurements (HH:MM):						
#	**Text Ref.**	**Location of Reading**	**Initial Reading**		**Final Reading (60 or 90 minutes)**	
			Left or A-End	**Right or B-End**	**Left or A-End**	**Right or B-End**
1	**3.5.3.1**	**Door emergency exit controls/manual releases-1**				
2		**-2**				
3		**-3**				
4	**3.5.3.2**	**Aisle-1**				
5		**-2**				
6		**-3**				
7		**-4**				
8		**-5**				
9		**-6**				
10		**-7**				
11		**-8**				
12		**-9**				
13		**-10**				
14		**-11**				
15		**-12**				
16		**-13**				
17		**-14**				
18		**-15**				
19		**-16**				
20		**-17**				
21		**-18**				
22		**-19**				
23		**-20**				
24		**Spatial average 1–20**				

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

#	Text Refer.	Location of Reading	Initial Reading		Final Reading (60 or 90 minutes)	
			Left or A-End	Right or B-End	Left or A-End	Right or B-End
25	3.5.3.2	Passageway-1				
26		-2				
27		-3				
28		-4				
29		Spatial average 1–4				
30	3.5.3.3	Stairway, top				
31		Stairway, middle				
32		Stairway, lower				
33		Spatial average				
34	3.5.3.4	Passage door threshold inside				
35		Passage door threshold outside				
36	3.5.3.4	Vestibule door threshold, inside-A				
37		Vestibule door threshold, outside-A				
38		Vestibule door threshold, inside-B				
39		Vestibule door threshold, outside-B				
40	3.5.3.5	Exterior side door threshold				
41		-Trap closed, door closed-L				
42		-Trap closed, door open-L				
43		-Trap open, door open-L				
44		-Trap open, door closed-L				
45		-Trap closed, door closed-R				
46		-Trap closed, door open-R				
47		-Trap open, door open-R				
48		-Trap open, door closed-R				
49	3.5.3.7	Vestibule steps				
50		-Top step-L				
51		-Bottom step-L				
52		-Average-L				
53		-Top step-R				
54		-Bottom step-R				
55		-Average-R				

FIGURE 3

Sample Data Sheet for Emergency Light Performance Test

#	Text Refer.	Location of Reading	Initial Reading		Final Reading (60 or 90 minutes)	
			Left or A-End	Right or B-End	Left or A-End	Right or B-End
56	3.5.3.8	End frame door threshold inside				
57		End frame door threshold outside				
58	3.5.3.9	Diaphragm/gangway				
59	3.5.3.10	Restroom area				
60		Restroom: ADA -1				
61		-2				
62		-3				
63		Spatial average				
64	3.5.3.11	Crew area of MU or cab car				
65		-Door exist path				
66		-Stair step				
67	3.5.3.12	Galley/cafe behind counter-1				
68		-2				
69		-3				
70		-4				
71	3.5.3.13	Sleeping car rooms (each room separately)				
72						
73						
74						
75	3.5.3.14	Other specialty areas				
76						
77						
78						
79		Additional areas as needed				
80						

Appendix D (Informative): Alternatives to increase illumination levels

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

- Check the battery voltage.
- Check the light fixtures near the test areas to ensure proper working order.
- Clean light fixtures and check to ensure that the diffusers 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 they are not near the ends of their service lives, when light output drops significantly.
- Replace warm-white fluorescent lamps with cool-white fluorescent lamps.
- Replace incandescent luminaires with fluorescent lamps or LED luminaires.
- Replace existing fluorescent lamps with those of recent design that provide 10% to 15% more light for the same wattage rating and double the service life.

Appendix E (informative): Representative sample sizes, periodic maintenance

E.1 Representative sample sizes

E.1.1 ANSI/ASQ

The American National Standards Institute (ANSI) and the American Society for Quality (ASQ) have developed detailed procedures for determining representative sampling plans for maintenance inspection operations. These may be found in “Sampling Procedures and Tables for Inspection by Variables for Percent Nonconforming” (ANSI/ASQC Z1.9-2003). In Section A7.1 of this standard, various inspection levels, which allow for alternative sample sizes, are explained. When operations do not permit the preferred inspection level of “General II” to be carried out, “Special Inspection Levels” (S3) may be used. If the total car fleet is smaller than the number of samples required by ANSI/ASQC Z1.9-2003, then the sample size is equal to the car fleet size.

In determining whether to accept or reject the fleet’s emergency light performance, the methods of Section B, Form 2, should be used, since variability of the fleet, or “lot,” is unknown. Additionally, a quality acceptance limit of not more than 2.5% shall be used, per industry practices.

If the first sample has acceptable results, as defined by ANSI/ASQC Z1.9-2003, no further action is needed. If the sample fails, a new sample should be tested using “tightened” inspection procedures. If the new sample passes, document and correct any single car/area that failed to meet the criteria of Table 1, Section 6, of this standard. After completion of the repair, no further action is needed. If the second sample fails, determine the cause, document, and implement a fleet-wide redesign/repair to correct the defect. Upon completion of repairs, reinspect using tightened inspection procedures.

Areas of similarity within a vehicle do not require additional testing.

E.1.2 Determining fleet size for sampling purposes

Cars of different manufacturers or different marking/signage designs cannot be considered as part of the same fleet when considering sampling for periodic testing.

Justification shall be provided if a railroad elects to include similar yet different rolling stock within the same fleet for sampling purposes. Examples of this include, but are not limited to, the following:

- cab cars, trailer cars, power cars, MUs and cab cars running as trailer cars
- different car orders
- identical areas across multiple variants of the same base design

Justification for the inclusion of similar yet different rolling stock within the same fleet for sampling purposes shall include either numerical or logical proof that the inclusion of the similar yet different cars shall not create a false positive sampling for any of the sub-fleets included. If sub-fleets are included within the same sample set, at least one sample from each sub-fleet shall be included within the sample set.

