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14	08/12/2025	Draft to be issued for public consultation

Statement on Public Consultation of AS 7531 Lighting and Visibility

We are pleased to announce that AS 7531 is being made available for public consultation. At this stage, feedback is sought on changes made to the following sections:

- Section 1 – Scope and General
  - Normative references
  - Defined terms
- Section 2 – Visibility design principles for rolling stock
- Section 3 – Headlights
- Section 4 – Visibility lights
- Section 11 – Livery
- Section 12 – Reflective deliniators
- Appendix A – Hazard Register
- Appendix B – Rolling stock lighting and livery profiles
- Appendix D – Heritage non-conformance risk mitigation identification and controls
- Appendix F – Headlights
- Appendix G – Visibility lights
- Appendix H – Luminance contrast
  - Luminance contrast metrics

We encourage stakeholders and interested parties to review these sections and provide comments, which will be carefully considered in the finalisation of the Standard. Input received will contribute to ensuring that the Standard reflects best practice and meets the needs of all relevant sectors.

Submissions should be provided by 27 February 2026 in accordance with the consultation process outlined on the Standards Australia website.

Preface

This Standard was prepared by the Rolling Stock Lighting and Visibility Development Group, overseen by the ARISO Rolling Stock Standing Committee.

Objective

The objective of this Standard is to provide the performance and technical requirements for interior and exterior rolling stock lighting and visibility. This includes conspicuity of rolling stock in day and night times and the identification of environmental factors affecting visibility of rolling stock.

Technical changes from previous editions of this Standard include the following:

(a) The review of technical requirements and corrections for rolling stock lighting design.

(b) The review of livery design on front facing areas of the leading rolling stock and retroreflector technology.

(c) Forward facing beacon lighting arrangements for rolling stock.

(d) Side lights arrangements for rolling stock.

(e) Luminance contrast specifications and testing methodology to support rolling stock conspicuity.

The requirements and recommendations provided in this Standard are derived from current validated practice in the Australian rail industry. This Standard supports innovation whilst remaining technology agnostic by providing permissive clauses and guidance material that rail transport operators (RTOs) can utilize to supplement the requirements and recommendations where deemed appropriate to do so by the applicable RTO.

Compliance

There are four types of provisions contained within Australian Standards developed by ARISO:

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard. Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred. Recommendations are identified within the text by the term ‘should’.

Recommendations recognize that there could be limitations to the universal application of the control, i.e. the identified controls are not able to be applied or other controls are more appropriate or better.

For compliance purposes, where a recommended control is not applied as written in the Standard it could be incumbent on the adopter of the Standard to demonstrate their actual method of controlling the risk as part of their WHS or Rail Safety National Law obligations. Similarly, it could also be incumbent on an adopter of the Standard to demonstrate their method of controlling the risk to contracting entities or interfacing organisations where the risk may be shared.

Permissions – conveys consent by providing an allowable option. Permissions are identified within the text by the term ‘may’.

Constraints – provided by an external source such as legislation. Constraints are identified within the text by the term ‘must’.

ARISO Standards address known hazards within the railway industry. Hazards, and clauses within this Standard that address those hazards, are listed in Appendix A.

Appendices in ARISO Standards may be designated either “normative” or “informative”. A "normative" appendix is an integral part of a Standard and compliance with it is a requirement, whereas an "informative" appendix is only for information and guidance.

Commentary

Commentary *C Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Section 1 Scope and general

1.1 Scope

This document provides the performance and technical requirements for rolling stock lighting and visibility for self-propelled locomotive, freight, passenger, road rail vehicles and infrastructure maintenance rolling stock including older/legacy locomotives, tourist and heritage rolling stock.

This document establishes the performance requirements for rolling stock lighting, livery and reflectivity that provide good practice for enhancing and maintaining train visibility.

This document specifies the design of lighting arrangements and systems, the design and colour application and maintenance of livery on rolling stock.

The document defines the technical specification for rolling stock conspicuity performance measures and testing methodologies. This includes a definition of luminance contrast levels applied to front facing areas of the leading rolling stock that identifies various backgrounds and environmental conditions.

This document is applicable to new, existing, and modified rolling stock and sets out to provide guidance for RTOs in identifying and addressing hazards that impact the conspicuity of a train:

(a) when approaching level crossings;

(b) where workers are performing duties in the proximity of operational rolling stock; and

(c) to facilitate the safe access and egress of rail traffic crew within the rail corridor.

This document provides guidance and support for identifying and mitigating risks for RTOs that operate non-conforming heritage rolling stock. See Appendix D.

Where requirements apply to rail freight wagons and other non-self-propelled rolling stock, it is indicated within the specific section.

This document does not specifically apply to rolling stock used on light rail or cane railways but items from this document can be applied to such systems as deemed appropriate by the relevant rail transport operator.

1.2 Normative references

The following documents are referred to in the text in such a way that *some* or all of their content constitutes requirements of this document:

- AS 7502, Road Rail Vehicles
- AS 7722, EMC Management
- AS 60529, Degrees of protection provided by enclosures (IP Code)
- AS/NZS 1680.2.1:2008, Interior and workplace lighting, Part 2.1: Specific applications - Circulation spaces and other general areas
- AS/NZS 1680.2.2:2008, Interior and workplace lighting, Part 2.2: Specific applications - Office and screen-based tasks
- AS/NZS 1680.2.4:2017, Interior and workplace lighting Industrial tasks and processes
- AS/NZS 1906.1, Retroreflective materials and devices for road traffic control purposes - Retroreflective sheeting
- IEC 61373, Railway Applications - Rolling stock equipment – Shock and vibration tests
- ISO/CIE 23539:2023, Photometry – The CIE system of physical photometry

- ISO/CIE TR 21783:2022: Light and lighting – Integrative lighting – Non-visual effects
- BS EN 13272, Railway applications – Electrical lighting for rolling stock in public transport systems
- 49 CFR 229.133, Interim locomotive conspicuity measures—auxiliary external lights
- 49 CFR 229.125, Headlights and auxiliary lights
- APTA SS-PS-004-99, Standard for Low-Location Access Path Marking
- Australian Government Australian Design Rules for road vehicles (ADR)
- CIE 251:2023, LED reference spectrum for photometer calibration
- Disability Standards for Accessible Public Transport (DSAPT)

NOTE:
Documents for informative purposes are listed in a Bibliography at the back of the document.

1.3 Defined terms and abbreviations

For the purposes of this document, the following terms and definitions apply:

1.3.1
AAR
Association of American Railroads

1.3.2
beacon lights
lights mounted on the brow of a locomotive or leading powered vehicle displaying lunar or white flashes of light to warn road users

1.3.3
candela (cd)
SI base unit of luminous intensity

1.3.4
chromaticity
objective specification of the quality of a colour regardless of its luminance, that is, as determined by its hue and colourfulness or saturation, chroma, intensity, or excitation purity

1.3.5
colour rendering index (CRI)
measure between 1 and 100 that defines the ability of a light source to accurately reveal the colour of an object

1.3.6
conspicuity
attribute that ensures that an object attracts attention in its surroundings

1.3.7
electronically controlled pneumatic (ECP)
type of freight car braking system in operation on self-propelled locomotive trains

1.3.8
emergency lighting
lighting powered from a separate source to the vehicle's main power source, providing illumination for evacuation purposes

1.3.9
end of train device (EoTD)
device mounted at the rear of a train that provides the functionality of an EoTM plus other features that can include monitoring brake pressure at the rear of the train and application of emergency brakes from the rear of the train

Note 1 to entry: Includes the provision of monitored information to the leading cab.

1.3.10
end of train marker (EoTM)
device, including tail lights, fitted to the trailing end of the last vehicle of a rail traffic consist to indicate the end of the consist

1.3.11
forward facing beacon lighting
visibility beacons fitted to improve luminance contrast due to the increased efficacy that the additional lighting has on forward facing areas of rolling stock

1.3.12
head-end unit (HEU)
leading self-propelled car of a rolling stock consist

1.3.13
illuminance (E)
amount of light falling on a surface from a light source and is typically expressed in lux measurements

1.3.14
kelvin (k)
scale in which the warmth or colour temperature of light is measured

1.3.15
light emitting diode (LED)
device that emits light when electric current flows through it

1.3.16
headlight assembly
headlight fitting that contains two or more separate bulbs or globes and able to be switched to a dim or bright setting

1.3.17
luminance (L)
intensity of light emitting from a source or surface per unit area in a given direction and measured in cd per metre square (cd/m^2)

1.3.18
luminance coefficient (q)
ratio of the luminance (L) of a surface element in a given direction by the illuminance (E) on the surface element expressed in inverse of steradians (1/sr)

1.3.19
luminance contrast (C)
difference in the amount of light reflected by two adjacent surfaces, which helps make them visually distinguishable regardless of colour

1.3.20
luminance contrast minimum and maximum thresholds
minimum and maximum luminance contrast levels required for the front face of the rolling stock to be visibly distinguishable from its background

Note 1 to entry: These thresholds, based on empirically determined reference luminance contrast, define the luminance contrast levels at which the front face of the rolling stock becomes visible.

1.3.21
luminous intensity
luminous flux emitted per unit solid angle, measured in cd

1.3.22
photometric performance
measurement of a lighting system's effectiveness, focusing on how it produces and distributes light to illuminate a space

1.3.23
RTO
rail transport operator as defined in the Rail Safety National Law

1.3.24
side lights
lights mounted on the side sill of rolling stock to improve side visibility or detection of rolling stock

1.3.25
visibility beacons
flashing lights placed on the front facing areas of rolling stock aimed at improving visibility to motorists and pedestrians at level crossings

1.3.26
wigwag
alternating light pattern where the left and right lights flash in sequence

General rail industry terms and definitions are maintained in the RISSB Glossary. Refer to:
https://www.rissb.com.au/glossary/

Section 2 Visibility design principles for rolling stock

2.1 Lighting and visibility design requirements

The following design requirements apply to rolling stock lighting and visibility design:

(a) Rolling stock lighting and livery design shall seek to improve rolling stock conspicuity for both day and night operation.

(b) Design for conspicuity of rolling stock shall incorporate the following environmental factors:

(i) ambient light, including typical brightness, angle and direction of the sun in relation to the track;

(ii) typical route backdrop and contrast;

(iii) typical route topography;

(iv) level crossing layouts and the angle of approach of road users to level crossings;

(v) typical environmental factors in local areas related to weather, dust and pollution;

(vi) local environmental regulations relating to light pollution; and

(vii) impacts to oncoming rail traffic crew and adjacent properties.

(c) The overall design for conspicuity of the rolling stock shall be effective to allow for rail traffic crew, track workers and interfacing road and pedestrian users to identify oncoming rolling stock and have time to respond and avoid an incident.

(d) The lighting design shall facilitate safe working operations, safe access and egress of rail traffic crew, and interaction with track workers performing duties in proximity to operating rolling stock.

(e) Lighting design shall provide for effective illumination of turnout components and other track infrastructure for rail traffic crew.

Light fittings and enclosures shall be robust in design and protection against the ingress of dust and fluids commensurate with the environment in which they are installed, resulting from maintenance activities and/or acts of vandalism in accordance with IEC 61373 and AS 60529.

