AS 7531:2023

Rolling stock lighting and visibility

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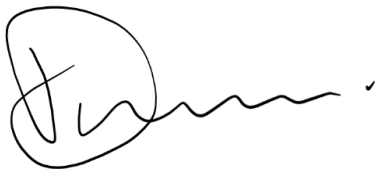
Development of this Standard was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

Aurizon, RTBU, TfNSW, TTM, Rail Department of Transport (Vic), Metro Trains Melbourne, Department of Infrastructure & Transport (SA), Pacific National, ARTC, BRAEMAC, J.W. Speaker, P7 Safety, ONRSR, Monash Institute of Railway Technology.

The Rolling stock Standing Committee verified that RISSB's accredited process was followed in developing the product, before the RISSB Board approved the document for publication.

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this Standard. Their efforts ranged from membership of the Development Group through to individuals providing comments on a draft of the Standard during the open review.

I commend this Standard to the Australasian rail industry as it represents industry good practice and has been developed through a rigorous process.



Damien White
Chief Executive Officer
Rail Industry Safety and Standards Board

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Document details

First published as: AS 7531:2006

ISBN: 978 1 76139 454 6

Document history

Publication Version	Effective Date	Reason for and Extent of Change(s)
2023	21 December 2023	Added principles for design of rolling stock conspicuity. Additional content provided for LED lighting. Improved livery design requirements. Additional maintenance planning requirements
2015	19 June 2015	Consolidated four versions. Updated references to hazards. Adjusted some content to make it easier to measure compliance with the performance requirements. Adjusted some content to ensure that the standard is technology-agnostic.
2007	17 December 2007	Change from Code Management Company to RISSB Title change to AS 7531.1:2007, AS 7531.2:2007, AS 7531.3:2007, AS 7531.4:2007.
2006	10 October 2006	First edition

Approval

Name	Date
Rail Industry Safety and Standards Board	21 December 2023

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Preface

This standard was prepared by the Rolling stock lighting and visibility Development Group, overseen by the RISSB Rolling stock Standing Committee.

Objective

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

Technical changes from previous editions of this Standard include:

(a) Additional content provided for LED lighting;

(b) additional requirements for forward visibility lights;

(c) livery design considerations; and

(d) additional maintenance planning requirements.

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 RTOs should utilise 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 RISSB:

(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 control is not able to be applied or other controls are more appropriate or better.

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’.

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.

RISSB 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 RISSB 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.

Table of Contents

Section 1 Scope and general

1.1 Scope

This Standard applies to lighting and visibility requirements for new and modified self-propelled locomotive, freight, passenger, road rail vehicles and infrastructure maintenance rolling stock.

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

This document is applicable for rolling stock operating up to 160 km/h nominal maximum speed. The document covers the design of lighting arrangements and systems, the design and colour application of livery and maintenance on rolling stock.

This Standard does not specifically cover rolling stock used on light rail, cane railway and monorail networks, but items from this Standard may be applied to such systems as deemed appropriate by the relevant rail transport operator.

Commentary *C1.1*

This Standard forms part of a multifactor approach to the improvement of overall level crossing safety. Additional strategies considered as part of the overall risk minimisation approach in conjunction with this Standard include the following:

- Level crossing elimination.
- Level crossing design.
- Corridor design and maintenance.
- Driver behaviour safety campaigns and educational reform.
- Signage and indications to road users.
- Operation of rolling stock, including the use of audible warning devices.
- Installation and operation of audible alarms at level crossings.

Consideration of causal factors of risks that are not related to lighting and visibility of rolling stock are not included in the scope of this Standard.

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 1680.2.1 Interior lighting - Circulation spaces and other general areas.
- AS 1680.2.2 Interior lighting - Office and screen-based tasks.
- AS 1680.2.4 Interior lighting - Industrial tasks and processes.
- AS 60529 Degrees of protection provided by enclosures (IP Code)
- AS 7502 Road Rail Vehicles.
- AS 7658 Level crossings – rail industry requirements.
- AS 7722 EMC Management
- AS/NZS 1906.1 Retroreflective materials and devices for road traffic control purposes - Retroreflective sheeting.
- AS/NZS 1906.2 Retroreflective materials and devices for road traffic control purposes - Retroreflective devices (non-pavement application).
- APTA SS-PS-004-99 Standard for low-location access path marking.
- Australian Government Australian Design Rules for road vehicles (ADR).

- Disability Standards for Accessible Public Transport (DSAPT).
- BS EN 13272 Railway applications — Electrical lighting for rolling stock in public transport systems.
- IEC 61373 Railway Applications - Rolling stock equipment – Shock and vibration tests.
- US Code of Federal Regulations 49 CFR 229.125 Headlights and auxiliary lights.