Appendix F: Test procedures (normative)

F.1 Overview

The test shall be conducted to demonstrate the system performance of emergency lighting system from each power source, including main battery and/or independent power sources.

Table 5 is used to establish which testing scenario is required: duration only, or intensity and duration.

For cars requiring intensity testing, the procedure followed should comply with the requirements of Section 3.5, "Procedures for measuring illuminance of emergency lighting systems."

F.2 Test procedure

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

1. Purpose (periodic eight-year, etc.) including identifying which scenario applies
2. Equipment on which it will be conducted (typically car number series)
3. Any references required, such as drawings, etc. (lighting arrangement drawing)
4. Prerequisites for the test (identifying the state of the car to be tested: battery condition, IPS condition, light fixture lenses clean, new lamps, etc.)
5. Test equipment to be employed (light meter, multimeter, etc.)
6. Initial conditions required (only for intensity test, include sketch identifying exact site of each measurement)
7. Step-by-step procedure for taking the measurements
8. Data sheet to record readings (refer to **Figure 3**)
9. Final conclusion with signatures of those conducting/witnessing the test

F.3 Test sequences for duration tests (including those requiring intensity readings)

Emergency lighting system design can take three forms, as indicated below. The sequence of events in the duration tests should follow as indicated.

Emergency lighting provided solely by independent power sources (no power from main battery)

1. Establish initial conditions.
2. Trigger emergency lighting by shutting off HEP/auxiliary power.
3. Measure time duration lighting system remains on.

Emergency lighting provided solely from main battery (standby lighting)

1. Establish initial conditions.
2. Trigger emergency lighting by shutting off HEP/auxiliary power.
3. Measure time duration lighting system remains on.

Combination, with standby lighting provided from main battery, followed by emergency lighting provided from independent power sources

1. Establish initial conditions.
2. Trigger emergency lighting by shutting off HEP/auxiliary power.
3. Conduct test of standby emergency lighting, followed by IPS-powered lighting.
4. Measure time duration standby lighting system remains on.
5. Verify that IPS is triggered on after standby system shuts down.
6. Measure time duration emergency lighting system remains on.

If light intensity testing is required employing the main battery, Section 3.2, "Battery emulation," may be used.

F.4 Preparation for tests

F.4.1 Car preparation

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

Functional test

1. Activate the emergency lighting system and verify that all the required lights are illuminated and are functioning normally. For cars employing both main battery standby and IPS emergency lighting, both systems must be tested. Verify that the scheme used to trigger emergency lighting functions correctly, especially on equipment employing both main battery and IPS sources.
2. Verify that none of the emergency lighting components have fault indications illuminated (including but not limited to "end-of-life").
3. Correct any problems identified.

F.4.2 Initial conditions

Battery system

1. Information should be recorded identifying date of manufacture and time in service of main and independent power source batteries (if available).

Main battery

1. Main battery should be clean; for any wet batteries, fluid levels should be topped up as required.
2. Battery should be fully charged, as identified by the manufacturer.

Independent power sources

1. These should be fully charged, as identified by the manufacturer.

Temperature

1. Lighting is temperature sensitive; car interior should be nominally 70 °F or above.
2. 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.

The following two items apply only to cars undergoing intensity and duration testing:

Light fixtures

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

Car interior

1. The car should be free of trash and tools.
2. Protective wall and floor coverings that could influence readings must be removed.
3. The car should be configured and equipped as it would be when ready for revenue service.

F.4.3 Darkening the car and car setup

The car shall be configured as indicated before beginning the light level measurements. The intent is to configure the car in test to simulate it being disabled in a dark area on a clear, moonless night. The car should be arranged to depict it as it would be in typical revenue service. In addition, the individual reading locations are intended to be areas of interest to a passenger attempting to exit the area. For example, finding the emergency release instructions is relevant only if the door is closed. For further details, refer to Section 3.3.

F.4.4 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 in. height, 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.

F.4.5 Configure car power system for test

1. All the battery loads that may be applied under emergency conditions shall be identified. Circuit breakers shall be set so that those loads (door operators, PA system, controls, headlights or marker lights, etc.) that are normally present in revenue service are energized during the emergency lighting tests.
2. The tests shall be conducted with main battery power and/or IPS only; any feeds from HEP, auxiliary or wayside sources shall be disconnected.

F.5 Data collection

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

1. Number of car
2. Car type (e.g., Superliner-1 Sleeper)
3. Location where test is conducted: geographic location and where (e.g., in car wash building in Amtrak 14th Street shops, Chicago)
4. Year car put into service (identify grandfathering, as applicable)
5. Identification of individual(s) conducting test
6. Dates test conducted
7. Time of day
8. Record the status of the following:
    - Last renewal of main battery as required by authority maintenance policy (if available)
    - Last renewal of LED light fixtures as required by authority maintenance policy (if available)
    - Last renewal of IPS power sources (battery and/or supercapacitor) as required by authority maintenance policy (if available)
    - Last renewal of fluorescent and/or incandescent lamps as required by authority maintenance policy (if available)

    NOTE: These record are desirable to allow the railroad to better understand trends of components versus their age.

9. Record the instruments used:
    - Manufacturer and model number
    - Serial number of instrument
    - Date of last calibration
    - Whether equipped with color correction filter
10. Car interior air temperature
11. Outside ambient temperature

12. Method of darkening the car (photos may be used as reference)
13. Start, end and duration times for standby (if equipped) and emergency.

    NOTE: Standby mode does not have a mandatory duration requirement

14. Location of readings (need an illustration to show this; could be lighting arrangement drawing)
15. Light intensities (required only for cars undergoing intensity and duration test)

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

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