Commentary C2.1

RTOs have an option of increasing the level of compliance through the addition of other measures, including beacon lights, to increase the luminance contrast levels that will further improve train conspicuity in level crossings.

2.2 Luminance contrast

The following principles apply when determining the visibility and luminance contrast of the front facing areas of rolling stock including the light fittings:

(a) The luminance contrast between the front face of the rolling stock and the background shall satisfy the minimum luminance contrast under typical environmental conditions that the rolling stock operates as defined in Clause 2.1 (b) of this document.

(b) Rolling stock lighting shall be turned on when calculating luminance contrast levels for trains that are approaching level crossings.

(c) The potential glare caused by high-intensity headlights or visibility lights from rolling stock shall be assessed, including its effect on rail traffic crew on adjacent and oncoming track, track workers, and interfacing road and pedestrian users.

(d) The luminance contrast shall be demonstrated by evaluating the luminance contrast metrics defined in this document for relevant combinations of viewing angles and viewing position based on the level crossing layouts and the angle of approach of road users as defined in Clause 2.1 of this document.

(e) The luminance contrast maximum and minimum thresholds shall be increased by the luminance contrast threshold increment defined in this document for the ambient light and typical brightness and direction of the sun at the time of measurement.

Commentary C2.2

Normal operations are the unique characteristics applicable to the RTO's operations, including the type of operation conducted and the rolling stock lighting setting, the rolling stock used, geographical locations and routes and anticipated weather conditions.

For further details regarding the effect of glare and eye strain from lighting, see Appendix H.3

For further details regarding luminance contrast metrics, see Appendix H.1

2.3 Luminance contrast testing methodology

When measuring the luminance of the front facing area and the background region of the rolling stock, a calibrated imaging luminance camera or equivalent shall be used. The imaging luminance camera shall capture the luminance of the rolling stock front face and the background, measuring the average luminance of the regions of interest. Alternatively, a calibrated spot luminance meter with appropriate aperture and sampling can be used.

The following steps shall be taken to determine viewing circumstances:

(a) Place the measurement instrument on the observer axis of interest (e.g. at the typical sightline of a road user approaching a level crossing or a driver vantage point).

(b) Pick range(s) such as angle and distance as appropriate to your risk case.

(c) Record the viewing distances and the angle between the rolling stock front face orientation and the sightline of the instrument/observer.

The following angular fields of view shall be used to define the background regions of interest:

(d) Immediate background region of interest: angular subtend between 3.5° – 5.5° vertically and 5.5° - 7.5° laterally around the front face of the rolling stock, depending on the viewing distance.

(e) Wider background region of interest: angular subtend between 5.5° - 8.5° vertically and 7.5° - 12.5° laterally around the front face of the rolling stock, depending on the viewing distance.

Depending on the measuring instrument, the subtended angle may be translated to a pixel size or region of interest size in the camera or to an aperture/distance in spot measurements.

For further details regarding luminance parameters and contrast definitions, see Appendix H.2

For further details regarding luminance contrast thresholds, see Appendix H.3

For further details regarding the luminance contrast calculation procedure, see Appendix H.4

For further details regarding the luminance contrast threshold increments procedure, see Appendix H.4

2.4 Environmental variability and temporal conditions

Measurements shall be conducted:

(a) during typical weather conditions; and

(b) under normal operating conditions.

Measurements during rapidly changing ambient light should be avoided unless explicitly testing those states.

Commentary C2.4

Typical weather conditions are the median long-term patterns that occur in a specific area and are attributed to variations in temperatures, precipitation and humidity. Luminance contrast measurements will vary depending on weather condition such as full/part sunshine, rain, fog and dusty conditions.

Measuring instruments should meet photometric performance guidance to the following:

(c) CIE 251:2023, LED Reference Spectrum for Photometer Calibration;

(d) ISO/CIE 23539:2023, Photometry — The CIE system of physical photometry; and

(e) ISO/CIE TR 21783:2022, Light and lighting — Integrative lighting — Non-visual effects.

Three measurement tests should be captured to record the median and standard deviation.

Section 3 Headlights

3.1 General

Self-propelled locomotive, passenger and infrastructure maintenance rolling stock shall have a headlight assembly fitted at each leading end of the rolling stock, that is configured in a design, to the requirements of this document. See Appendix F for further information regarding headlights.

Self-propelled locomotive, passenger and infrastructure maintenance rolling stock shall have a functioning headlight fitted to the leading vehicle when the rolling stock is moving. Headlights shall be installed symmetrically nearest to the centreline of the rolling stock.

See Appendix B for diagrams of headlight profiles of locomotive and passenger rolling stock.

3.2 Headlight colour temperature and luminous intensity

The headlight assembly shall produce light with a colour temperature between 3000 K and 4500 K.

On rolling stock types that can travel at speeds greater than 60 km/h or weigh more than 20 tonnes gross train/consist mass:

(a) A minimum luminous intensity output of 200,000 cd shall be produced by each headlight.

(b) If multiple headlight assemblies are installed, the total headlight arrangement shall have a maximum luminous intensity output of 500,000 cd.

The headlight assembly shall have the functionality to be reduced to a dim state of between 26,000 cd and 80,000 cd.

From the centreline of rolling stock when lights are in the final in-service position and aim, regardless of track alignment, each headlight assembly on bright setting shall produce;

(c) a minimum of 3,000 cd at an angle of 7.5^{o}, and

(d) at least of 400 cd at an angle of 20^{o}.

These angles apply to the horizontal beam as measured from the offset from the centre of the beam.

The candela requirement shall be met even if the headlights are fitted with devices to protect or diffuse the lighting output.

3.3 Headlight positioning and aim

Headlights on self-propelled locomotives, passenger rolling stock, and infrastructure maintenance rolling stock should be installed at a minimum of 2.3 m above the rail.

The centreline of each headlight beam shall be aimed at a point of one metre above the top of the rail at the centre of the track at a distance of 240 m.

3.4 Infrastructure maintenance rolling stock

The headlight assembly on Infrastructure maintenance rolling stock unable to travel at speeds greater than 60 km/h and weighing less than 20 tonnes gross train/consist mass shall produce a peak intensity of 100,000 cd.

The headlight assembly shall have the functionality to be reduced to a dim beam state by the driver to a luminous intensity between 26,000 cd and 80,000 cd.

Infrastructure maintenance rolling stock with a driving station at each end shall have a headlight arrangement fitted at each leading end.

Headlights on self-propelled road rail vehicles shall comply with the applicable Australian Design Rules (ADR) for road vehicles.

The headlights on road-rail vehicles shall be suitably interlocked with the direction control to provide clarity of direction of travel while on track and avoid contravention of ADR regulations while on the road.

3.5 LED headlights

LED headlights and their system components, such as drivers, controls, indicators and system interfaces shall comply with AS 7722.

LED light centreline positioning and aim shall minimize the distance in which the focused beam of an LED headlight is directly impacting the on-coming rail traffic crew at a windscreen level. Anti-glare beam patterns and lens technology should be used when choosing lighting assemblies for rolling stock.

To ensure quality of light emitted from LED fixtures:

(a) the fitting shall have a minimum colour rendering index of 70;

(b) the LED light shall not emit any visible signs of flicker; and

(c) the headlight shall not cause shutter roll in CCTV cameras, or video monitors on rolling stock or rail infrastructure.

Any system used to adjust or control the luminous intensity of an LED headlight shall not alter the spectral distribution of the light it produces.

Commentary *C3.5*

Anti-glare beam patterns including proprietary designs, asymmetric lenses and Fresnel lenses are widely available in LED light fixtures and are used to reduce glare for on coming rail traffic crews or adjacent road users.

Section 4 Visibility lights

4.1 General

Where fitted, visibility lights shall optimize the visibility of the leading end of the rolling stock through a horizontal spread of light across an arc of 180° at the front of the rolling stock to persons beside and approaching the track.

Visibility lights shall be switched on when a train is in operational mode. Visibility lights may be switched off for reasons of safety when the headlight is dimmed.

Visibility lights shall be used by rail train crews in yards and sidings and other areas where people need to be aware of the train's position and movement.

Visibility lights shall be installed on both ends where rolling stock perform reverse propelled movement at speeds greater than 30 km/h for a distance greater than 5 km in a typical operational context.

Visibility lights shall have the functionality to be switched on and off separate to the headlights.

Visibility lights shall have the functionality to be reduced to a dim state of between 26,000 cd and 80,000 cd. See Appendix G for general further information regarding visibility lights.

4.2 Forward visibility lights – Colour temperature and luminous intensity

Forward visibility lights shall produce white light with a colour temperature of between 2800 K and 4500 K.

Each forward visibility light shall produce a luminous intensity of between 20,000 cd and 30,000 cd.

From the centreline of the rolling stock when the light is aimed at the final installed angles, each forward visibility light shall produce:

(a) a minimum of 3,000 cd at an angle of 7.5°; and

(b) a minimum of 400 cd at an angle of 22.5°

Commentary *C4.2*

The maximum intensity of 30,000 cd is below the US 49 CFR 229.133 requirements of 200,000 cd for forward visibility lights. The lower output allows the lights to remain illuminated during day and nighttime operation without causing glare or discomfort to oncoming rail traffic crew and drivers of road vehicles.

4.3 Forward visibility lights – positioning

Forward visibility lights installed on forward-facing areas of rolling stock shall be installed between 600 mm and 1,800 mm above the top of the rail. If such placement compromises the integrity of the train cab body or is otherwise impractical, the RTO should conduct a risk assessment to validate the safe positioning of the forward visibility lights.

If forward visibility lights are mounted more than 1,500 mm below the headlights, the visibility lights shall be laterally separated by a minimum 900 mm and positioned symmetrically from the vehicle centreline.

4.4 Forward visibility lights – Aiming

Visibility lights shall be aimed using the crossed-beam arrangement. To apply the crossed-beam arrangement, visibility lights shall be aimed at a point between 25 m and 30 m in front of the vehicle at the top of the rail.

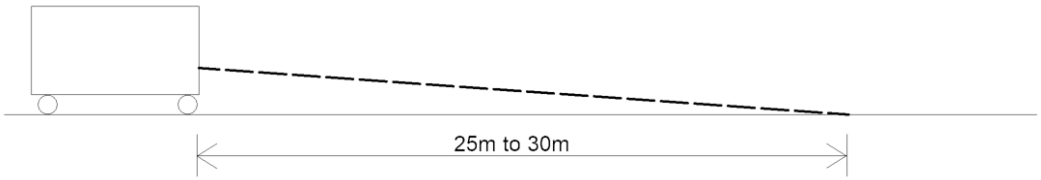


Figure 1 Side view of visibility light crossed-beam aiming arrangement

Visibility lights shall then be aimed and turned crossed-beam so that they intersect at a point between 4 m and 12 m, or up to 15^{o} from the vehicle centreline.