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

1.3 Defined terms and abbreviations

1.3.1

AAR
Association of American railroads

1.3.2
ADR
Australian Design Rules for road vehicle safety, anti-theft and emissions

1.3.3
colour rendering index (CRI)
A measure between 1-100 that defines the ability of a light source to accurately reveal the colour of an object

1.3.4
conspicuity
the ease with which an item is seen or noticed, readily visible or discernible from a defined point

1.3.5
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

1.3.6
electronically controlled pneumatic (ECP)
a type of freight car braking system in operation on self-propelled locomotive trains

1.3.7
electromagnetic compatibility (EMC)
the ability of devices and systems to operate in their electromagnetic environment without impairing the function of other devices or systems

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)
a device mounted at the rear of a train that provides the functionality of an EoTM plus other features that may include monitoring brake pressure at the rear of the train and application of emergency brakes from the rear of the train. Includes the provision of monitored information to the leading cab

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

1.3.11
head-end unit (HEU)
the leading self-propelled car of a rolling stock consist

1.3.12
illuminance uniformity
ratio of the least favourable illuminance to the average illuminance within the specified measurement surface, which can be either the minimum or maximum illuminance over all the measurement points

1.3.13
Kelvin (k)
the scale in which the warmth or colour temperature of light is measured

1.3.14
light emitting diode (LED)
a device that emits light when electric current flows through it

1.3.15
lighting assembly
a light fitting that contains 2 or more separate bulbs or globes and able to be switched to a high or low setting

1.3.16
luminous intensity
photometric measure of the luminous intensity per unit area of light travelling in a given direction, i.e., the amount of light that passes through or is emitted from a particular area

1.3.17
maximum illuminance uniformity
ratio of the maximum illuminance and average illuminance on the surface being considered

1.3.18
pulse width modulation (PWM)
a type of digital signal that is used to dim the output of LED lights

1.3.19
RIM
rail infrastructure manager

1.3.20
RRV
road rail vehicle

1.3.21
RTO
rail transport operator

1.3.22
sense and break unit (SBU)
a type of freight car braking system in operation on self-propelled locomotive trains

1.3.23
spectral power distribution
the colour composition of light as measured by a series of bands of wavelengths or frequencies over the visible range of the human eye

1.3.24
visibility light
common alternative terms to describe visibility lights include “auxiliary lights”, “crossing lights”, “ditch lights” and “fog lights”

1.3.25
wig-wag
illuminating the right and left lights alternately, with each light lit for around half a second at a time

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

Section 2 Lighting and visibility design principles

The RTOs shall ensure rolling stock lighting and visibility design adhere to following principles.

(a) Rolling stock livery and lighting 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.

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 with sufficient time to respond and avoid an incident.

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

(e) The conspicuity of both the front and side of self-propelled rolling stock HEUs and the last car at level crossings, where pedestrian and road vehicle users’ interface at any angle to the track shall be taken into account.

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

All light fittings shall comply with the requirements of IEC 61373 and AS 60529.

Light fittings and enclosures shall provide protection against the ingress of dust and fluids commensurate with the environment in which they are installed, which may result from maintenance activities and acts of vandalism.

Section 3 Headlights

3.1 General

Locomotive, self-propelled passenger, and infrastructure maintenance rolling stock shall have a headlight assembly fitted at each leading end, configured in a design in which the RTO can demonstrate the reliability to perform to the requirements of the Standard.

If multiple headlight assemblies are fitted as part of the arrangement design, the fixtures shall be installed symmetrically from the centreline of the rolling stock profile. See Appendix A for typical headlight arrangement diagrams.

Commentary *C3.1*

RTOs may impose supplementary conditions on rolling stock headlights, including but not limited to requirements relating to:

- interfaces with other rolling stock; or
- interfaces with parallel roadways; or
- user acceptance testing for the introduction of new lighting systems; or
- operational requirements when headlights are in a degraded mode of operation; or
- interpretation based on safe working modes; or
- interfaces with other rail users on the network.

While the main purpose of the headlight is to provide forward visibility for drivers in low light conditions, when incorporated with the AAR or cross-eyed arrangement visibility lighting design and 180-degree horizontal arc considerations, the headlight can also enhance the visibility of the leading end of the rolling stock for track workers, road users and pedestrians at level crossings.

3.2 Headlight colour temperature and luminous intensity

The headlight assembly shall produce light with a colour temperature between 2800k and 4500k.

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

(a) each headlight assembly shall have a minimum luminous intensity when in high beam mode of 200,000 candela.

(b) If one (1) or multiple headlight assemblies are installed the total headlight arrangement shall have a maximum luminous intensity output of 520,000 candela.

The headlight luminous intensity shall have the functionality to be reduced to a low beam state by the driver to a luminous intensity between 26,000 and 80,000 candela in the dimmed state.

From the centreline of the rolling stock when the light is aimed parallel to the running rails, each headlight assembly on high beam setting shall produce;

(c) a minimum of 3,000 candela at an angle of 7.5 degrees,

(d) a minimum of 400 candela at an angle of 22.5 degrees,

(e) a minimum of 100 candela at an angle of 45 degrees, and

(f) a range of between 10 to 50 candela at an angle of 90 degrees.