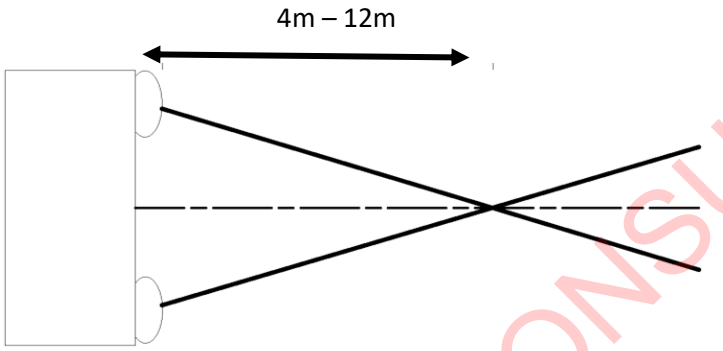


Figure 2 Top view of visibility light crossed-beam aiming arrangement

4.5 Triangle of light

Where the triangle of light arrangement is applied, the aim of the visibility light shall be arranged in accordance with auxiliary lighting requirements outlined in *US Code of Federal Regulations Title 49 Transportation Part 229.125 Railroad Locomotive Safety Standards – Headlights and Auxiliary lights*.

4.6 Forward visibility lights - Flashing

Where visibility lights are arranged to flash when the horn is sounded, they shall each flash on and off, such that the visibility lights are illuminated alternately in a wigwag pattern.

When the flashing function has been initiated by the sounding of the horn, the flashing shall continue for a minimum of 25 seconds after the horn has been sounded.

The flashing of the visibility lights shall occur with the triggering on the horn whether the visibility lights are on or off at the time of horn operation. When the wigwag is active, the light on duration shall equal the light off duration.

The duration of the flashing should be adjusted as per the operational requirements of the RTO.

When passenger, freight, locomotive or infrastructure maintenance rolling stock changes from a forward to a reversing move, visibility lights shall each flash on and off for a minimum total duration of 25 seconds, such that the visibility lights operate in a wigwag style on the forward-facing end in the direction of movement.

The rate of alternate flashing shall be a minimum of 40 flashes per minute and a maximum of 180 flashes per minute. All flashing lights installed across the rolling stock shall be synchronized to minimize distraction to oncoming rail traffic crew. The rate and duration of flashes should be determined by the likely speed in which the rolling stock is travelling and the position of the whistle boards.

Flashing visibility lights are not required on infrastructure maintenance rolling stock that operate at 30 km/h or less on the network or where it impedes the requirements of ADR.

Additional functionality can be added within the driver's cab to activate the flashing function of the visibility lights independently of the horn. Where provided, this additional functionality shall not provide any means to suppress the flashing of the visibility lights when the horn is sounded.

Where rolling stock operate in high frequency rail networks or through locations with a dense volume of level crossings, the duration of flashing should be increased from the minimum duration as detailed this document.

4.7 Forward-facing visibility beacons

Visibility beacons should be fitted to the lead rolling stock of a train to increase visibility in the forward direction. If fitted, the visibility beacons shall:

(a) be white in colour; and

(b) installed so as not to detract from the effectiveness of the headlights and the visibility lights.

Visibility beacon(s) should;

(c) have a minimum of 100 cd at an angle of 45^{o};

(d) have between 10 to 50 cd at an angle of 90^{o};

(e) be of a luminous intensity that does not contravene local environmental light pollution levels in which the rolling stock operates; and

(f) not cause distraction or glare to oncoming track workers, rail traffic crew or road users.

RTOs may use forward facing visibility beacons during the night to improve train conspicuity in areas where headlights are placed in dim mode due to operational restrictions or procedural requirements.

If interlocked when sounding the train horn, visibility beacons shall each flash on and off, such that the visibility beacons are illuminated in a wigwag pattern.

Where visibility beacons have variable rates of flashing, the frequency of flashing between any two consecutive flashes should be between 40 flashes per minute and 180 flashes per minute.

Light bars or beacons with adjacent light sources should be identified as single beacons to determine the rate of flashing.

All flashing lights installed across the rolling stock shall be synchronized to minimize distraction to oncoming rail traffic crew.

Commentary C4.7-1

Visibility beacons can improve luminance contrast due to the increased efficacy that the additional lighting has on forward facing areas of rolling stock at night, at wide-view angles and in foggy weather conditions.

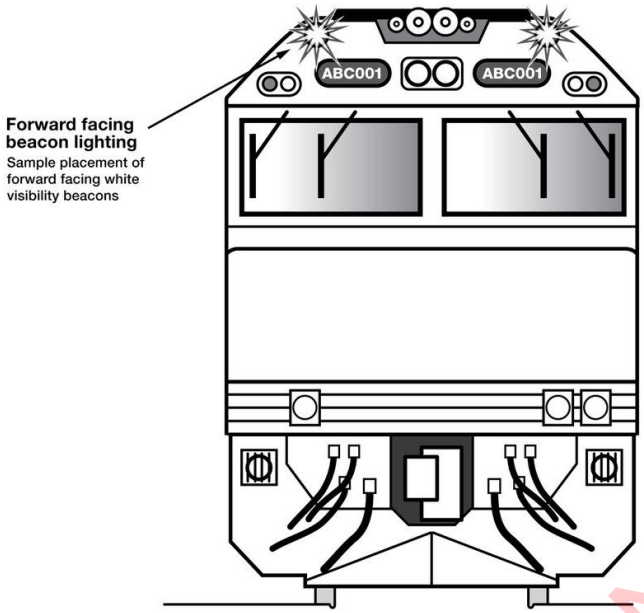


Figure 3 Sample of visibility beacons placed on the forward-facing end of a locomotive

Commentary *C4.7-2*

For further information regarding the classification and application of flashing beacons, refer to https://www.sae.org/papers/flashing-emergency-lights-influence-intensity-flash-rate-synchronization-driver-visibility-comfort-confidence-2022-01-0801

4.8 Side lights

Side lights should be fitted to each side of rolling stock to improve train conspicuity, particularly at night. Where installed, there should be a minimum of three (3) side lights placed on each side of the rolling stock, positioned at intervals from 25% to 50% to 75% of the length of the rolling stock.

Side lights shall be the same colour as the reflective delineators that are affixed to the rolling stock, either yellow or white.

Each side light should produce a luminous intensity of between 10 cd and 50 cd at an angle of 90^{o} and remain continuously illuminated whilst the train is in operational mode.

Side lights should be installed between 600 mm and 1,800 mm above the top of the rail and be placed in a position that allows for a 180 degree viewing angle.

4.9 Road rail vehicles (RRV)

For ADR-compliant RRVs, the normal ADR-compliant road headlights should be used as visibility lights when travelling in the forward direction.

Where compliance with the visibility requirements of this document cannot be achieved using the vehicle headlight, ADR-compliant vehicles should use rail headlights as visibility lights where this does not impede compliance with the ADR.

Use of light bars, work lights or any other light installations shall not:

(a) impede ADR regulations;

(b) exceed the maximum peak intensities prescribed for headlights; and/or

(c) be aimed directly at the oncoming rail or road traffic when in use.

Visibility lights on road-rail vehicles shall be suitably interlocked with the direction control to provide clarity of direction of travel while on track and avoid contravention of ADR regulations while on the road.

Each visibility light shall be of the same specification.

Section 5 Taillights, marker lights and EoTMs

5.1 General

Locomotives, self-propelled passenger rolling stock and self-propelled infrastructure maintenance rolling stock shall have red tail and white marker lights fitted as high and wide as practical, at both sides of each end of the rail vehicle.

Self-propelled track machines shall have red tail and white marker lights fitted as high and wide as practical, at each terminal end.

White marker lights shall be illuminated at the leading end.

Red marker lights shall be illuminated at the trailing end.

Each marker and tail light shall have a minimum luminous intensity of 75 cd.

If operating in a network where the safeworking system allows permissive working, each tail light shall have a minimum luminous intensity of 100 cd.

Track machines should have a specific marker light function in work mode, illuminating white marker lights at both ends.

The RTO shall demonstrate the reliability and redundancy of tail and marker light arrangements in the context of:

(a) degraded modes of lighting while in operation;

(b) visibility of rolling stock units lying dormant in sidings for other rail traffic crew; and

(c) in field maintenance requirements where rolling stock units with failed tail, marker or EoTM/D assemblies are not in proximity to maintenance facilities.

5.2 Road rail vehicles (RRV)

RRVs shall be fitted with tail and marker lights that comply with the applicable Australian Design Rules for road vehicles.

If duplicated, the tail lights on road-rail vehicles shall be suitably interlocked with the direction control to provide clarity of direction of travel while on track and avoid contravention of ADR regulations while operating on the road.

If operating in a network where the safeworking system allows permissive working, each tail light shall have a luminous intensity of a minimum of 100 cd.

Duplicate marker light(s) and tail light(s) should be installed on ADR-compliant RRVs, where reverse propelled movements are performed at speeds greater than 30 km/h for a distance greater than 5 km in a typical operational context.

Commentary C5.2

For further information regarding Australian Design Rules for road vehicles, refer to https://www.infrastructure.gov.au/infrastructure-transport-vehicles/vehicles/vehicle-design-regulation/australian-design-rules

AS 7502 provides additional requirements for RRVs.

5.3 End of train marker (EoTM)

Every operational train shall have an EoTM fitted at any trailing end of the train unless the rolling stock is fitted with functioning red tail lights.

Commentary C5.3

The primary function of the EoTM is to alert approaching rail traffic to the presence of a rail vehicle that could obstruct the path of the approaching rail traffic vehicle.

The EoTM can have the functionality to be automatically activated, manually activated and continuously illuminated. Where EoTMs are manually operated, the switching on/off can be achieved by local or remote switching.

The EoTM shall contain a light. The lit surface of the light should be between 8,000 mm^2 and 12,000 mm^2.

Any light used as an EoTM shall be red as defined in Appendix E CIE chromaticity limits (colour spaces) for colour designation in AS 1906.1:2017

The design and construction of the light used as an EoTM and its associated power supply shall have sufficient energy storage capacity and be sufficiently robust to ensure that it performs its intended function as detailed in this document.

The method of securing the EoTM assembly shall be engineered to ensure the EoTM remains vertically aligned and that the centre of the beam remains directed to the rear of the train in line with the longitudinal axis of the vehicle.

The luminous intensity of the EoTM light shall be between 100 cd and 250 cd.

The EoTM shall have the functionality to flash. The rate of flashing for an EoTM shall be between 40 and 180 flashes per minute.

The EoTM should include reflective delineators.

The colour of reflective delineators shall be white or red. The reflective delineators should have a minimum area of 14,000 mm^2 and a minimum dimension of 90 mm.

EoTM units shall be chosen for safe portability and connection capability for both rail traffic crew and maintenance technicians.

5.4 End of train device (EoTD)

If a EoTD is installed, it shall incorporate all the visibility functionality as described in Clause 5.3

The EoTD should incorporate other operational features to monitor functions such as brake pipe pressure and voltage.

EoTDs connected to electronically controlled pneumatic (ECP) or air turbine and sense and brake unit (SBU) brake systems shall automatically activate in low light conditions, including movement through tunnels.

When communication between an EoTD and HEU is lost, the EoTD shall be able to provide marker light capability and flash under battery operation for 12 hours until the battery depletes.

Commentary C5.4

Within the Australian rail industry, EoTMs can also be known as EoT monitors and EoTDs used interchangeably. For the purpose of this document, EoTM and EoTD have been used to define an end of train device.

If the EoTD incorporates additional features that support monitoring of brake pressure functionality, additional considerations can be given to the integration or installation of a head of train unit in the drivers cab and supporting back-end systems as per the technical requirements of the EoTD chosen for installation.

AS 7523.1 provides further guidance on EoTMs for locomotives.

Appendix C details the typical arrangement of different styles of EoTM/Ds and how these requirements can be incorporated into an operational setting.

Section 6 Number lights

Locomotives shall be fitted with two forward-facing, internally illuminated number boxes at each leading end where the safeworking system requires observance of locomotive numbers by RSWs, rail traffic crew and other trains.

Section 7 Construction or worksite warning light

Amber or orange flashing warning light(s) shall be fitted to self-propelled track machines and RRVs that operate within a worksite or construction zone.

Each warning light shall have a minimum luminous intensity of 18,000 cd.

Warning light(s) shall be mounted on the top of each vehicle, or in suitable locations, so that the warning light is visible to a person standing a minimum of 4 m, in any direction, from the vehicle at track level.

The flashing of the construction warning lights shall:

(a) be interlocked with the operation of the horn and brakes;

(b) operate when the rolling stock is performing a forward or backward movement; and

(c) flash as part of any other safety-related operation in the context of the specific vehicle or worksite.

The flash rate of warning light(s) shall be a minimum of 40 flashes per minute and shall be at most 180 flashes per minute.

All flashing lights installed across the rolling stock shall be synchronized to minimize distraction to rail traffic crew.

Commentary C7.1

Amber or orange flashing warning lights are installed to ensure compliance with relevant state legislation covering construction sites. They are primarily intended to reduce risk to workers on or around the track. Flashing warning lights are often classed as SAE Class 1, 2 or 3, which determines several characteristics such as flash rate and luminous intensity.

For further information regarding the classification and application of flashing warning lights, refer to https://www.infrastructure.gov.au/infrastructure-transport-vehicles/vehicles/vehicle-design-regulation/australian-design-rules

Section 8 Stop lights

8.1 Road rail vehicles (RRV)

RRVs shall be fitted with stop lights that comply with the requirements as detailed in the ADR.

Stop light arrangements should be installed on both ends of RRVs where the vehicle performs reverse propelled movement at speeds greater than 30 km/h for a distance greater than 5 km in a typical operational context.

If duplicated, the stop lights on RRVs shall be suitably interlocked with the direction control to provide clarity of direction of travel while on track and to avoid contravention of ADR regulations while on road.

Rail mounted trailers shall be fitted with a red stop light that comply with ADR requirements at the trailing end if the brake lights of the towing vehicle are obscured.

8.2 Track machines

Self-propelled track machines able to travel at speeds greater than 15 km/h shall be fitted with a red stop light at any trailing end.

Rail mounted trailers shall be fitted with a red stop light at the trailing end if the brake lights of the towing vehicle are obscured.

Stop lights on track machines shall have a luminous intensity of a minimum 60 cd per light.

Stop lights on track machines should be fitted with a flashing feature having a flash rate of a minimum 40 flashes per minute and at most 180 flashes per minute.

Section 9 Normal (non-emergency) interior lights

Normal (non-emergency) lighting levels inside the locomotive or passenger rail traffic crew cab areas should comply with the following:

(a) Drivers' cab - general: Minimum 75 lux (illuminance uniformity 0.5 to 2.5).

(b) Rail traffic crew workstation: Minimum 75 lux at desk level (illuminance uniformity 0.7 to 1.3).

(c) Timetable light: Minimum 160 Lux at 150 mm (illuminance uniformity 0.7 to 1.3).

(d) Rail traffic crew reading light: Minimum 150 lux (illuminance uniformity 0.7 to 1.3).

(e) Kitchen and other working areas: Minimum 300 lux (illuminance uniformity 0.7 to 1.3).

Normal (non-emergency) lighting levels inside the passenger car and defined passenger seating areas eating areas where no additional reading lights are provided should have an average illuminance greater than or equal to 300 lux.

Normal (non-emergency) lighting in passenger areas shall comply with the requirements of the Disability Standards for Accessible Public Transport (DSAPT).

Normal (non-emergency) lighting levels inside track machines should comply with the appropriate task lighting levels recommended by AS 1680.2.1, AS 1680.2.2 and AS 1680.2.4

Section 10 Emergency lights

Spaces (cabins, rooms, vestibules, aisles, crew cars etc.) on locomotives, passenger rolling stock, and track machines where people can be enclosed in during operation, shall have emergency lighting.

Emergency lighting on locomotives and track machines shall be able to operate for a minimum of 90 minutes after the main power is switched off.

Emergency lighting on passenger rolling stock shall be able to operate for a minimum of 180 minutes after the main power is switched.

Emergency lighting on track machines shall provide a minimum of 0.2 lux illuminance at floor level along exit paths.

Emergency lighting on passenger rolling stock shall provide a minimum of 1.0 lux illuminance at floor level along exit paths.

Where power supply permits, emergency lighting on rolling stock should provide a minimum of 5.0 lux illuminance at floor level along exit paths.

A minimum illuminance uniformity ratio of 0.2 should be achieved when measured along the centre line of the escape route lighted pathway.

The maximum illuminance uniformity ratio of the emergency lighting, measured along the centre line of the escape route should be 5.0

The minimum value of the average illuminance of emergency lighting in the passenger and crew areas on locomotives, passenger rolling stock and track machines shall not be less than 75 lux measured in accordance with EN 13272-:2020. This shall include floor areas that provide access to and at emergency exit doors, as well as the illumination of any equipment necessary to provide emergency egress.

Emergency lighting on passenger rolling stock in passenger areas shall include both:

(a) ceiling mounted lighting that is powered by the normal battery supply of the rolling stock; and

(b) illuminated emergency exit paths and exit equipment that is crash-tolerant and mounted near the vehicle floor as per APTA SS-PS-004-99

Commentary C10.1
Methods of illuminating emergency exit paths is also intended to provide illumination in the event of fire and/or loss of main batteries.

Refer to APTA SS-PS-004-99 Standard for Low-Location Access Path Marking for a specification describing passive and active means of achieving the clause above.

Refer to BS EN 13272 for further information on the method of measuring illumination.

RTOs apply additional emergency lighting requirements to tail lights, marker lights or EoTM/Ds where deemed appropriate in managing risks.

Section 11 Livery

11.1 General

The lead vehicle of a passenger train that is hauled by locomotives or has powered cars shall have a high visibility livery design applied to a minimum of 30% of the front and sides of the vehicle.

Selection of colour and arrangement of high visibility and general colour areas shall enhance overall visibility and provide contrast with:

(a) track workers in rail high-visibility clothing standing at track level;

(b) typical local environment background colours in which the rolling stock operates; and

(c) access doorways and emergency access points on the side and rear of a rolling stock.

Logos shall not be applied in a way that reduces compliance with the livery section of this document.

See Appendix B for typical livery arrangements for locomotives and passenger rolling stock

11.2 High-visibility colour areas

High-visibility colours shall be applied to front facing areas of each leading end of locomotives and a passenger train that is hauled by locomotives or has powered cars. An area of high-visibility colour should be extended down the sides of the rolling stock to a minimum of 75% of available space.

Locomotive and passenger rolling stock shall have high-visibility livery colours to the maximum available space of front facing areas. The livery shall incorporate high-contrast patterns or shapes to enhance conspicuity for at least 30% of the area.

Commentary C11.2

High-contrast patterns or shapes which enhance conspicuity include straight lines and angles not generally found in backgrounds. These include chevrons, often applied to cow catchers, V patterns often applied to the fronts of locomotives in the past and square checkerboard patterns.

Other patterns and shapes can be employed including company logos if they stand out from the livery visually. Colours, patterns and shapes that blend in with backgrounds are unsuitable for high visibility areas.

Infrastructure maintenance rolling stock shall have livery applied with high visibility colour to the maximum available space on the front and sides of the vehicle body above the headstock. This should include any articulated component as part of the track machine such as the excavator boom arm.

ADR compliant RRVs should have livery applied with high visibility colours to the maximum available space of the front facing areas.

Front facing area of colour can be divided by the features of the front of the rolling stock.

High-visibility colour should be applied to front facing areas above the headstock and on front facing curtain areas below the headstock where available. This excludes bogie structural components below the headstock.

If the front of the rolling stock slopes from vertical or is rounded, the area of the coloured surface and its vertical and/or horizontal dimensions shall be increased to produce the equivalent required areas.

Available space on front facing areas of rolling stock shall exclude:

(a) windscreens;

(b) fixtures and fittings for lighting assemblies;

(c) identification markers, illuminated locomotive rolling stock numbers and destination boards;

(d) hot surfaces such as steam boilers;

(e) coupler assemblies and buffer stops; and

(f) hoses and cocks.

The high-visibility areas on locomotives and passenger rolling stock can include the colours red, yellow or orange as defined in Appendix E CIE chromaticity limits (colour spaces) for colour designation or white as described in AS 1906.1.

The high-visibility areas on infrastructure maintenance rolling stock or RRVs may be yellow as defined in Appendix E CIE chromaticity limits (colour spaces) for colour designation or white as described in AS 1906.1.

The red, yellow or orange high visibility areas shall have a minimum luminance factor in accordance with AS/NZS 1906.1.

The livery design shall include hazard marking patterns using two colours with a contrast of greater than 50% for the entire width of front facing available areas below the headstock of locomotive rolling stock and infrastructure maintenance rolling stock.

The application of the patterns using colours and shapes, including within logos, in the livery design shall be reviewed to ensure that when the livery is viewed the patterning of colours does not reduce the conspicuity of the vehicle through camouflage effects.

If a hazard marking pattern is included within the front facing livery design, it shall not detract from the requirements of this document.

11.3 General colour areas

Minimum sectional area sizes for applying general colour on front facing areas on all rolling stock shall:

(a) be a minimum of 1 m^2 in area with a minimum continuous height or width of 0.6 m; and

(b) have sections with divided colour surfaces with an uninterrupted area of 0.4 m^2 and a minimum continuous height or width of 0.6 m.

Any application of general colours on front facing areas of rolling stock shall not detract from the requirements of Clause 11.2 of this document.

New rolling stock to be operated in rail corridors with signalling and other safety critical equipment, shall not use the colours green or red in the livery design of front facing areas.

The use of the colours green or red in livery applications on front facing areas of existing rolling stock should be subject to a risk assessment, with controls applied to limit conflicts with signalling and other safety critical equipment within the rail corridor.

Fluorescent colours compliant with AS/NZS 1906.1 may be used to improve daytime visibility.

Hazard patterns may include angled chevron markings that provide a clear distinction from the typical background environment.

The extension of the high visibility colours down the sides of the vehicle should be determined using a risk assessment that considers the vehicle design, access openings and environmental factors.

Commentary C11.3

Various conspicuity measures are developed considering the operational context of the rolling stock. As the rolling stock travels through the rail corridor, the contrast achieved with the surrounding environment will vary.

Application materials with the capability of glow in the dark colours that do not interfere with the above requirements can be used to improve the visibility of rolling stock at night.

Section 12 Reflective delineators

Reflective delineators shall be fitted to vertical surfaces on each side of all self-propelled and non-self-propelled rolling stock and freight wagons.

Reflective delineators shall be located from a minimum of 800 mm above rail level to a maximum of 2,000 mm above rail level.

Reflective delineators shall be rectangular strips or panels with a height of between 75 mm and 150 mm, and length of not less than 350 mm nor more than 500 mm.

The length of reflective delineators whose height is 100 mm or less shall be 450 mm.

The colour of reflective delineators shall be white or yellow.

Reflective delineator dimensions shall be adjusted to fit available spaces for all installations.

Reflective delineators shall be installed in a location that reflects light at night that is clearly visible on the outer most body area of the rolling stock or wagon.

Reflective delineators shall be mounted on each side within 500 mm of each end of the rolling stock or in a location close to that distance that allows clear visibility at the road user level.

Additional reflective delineators shall be fitted every 2,000 mm to 3,000 mm between the end-mounted delineators for locomotives, passenger, infrastructure maintenance rolling stock and freight wagons where the design and space allows.

For skeletal container wagons, reflective delineators shall be applied on the transoms or full width bolsters at each end and in the centre or on the side frame of bogey structure where the design and space allow.

Reflective delineators should be fitted to the outer extremities of the headstock on both ends of each vehicle. Each reflective delineator should have a minimum height of 75 mm and a minimum width of 350 mm.

Reflective delineators shall be installed in locations on rolling stock that minimize the risk of damage to the delineators, such as, away from tie down and lashing points.

Class 1100 reflective material compliant with AS/NZS 1906.1:2017 or above shall be used.

Section 13 Access lighting

Lighting shall be provided on locomotives to illuminate exterior walkways and steps, ladders and the ground below ground-access steps and ladders.

A minimum illumination level of 150 lux on the access treads shall be achieved on passenger rolling stock, or a minimum illumination level of 80 lux for locomotives and infrastructure maintenance rolling stock.

The positioning of the step light should not cast shadows on step rungs or the ground below.

Access lighting shall remain illuminated for safe boarding of the vehicle, including when the vehicle is powered off under normal conditions.

The access light controls shall be installed in a position to facilitate safe operation while boarding and alighting from ground level.

Section 14 Coupler lighting

Lighting shall be provided on locomotives and passenger rolling stock to illuminate the area around couplers that can be separated during service operation.

Lighting should be provided on infrastructure maintenance rolling stock to illuminate the area around couplers which can be separated during service operation.

The top and sides of the coupler head, and any coupler manual release point should have a minimum illumination level of 20 lux.

Section 15 Work lighting

Infrastructure maintenance rolling stock working in conditions of poor visibility shall have lighting to illuminate areas that are hazardous to workers on or around the vehicle.

Minimum illumination level shall be 150 lux.

> Commentary C15.1
>
> Considerations for the selection and operation of work lighting could include the expected maximum luminous intensity, position, and aim of the work lighting.

Poor visibility conditions include working in tunnels or at night when nil or inadequate wayside lighting has been provided.

Section 16 Maintenance

The RTO shall ensure that all rolling stock operating within its responsibility has a maintenance plan that defines maintenance activities that assure:

(a) the preservation or enhancement of the illumination and alignment properties of all lighting fixtures and arrangements; and

(b) conspicuity levels of high visibility colour areas and livery designs are maintained.

Where any lighting design or configuration on rolling stock is changed though a periodic upgrade or defined maintenance program, the RTO shall undertake a change management process to ensure that any identified impacts of the design change on affected parties are appropriately mitigated.

Maintenance plans shall include as a minimum:

(c) definition of the key roles responsible for all prescribed maintenance activities;

(d) planned routine inspection activities of all lighting and visibility equipment installed;

(e) identify and replace components that have reached the end of their service life or show a level of wear and degradation of illumination properties;

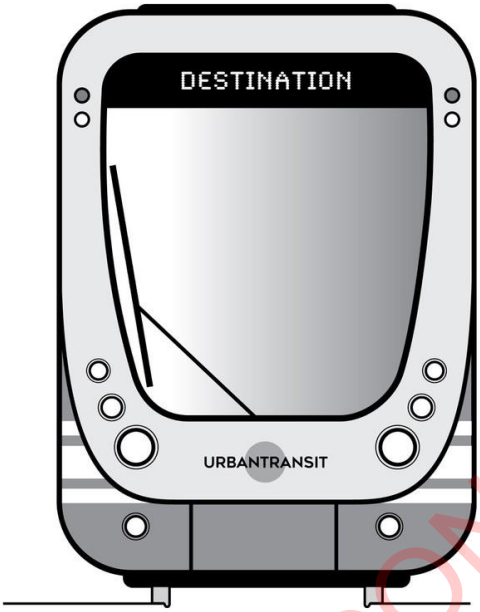
(f) provide specific, scheduled cleaning requirements to remove the build-up of dirt, debris and graffiti contamination on livery and lighting fixtures; and

(g) check the presence, integrity and cleanliness of reflective delineators.

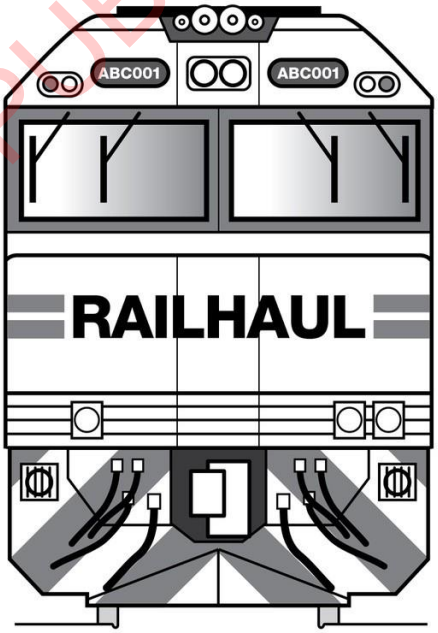
Appendix A Hazard Register (Informative)

Hazard number	Hazard
5.3,5.3.1	Harm to persons, Derailment or Collision
5.4,5.4.1	Harm to Rolling Stock, Derailment or Collision
5.5,5.51	Harm to Rolling Stock Related Processes, Derailment or Collision, Track Obstruction
5.7,5.71,5.7.11,5.7.25	Path Infringement, Derailment or Collision, Track obstruction, Objects on track, Level Crossing Collision
5.8,5.8.1	Derailment, Track Obstruction
5.18, 5.18.1,5.18.15, 5.18.17,5.8.18,5.18.1.17, 5.18.1.18,5.18.1.29, 5.18.1.32	Level Crossing Collision, Derailment, Track Obstruction, Poor Visibility of Trains, Poor Audibility of Trains by Road Traffic and Pedestrians, Overspeed by Road Traffic, Inadequate Crossing Signage, Road Vehicles or Pedestrians being Distracted, Road Vehicles deliberately Parking over Crossings, Road Vehicle Driver Fatigue
5.29,5.29.1,5.29.1.7	Object on Track, Derailment or Collision, Level Crossing Collison
5.33,5.33.1, 5.33.1, 5.33.1.2,5.33.1.3,5.33.1.6, 5.33.1.7,5.33.1.9, 5.33.1.12,5.33.1.12, 5.33.1.27	Poor Visibility of Trains, Derailment or Collision, Track Obstructions, Vision obscured, Weather affecting Vision, Poor Train Livery Contrast, Dirty Faded Train Livery, Train Lights Not Switched On, Train Reflectors Dirty, Train Light Illumination Inadequate, Train Light and Reflector Output Insufficient
6.10,6.10.1,6.10.1.16	Train Path Infringement, Derailment or Collision, Track Obstructions Level Crossing Collisions,
7.1,7.1.1,7.1.1.1,7.1.1, 7.1.1.9,7.1.1,7.1.1.12	Human Factors, Derailment or Collision, Harm to Persons, Fatigue, Environmental Conditions, Loss of Situational Awareness
7.2,7.2.1,7,2,1,16	Harm to Persons, Human Factors, Motorists or Passengers Being Careless at Level Crossings
7.3,7.3.1,7.3.1.1,7.3.1.9,7.3.1.15	Damage to Rolling Stock and or Infrastructure, Fatigue, Environmental Conditions, Poor Equipment Layout
8.1,8.1.1,8.1.1.7,8.1.1.10	Operations, Derailment or Collision, Human Error, Environmental Impact, Network Rules and or Procedure breach, Unauthorized Motor Vehicle on Track
8.5,8.5.1,8.5.1.1,8.5.1.3	Injury or Death of a Third Party, Derailment or Collision, Human Error, Track Obstruction, Being Struck by Trains, Being Struck by Motor Vehicles

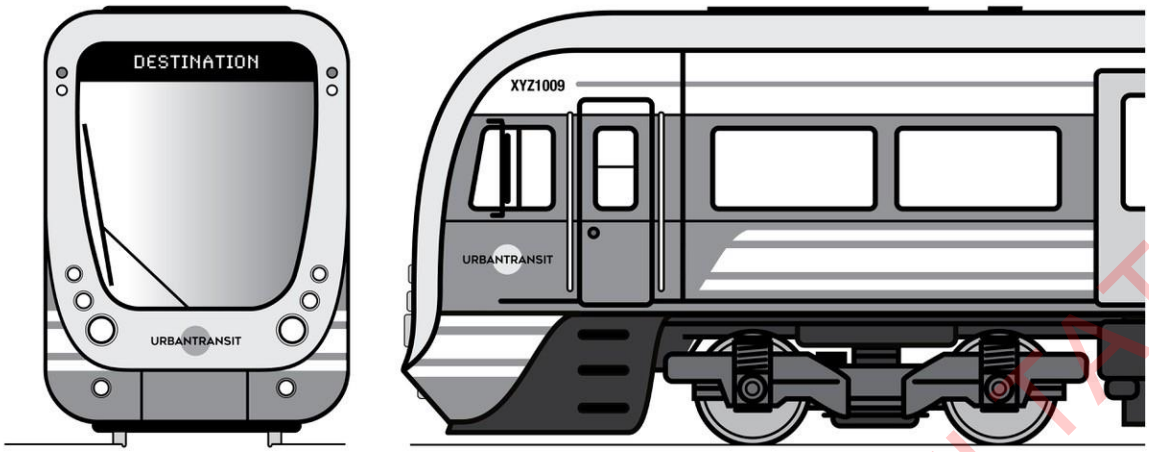
Appendix B Rolling Stock Lighting and Livery Profiles (Informative)



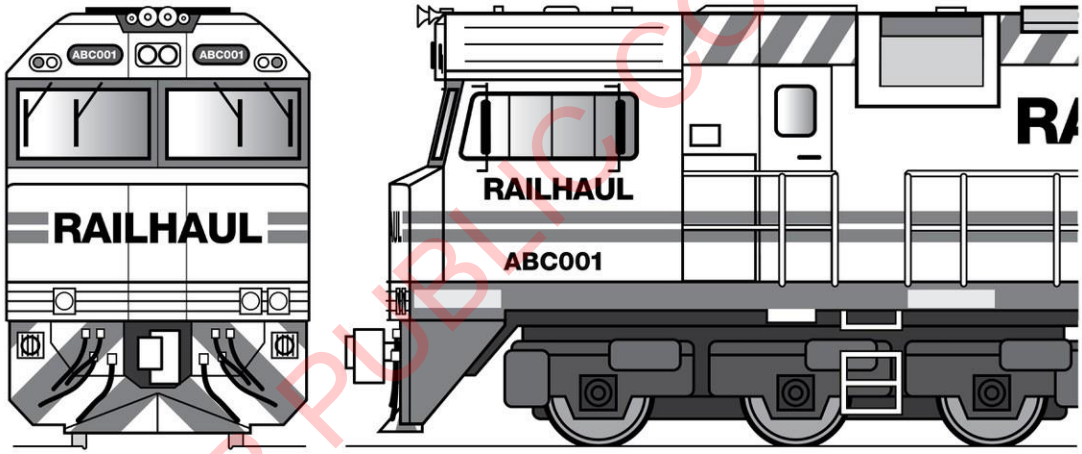
Appendix Figure B-1 Passenger rolling stock displaying headlight and visibility light arrangements



Appendix Figure B-2 Locomotive rolling stock displaying headlight and visibility light arrangements



Appendix Figure B-3 Passenger train displaying front and side livery aspects



Appendix Figure B-4 Locomotive displaying front and side livery aspects

Appendix C Typical Arrangements for EoTMs and EoTDs (Informative)

The arrangement for end of train markers can be tailored to the specific requirements of the rail operator and the type of train. The information below shows how these different operational requirements can be met.

Type of EOTM/D	Portable tail lamp	Air turbine and SBU EoTD	ECP EoTD
Function	Provides a flashing red light in low-light conditions.	Provides a flashing red light in low-light conditions plus increased safety and brake pipe monitoring.	Provides flashing light when the ambient light is low plus monitoring of critical ECP parameters.
Features	Simple, basic device that can be easily removed and replaced as required.	Battery backup, charged by a brake pipe generator. Remote air pressure supplied to the lead HEU via radio. The ability to trigger a brake pipe dump via remote switch on the lead HEU.	Battery back-up, charged by the trainline power. Trainline air pressure and electrical monitoring back to the lead HEU. End of train information – air pressure, voltage, via test button on the side. Second generation shows EoTD ID on the lead locomotive and can show as a marker in cross talk logs.
Flash rate	Between 40 and 180 flashes per minute with typical value 120 per minute and flash duration 25 ms.	Between 40 and 180 flashes per minute.	Between 40 and 180 flashes per minute.
Brightness	100 cd measured at the centre of the beam	100 cd measured at the centre of the beam	100 cd measured at the centre of the beam
Service interval	Each unit is inspected on a roll by to determine functionality.	12 - 18 months	Three yearly
Battery life	10,000 hrs with 2 50 Ahr alkaline batteries.	Nominal 12 hrs	Nominal 12 hrs
Maintenance requirements	Repair or battery replacement as indicated by condition	Servicing completed in accordance with AAR specifications by OEM.	Service, maintenance, and calibration is completed by OEM in accordance with AAR

Type of EOTM/D	Portable tail lamp	Air turbine and SBU EoTD	ECP EoTD
	monitoring and inspection program	LED lights are checked for functionality and flashing frequency while in service.	recommended practices. Each EoTD is also cleaned, and a full functional test is completed. Spare EoTDs are kept on charging racks ready for use at most depots.

Appendix D Heritage Non-conformance Risk Identification and Controls (Informative)

This appendix provides guidance to heritage operators in identifying typical non-conformances to AS 7531 that are associated with heritage rolling stock. The below table identifies controls that can be considered during an RTO's risk assessment process. The controls listed in the below table are not exhaustive and can be used as a guideline to mitigate abnormal operating risks. Any potential control adopted will need to be negotiated with the RIM before acceptance.

In principle heritage vehicles can apply AS 7501 to ensure an appropriate level of compliance suitable for their operation.

Abnormal Operating Risk	Acceptable Controls
Headlight is unable to be dimmed. Headlights can cause oncoming rail traffic crew to be 'blinded' by the light(s), if turned off vehicle visibility is significantly reduced.	**Main line** • Modify/replace headlight or switching - Engineering • Operate during daylight hours only – Substitution • Turn headlights off when approaching other trains (for rollingstock without the ability to dim headlights, it is acceptable to turn headlights off when crossing oncoming trains only on track with no level crossings or exclusively active level crossings) – Administrative • Driver training in headlight use in varying conditions – Administrative • Compliance with network rules and operating procedures – Administrative • Placement of rolling stock in consist – Compliant locomotive to operate in lead position - Substitution • Continuous operation of visibility lights on during operations – Administrative **Isolated Network** • Low likelihood of occurrence plus low speed of operations, very limited risk

Abnormal Operating Risk	Acceptable Controls
Headlights not being able to reach minimal intensity of 200,000 cd and/or minimum colour temperature of 3000 K. Colour temperature levels below 3000 K can produce a warm yellow or amber tone through the use of incandescent bulbs.	**Main line** • Modify/replace headlights - Engineering • Utilize/fit visibility lights to supplement headlight – Engineering • Increase whistle usage to align with heritage RTO's method of attracting attention – Administrative • Reduction of speed/train notices – Administrative • Rolling stock to operate on networks with active level crossings only – Isolation **Isolated Network** • Maintain Low speed operations – Substitution • Fitting of visibility lights to supplement headlights – Engineering • Increase whistle usage to align with heritage RTO's method of attracting attention – Administrative

Abnormal Operating Risk	Acceptable Controls
Visibility lights not fitted Ability for track workers and road users to identify the vehicle as a rail vehicle in poor visibility conditions is impaired. Ability for rail traffic crew to visually confirm setting of the roads in poor visibility conditions is impaired.	Main line • Fit visibility lights - Engineering • Rolling stock to operate on networks with active level crossings only – Isolation • Increase whistle usage to align with heritage RTO's method of attracting attention – Administrative • Reduction of speed – Administrative • Driver training of any procedural requirements – Administrative • Compliance with network rules and operating procedures – Administrative • Placement of rolling stock in consist – Compliant locomotive to operate in lead position - Substitution Isolated Network • Maintain Low speed operations – Administrative • Alternate lighting arrangements, e.g. increased intensity of marker lights – Engineering • Improve street lighting around level crossings – Engineering
No flashing interlock with horn activation & no alternate flashing light activated on horn activation. Rail traffic crew cannot visually alert track workers and members of the public to its presence or that it is starting a movement/direction change at an appropriate safe distance.	**Main line** • Upgrade/modify equipment to achieve integration – Engineering • Visibility lights on permanently - Engineering • Placement of rolling stock in consist – compliant locomotive to operate in lead position - Substitution • Steam locomotive noise emission from cylinders acts as audible warning **Isolated Network** • Maintain Low speed operations – Administrative • Steam locomotive noise emission from cylinders acts as audible warning

Abnormal Operating Risk	Acceptable Controls
Livery on front facing areas of rolling stock conflict with objects within the rail corridor such as signals and other safety critical infrastructure. Rolling stock that have the colours of red or green in front facing areas of lead rolling stock.	**Main line** • Paint over noncomplying areas of rolling stock – Elimination • Placement of rolling stock in consist – Compliant locomotive to operate in lead position - Substitution • Placement of boards and signs on the front facing areas of the lead rolling stock – Engineering **Isolated Network** • Low likelihood of occurrence due to network isolation very limited risk

Appendix E Lighting arrangement overview (Informative)

Lighting type	Luminous intensity requirement (cd)	Key notes
Headlight Locomotive and passenger rolling stock	Bright beam Between 200,000 – 500,000 Dim beam Maximum 80,000	Colour temperature between 3,000 K – 4,500 K Maximum aggregate cd across all headlight assemblies is 500,000.
Headlight Infrastructure maintenance rollingstock	Speeds > 60 km/h Bright beam Between 200,000 – 260,000 Dim beam Maximum 80,000 Speeds <60 km/h Bright beam Maximum 100,000 Dim beam Maximum 80,000	Colour temperature between 2,800 K – 4,500 K Units with driving stations at each end to have headlight arrangements fitted at both ends.
EoTM/D	See Appendix C, Typical Arrangements for EoTMs and EoTDs	
Visibility Lights	Between 20,000 – 30,000	Colour temperature between 2,800 K – 4,500 K
Road Rail Vehicles	To comply with all ADR regulations	
Tail, marker and EoTM/Ds	Between 100 – 250	White marker lights at leading end Red marker lights at the trailing end Self-propelled track machines to have both red and white marker lights fitted at each terminal end
Construction warning lights	Minimum 18,000	Orange or amber in colour Flash rates between 40 and 180 flashes per minute. Flashing across all to be synchronized

Appendix F Headlights (Informative)

Headlights act as a warning signal, alerting others to the train's approach, especially when approaching level crossings or other potentially hazardous areas.

Headlights are aimed/focused to illuminate the area in the direction of travel of a train, so that rail traffic crew can observe track signage and signals, assess track condition and perway obstructions.

Headlights are aimed/focused such that they do not illuminate areas outside of the rail corridor.

External observers outside the areas of the rail corridor include, but are not limited to:

(a) track workers;
(b) passengers standing on platforms;
(c) rail traffic crew in other trains;
(d) level crossing users;
(e) trespassers; and
(f) domesticated animals and livestock.

Appendix G Visibility Lights (Informative)

Visibility lights, also known as ditch or auxiliary lights, are designed to enhance a train's visibility, especially at level crossings to prevent accidents. They are typically positioned lower than the main headlight, closer to the track, and often flash alternately when the horn is sounded by the rail traffic crew.

Visibility lights help road traffic users and pedestrians to better estimate a train's distance and speed, particularly in situations where visibility could be poor. This differs from the use of the headlight to give the rail traffic crew better visibility.

Visibility lights help prevent collisions between trains and vehicles or pedestrians at crossings as they are positioned to illuminate the area around the train, making it more noticeable to those approaching level crossing.

For rail traffic crew, visibility lights are used:

(a) to illuminate an area, close to the front of the lead vehicle, that is not lit by the main headlight, for the purpose of giving visibility for ground operations or for detection of obstructions;

(b) to illuminate potential or actual obstructions or reportable problems such as water in the side of cuttings, rock falls, or personnel;

(c) to illuminate track maintenance equipment and personnel working or stored near the track;

(d) illuminate the inside of a curve; and

(e) to help reinforce rail train crews' attempts, along with the horn and headlight, to give motorists and pedestrians warning of an approaching train.

For road motorists, pedestrians and other road users' visibility lights are used:

(f) to catch the attention of motorists and other road users;

(g) to catch the attention of pedestrians;

(h) to assist the motorists, pedestrians and other road users estimate of the speed and distance of the train, so that so that they cross the railway safely; and

(i) to provide a visual notification in addition to the audible notification of the proximity of a train.

For rail traffic crew and workers positioned within the rail corridor, visibility lights are used:

(j) to alert other rail traffic crew of an approaching train; and

(k) to assist workers appreciation of train location and movement.

Appendix H Luminance Contrast (Normative)

H.1 Luminance contrast metrics

The degree to which the front face of the rolling stock stands out from its background is defined by its luminance contrast (C). The luminance contrast of the front face of the rolling stock is calculated for both the immediate background, the background area immediately surrounding the front face of rolling stock, and wider background, the broader background area surrounding the front face of rolling stock.

Luminance contrast (C) is given by:

Appendix Equation H.1-1

$$C = C_b \text{ or } C_{ib}$$

depending on the viewing distance and viewing angle.

where:

C_b– Luminance contrast of the front face of rolling stock relative to the wider background:

Appendix Equation H.1-2

$$C_b = \frac{L_0 - L_b}{L_b}$$

C_{ib} – Luminance contrast of the front face of rolling stock relative to the immediate (narrow) background:

Appendix Equation H.1-3

$$C_{ib} = \frac{L_0 - L_{ib}}{L_{ib}}$$

The luminance contrast shall be computed using the above metrics.

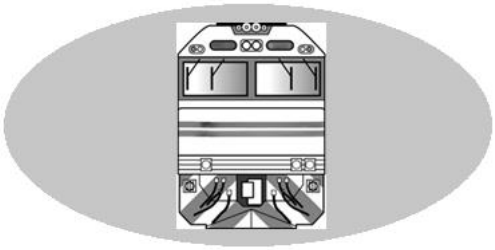
H.2 Luminance contrast parameters and contrast definitions

L_o – Average luminance of the front-facing rolling stock

Measured in cd·m⁻², this represents the mean luminance of the front face of rolling stock, including the cab surface and any marker or lighting elements that contribute to its visual conspicuity.

L_{ib} – Average luminance of the immediate background region

Measured in cd·m⁻², this value represents the mean luminance of the background area immediately surrounding the front face of rolling stock, within a narrow field of view. This is the area subtended by the field of view approximately 3.5° - 5.5° vertically and 5.5° - 7.5° laterally around the front face of rolling stock, depending on the viewing distance. The immediate background region excludes the rolling stock front region.

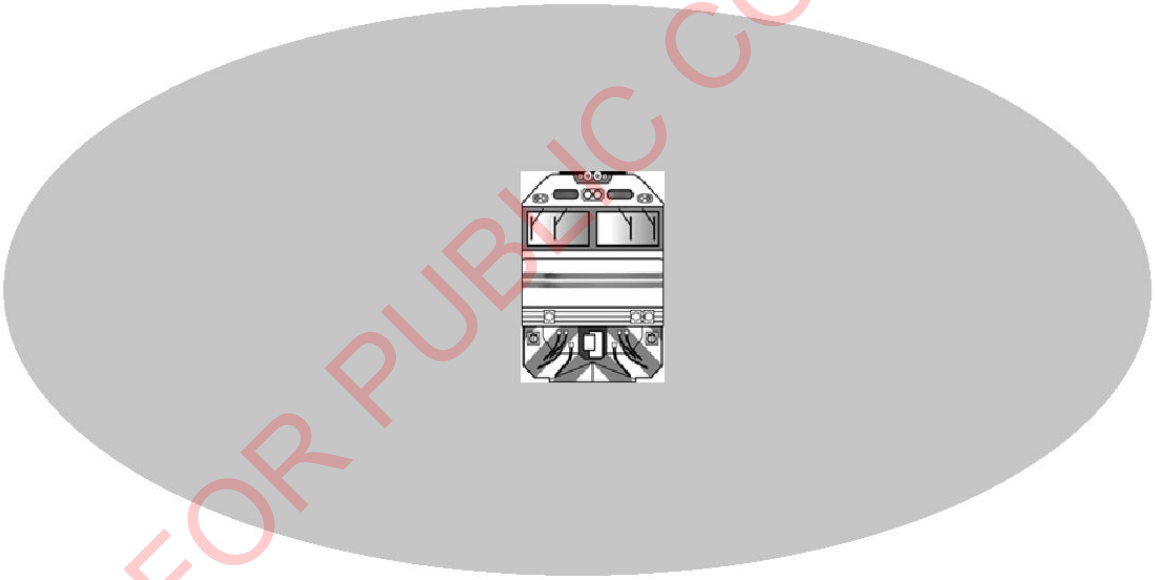


Appendix Figure H.2-1 Immediate background region excluding the front face of a rolling stock

This is the area subtended by the field of view approximately 3.5° - 5.5° vertically and 5.5° - 7.5° laterally.

L_b – Average luminance of the wider background region

Measured in cd·m^{-2}, this parameter represents the mean luminance of the broader background area surrounding the immediate background region. This is the area subtended by 5.5° - 8.5° vertically and 7.5° - 12.5° laterally, depending on the viewing distance, around the front face of rolling stock. The subtending angle can be wider for short viewing distances. This region includes the immediate background region and excludes the rolling stock front region.



Appendix Figure H.2-2 Wider background region excluding the front face of a rolling stock.

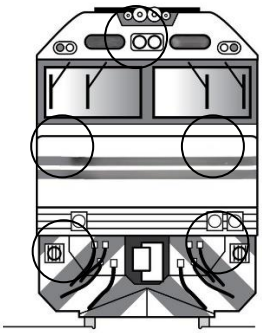
This is the area subtended by 5.5° - 8.5° vertically and 7.5° - 12.5° laterally.

If a spot luminance meter with a 1° or $^1/_3$° acceptance angle is used to measure luminance value, a luminance reading can be done at several points:

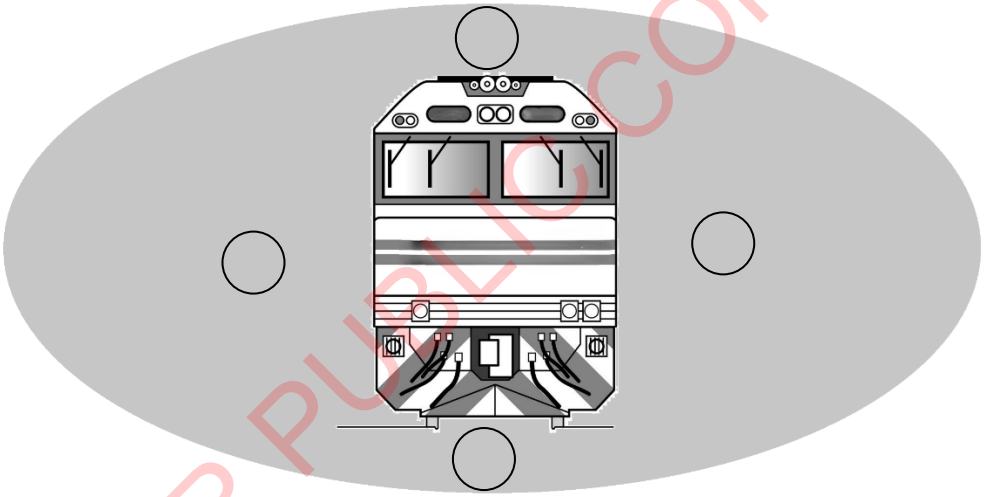
(a) For the front face of the rolling stock, readings shall be taken at the top, middle and lower sections, as illustrated in Appendix Figure H.2-3.

(b) For the background, readings shall be taken at areas around the rolling stock at the top, bottom and on both sides of the background, as illustrated in Appendix Figure H.2-4.

The spot area varies with viewing distance. For longer viewing distances, the spot area will be larger. The average measurement of the spot areas shall be used to determine the average luminance of the rolling stock and the average luminance of the background region.



Appendix Figure H.2-3 Points of interest on the front of rolling stock for measurements using spot meter



Appendix Figure H.2-4 Points of interest on the background region around a rolling stock

H.3 Luminance contrast thresholds

The luminance contrast C is either C_b or C_{ib} depending on the viewing distance and viewing angle as well as the proportion of sky, ground, and environmental elements within the observer's field of view.

Appendix Table H.3-1 Luminance Contrast Minimum Threshold for Typical Daytime Condition

Viewing circumstance	Luminance contrast minimum threshold for immediate background (C_{ib_min})	Luminance contrast minimum threshold for wider background (C_{b_min})
0° view angle at 250 m view distance	$C_{ib\_min} \geq 0.34$	$C_{b\_min} \geq 0.23$
0° view angle at 150 m view distance	$C_{ib\_min} \geq 0.13$	$C_{b\_min} \geq 0.10$

Viewing circumstance	Luminance contrast minimum threshold for immediate background (C_{ib_min})	Luminance contrast minimum threshold for wider background (C_{b_min})
0° view angle at 50 m view distance		$C_{b\_min} \geq 0.10$
7.5° view angle at 100 m view distance	$C_{ib\_min} \geq 0.24$	$C_{b\_min} \geq 0.11$
22.5° view angle at 75 m view distance		$C_{b\_min} \geq 0.01$
45° view angle at 35 m view distance		$C_{b\_min} \geq -0.22$

A minimum luminance contrast, not lower than the luminance contrast minimum threshold as shown in the table below, shall be maintained to ensure the visibility of the front face of the rolling stock for daytime conditions.

The maximum contrast threshold, as shown in the table below, shall be used as a maximum contrast (e.g. operational lighting scheme) to avoid glare discomfort and eye strain on other road or rail users from the locomotive lights for daytime conditions.

Appendix Table H.3-2 Luminance Contrast Maximum Thresholds for Typical Daytime Conditions

Viewing circumstance	Luminance contrast maximum threshold for immediate background (C_{ib_max})	Luminance contrast maximum threshold for wider background (C_{b_max})
0° view angle at 250 m view distance	$C_{ib\_max} \leq 3.50$	$C_{b\_max} \leq 3.30$
0° view angle at 150 m view distance	$C_{ib\_max} \leq 2.20$	$C_{b\_max} \leq 1.85$
0° view angle at 50 m view distance		$C_{b\_max} \leq 1.90$
7.5° view angle at 100 m view distance	$C_{ib\_max} \geq 1.80$	$C_{b\_max} \leq 1.64$
22.5° view angle at 75 m view distance		$C_{b\_max} \leq 1.44$
45° view angle at 35 m view distance		$C_{b\_max} \leq 0.48$

The average luminance of the rolling stock front face can be either higher or lower than that of the surrounding background, depending on the visual composition of the scene. Factors influencing this composition include the proportion of sky, ground, and environmental elements within the observer's field of view. Additionally, the position and angle of the sun relative to the rolling stock front can significantly affect its apparent luminance. Regardless of whether the rolling stock front is brighter or darker than the background, a minimum luminance contrast shall be maintained to ensure that the rolling stock front is perceptible.

The luminance contrast minimum and maximum threshold should be treated as a recommendation for typical daytime condition and can be increased depending on the scenarios at the time of measurement.

H.4 Luminance contrast threshold increments

The luminance contrast differs based on the distance from the observation to the locomotive front as well as depending on the luminance coefficient levels. Luminance coefficient (q) is the ratio of the

luminance of the front of a rolling stock divided by the illuminance on the front surface of the rolling stock, and is given by:

Appendix Equation H.4-4

$$q = \frac{L_o}{E}$$

Where L_o is the mean luminance of the front facing area of the rolling stock measured in cd per metre square (cd/m^2), and E is the illuminance measured at the middle region of the front of the rolling stock, which is the amount of light falling on a front face of the rolling stock due to the ambient natural light and is expressed in lux measurements. Illuminance (E) is measured with a calibrated light meter (lux meter).

The luminance contrast minimum threshold C_{min}, either C_{b_min} or C_{ib_min} depending on the viewing distance and viewing angle, provided in Appendix H.3, shall be increased by the coefficient-based increment for scenarios defined as per the table below.

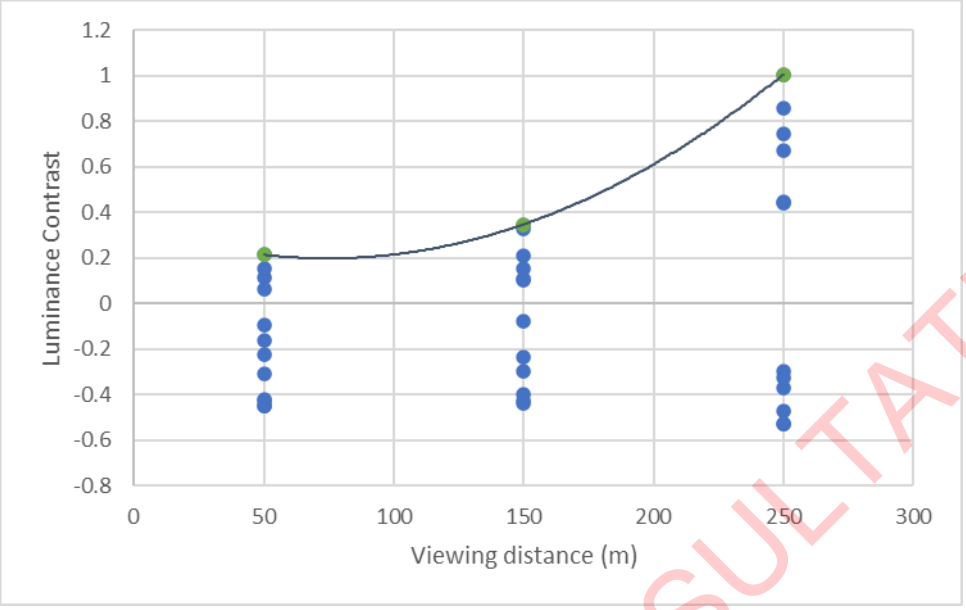
Similarly, the luminance contrast maximum threshold C_{max}, either C_{b_max} or C_{ib_max} depending on the viewing distance and viewing angle, provided in Appendix H.3, shall be increased for scenarios defined as per the table below. The luminance contrast threshold increment targets are intended to improve conspicuity of the front face of the rolling stock for the specific environmental conditions it's trying to improve.

Appendix Table H.4-1 Luminance Contrast Thresholds for Various Conditions

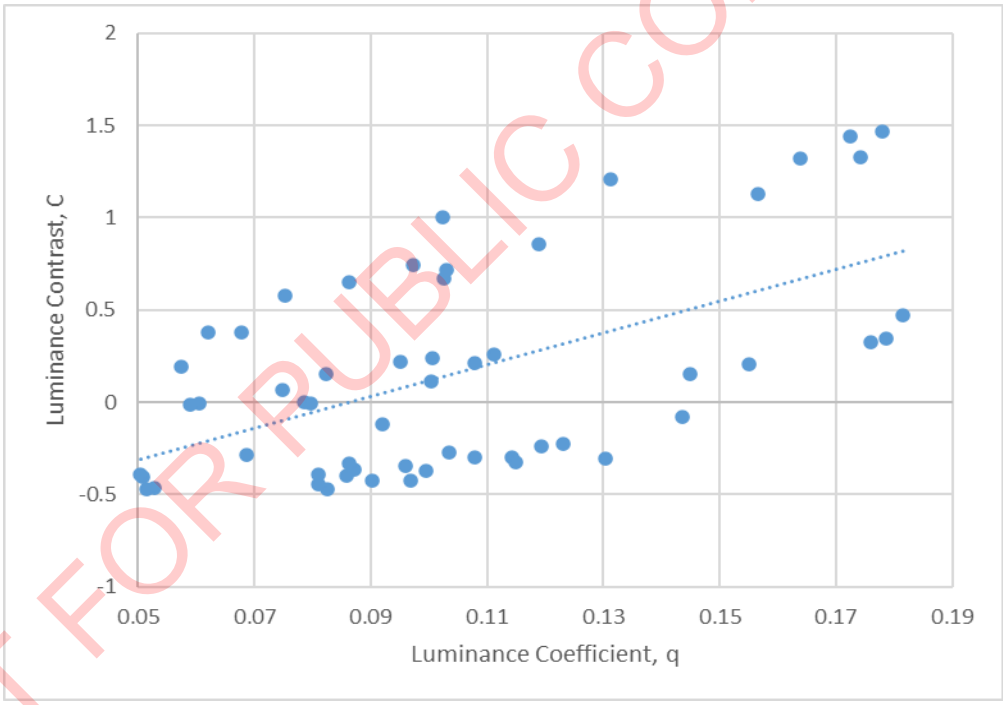
Ranges of luminance coefficient, q	**Luminance contrast threshold increment**	
	Minimum target	**Maximum target**
q = 0.1	≥ 1.1C_{min}	≤ 1.8C_{max}
0.1 < q ≤ 0.25	≥ 1.25C_{min}	≤ 2C_{max}
0.25 < q ≤ 0.40	≥ 1.5C_{min}	≤ 2.5C_{max}
0.40 < q ≤ 0.65	≥ 2C_{min}	≤ 5C_{max}
0.65 < q ≤ 0.85	≥ 4C_{min}	≤ 9.5C_{max}
0.85 < q ≤ 1.00	≥ 8C_{min}	≤ 21C_{max}
q > 1.00	≥ 14C_{min}	≤ 61C_{max}

Commentary H.4

The luminance contrast differs based on the distance from the observation to the locomotive front as shown in Appendix Figure H.4-1. The luminance contrast also varies depending on the luminance coefficient levels as shown in Appendix Figure H.4-2



Appendix Figure H.4-1 Visibility levels at different viewing distances for luminance coefficient q values below 0.1



Appendix Figure H.4-2 Luminance Contrast variation for various luminance coefficient levels

H.5 Luminance contrast calculation procedure (step-by-step)

This procedure shall be followed to calculate the luminance contrast and verify compliance with the minimum and maximum required thresholds:

Move rolling stock to location with desired background, viewing angle, and viewing distance for luminance measurements of both the front face of the rolling stock and surrounding background.

Capture luminance data by acquiring a calibrated luminance image using luminance camera, (or collect spot luminance samples using a spot meter) of the rolling stock front and surrounding scene from the defined observer position.

Define the regions of interest (ROIs) using the following images:

(c) The front face region (target), as in Appendix Figure B-1 and Appendix Figure B-2

(d) The immediate background region, as in Appendix Figure H.2-1

(e) The wider background region, as in Appendix Figure H.2-2

Mask out any light sources that do not form part of the intended background, such as stray lights, buildings, or other objects, so that only the actual surface background is considered.

Calculate average (arithmetic mean) luminance within each region of interest. If using a spot meter, take multiple samples across each region of interest, as illustrated in Appendix Figure H.2-3 and Appendix Figure H.2-4 and calculate the average (arithmetic mean).

Measure illuminance at the centre region of the rolling stock front using a calibrated light meter (lux meter).

Calculate the luminance contrast values, C_b and C_{ib}, using Appendix Equation H.1-2 and Appendix Equation H.1-3 in Appendix H

Determine the luminance coefficient (q) using Appendix Equation H.4-4 and apply the required coefficient-based increment to the luminance contrast minimum and maximum threshold levels provided in Appendix H.4

Verify compliance by comparing the calculated contrast values C_b and C_{ib} with the relevant minimum and maximum threshold values provided in Appendix H.3 or Appendix H.4 (where increment threshold applies).

Bibliography (Informative)

The following referenced documents are used by this document for information only:

- AS 1742.7, Manual of Uniform Traffic Control Devices – Railway Crossings
- AS 7501, Rolling Stock Compliance Certification
- AS 7523.1, Railway Rolling Stock Emergency Equipment Part 1 - Locomotive Rolling Stock
- AS 7658, Level crossings – rail industry requirements
- AAR Standard S-5515, LED Lighting for Locomotives
- AAR Standard S-5516, LED Headlights and Auxiliary Lighting for Locomotives
- BS EN 15153 Part 1, Railway Applications – External Visible and Audible Warning Devices – Head, Marker and Tail Lamps for Heavy Rail
- GM/RT 2483, Visibility Requirements for Trains
- Rail Industry Safety Standards Board (RISSB) Guideline, Consolidation of Public Level Crossings, 2022
- ATSB Investigation Report – RO-2019-022, Collision between freight trains 7MP5 and 2K66, at Jumperkine, Western Australia on 24 December 2019
- ATSB Investigation Report – RO-2020-013, Collision between coal trains MB526 and AH378, Koornang NSW, 29 July 2020
- ATSB Investigation Report – RO-2021-001, Review of level crossing collisions involving trains and heavy road vehicles in Australia
- ATSB Investigation Report – RO-2023-009, Level crossing collision between freight train 7SP5 and a truck at the Barrier Highway level crossing, near Cutana, South Australia, 31 December 2023
- ATSB Investigation Report – RO-2024-004, Level crossing collision between freight train 6839 and truck, Gooray Road, Gooray, Queensland, on 23 May 2024
- ATSB Investigation Report – RO-2024-005, Level crossing collision between Ghan passenger train and road train, 50 km north of Alice Springs, Northern Territory, on 15 September 2024
- ATSB Investigation Report – RO-2025-001, Level crossing collision between a track machine consist of and a road vehicle, Nicholson St, Dalby, Queensland, on 18 February 2025
- ATSB Investigation Report – RO-2025-006, Level crossing collision between passenger train DB09 and B-double truck near Runcorn, Queensland, on 14 August 2025
- Australasian Centre for Rail Innovation (ACRI) Review Report, Freight Train Visibility – SN0243974 v1.0 (31/01/2022)
- Monash Institute of Railway Technology (MIRT) Report, Assessment of Trials to Improve Train Conspicuousness Approaching Passive Level Crossings – Monash/RT/2023/1742. March 2023RISSB Code of Practice, Rail Traffic Train Horn Use
- ONRSR Briefing Note (ONRSR - 1984096326-3241), Monash Report ONRSR Overview (17/03/2023)
- ONRSR Code of Practice: Train Visibility at Level Crossings – Tourist and Heritage Case Study - 24 June 2025