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

The peak intensity requirement shall be met even if the headlights are fitted with devices to protect/diffuse the light.

3.3 Headlight positioning and aim

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

The centreline of each headlight beam shall be aimed at a point one metre above the top of the rail at the centre of the track at a distance between 240 m and not more than 260 m ahead and in front of the headlight.

Commentary *C3.3*

Headlight arrangements commonly are comprised of two headlights, which provides some redundancy. When used in conjunction with visibility lights, they can form a “triangle of light”, which further improves conspicuity, as the approaching “triangle of light” is distinguishable as rolling stock, as opposed to other sources of light. The “triangle of light” can also help drivers to perceive the distance and speed of approaching rolling stock.

Colour temperature, luminous intensity and positioning can cause distraction via glare for oncoming rail traffic crew; an effective safety in design process shall minimise this risk.

3.4 Infrastructure maintenance rolling stock

Headlight arrangements 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 candela.

The headlight luminous intensity shall have the functionality to be reduced to a low beam state by the driver to a luminous intensity between 26,000 and 80,000 candela in the dimmed state.

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 the EMC management requirements outlined in 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 windscreen level while maximising the reach of forward visibility. Anti-glare beam patterns and lens technology should be employed when choosing lighting assemblies for rolling stock.

To ensure quality of light emitted from LED fixtures;

(a) The fitting shall have a colour rendering index of between 70 - 80; and

(b) The LED light shall not emit any visible signs of flicker or shutter roll because of the installed PWM regulator circuits. The design of regulator or LED circuitry shall not interfere with digital cameras or video monitors installed either on rolling stock or interfacing fixed infrastructure.

Any arrangement used to adjust or control the luminous intensity of the headlight shall not cause a shift in the spectral power distribution of the light produced by the headlight.

Commentary *C3.5*

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

AAR Standard S-5516 LED Headlights and Auxiliary Lighting for Locomotives and BN EN 15153 Part 1 Railway Applications – External Visible and Audible Warning Devices – Head, Marker and Tail Lamps for Heavy Rail provides industry-tested guidance on installing and changing LED lighting on rolling stock.

Section 4 Visibility lights

4.1 General

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 degrees at the front of the rolling stock.

Forward visibility light arrangements should be installed on both ends where rolling stock perform reverse propelled movement at speeds greater than 30km/h for a distance greater than 5km in a typical operational context.

4.2 Forward visibility lights - colour temperature and luminous intensity

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

Each visibility light shall produce a peak intensity of between 20,000 and 30,000 candela.

From the centreline of the rolling stock when the light is aimed parallel to the running rails, each visibility light on high beam setting shall produce:

(a) a minimum of 3,000 candela at an angle of 7.5 degrees,

(b) a minimum of 400 candela at an angle of 22.5 degrees,

(c) a minimum of 100 candela at an angle of 45 degrees, and

(d) a range of between 10 to 50 candela at an angle of 90 degrees.

These angles apply to both the horizontal and vertical beam as measured at the offset from the centre of the beam.

The peak intensity requirement shall also be met if devices to protect/diffuse the visibility lights are fitted while in service.

Commentary *C4.2*

The peak intensity maximum of 30,000 candela is well below the US 49 CFR 229.133 requirements of 200,000 candela for 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

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.

Visibility lights shall be laterally separated by a minimum of 900 mm and positioned symmetrically around the centreline of the vehicle if they are mounted more than 1,500 mm below the headlights.

A minimum of 1500 mm shall laterally separate visibility lights if they are mounted less than 1,500 mm below the headlight and positioned symmetrically around the centreline of the vehicle.

4.4 Forward visibility lights - aiming

4.4.1 General

Visibility lights shall be aimed using one of the following two methods:

(a) Cross-eyed arrangement.

(b) AAR arrangement - commonly referred to as ‘triangle of light’ arrangement.

4.4.2 Cross-eyed arrangement

Where the cross-eyed arrangement is applied, visibility lights shall be aimed at a point between 25 metres and 30 metres in front of the vehicle at the top of the rail.

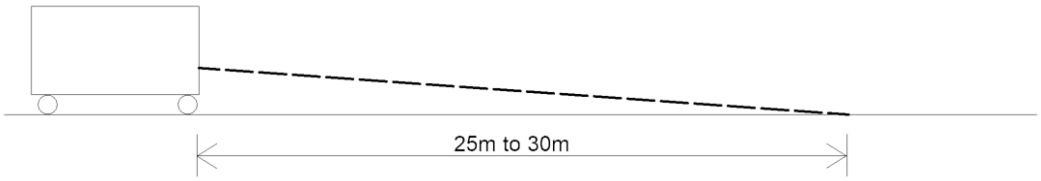

Figure 4-1 – Side view of visibility light cross-eyed aiming arrangement

Visibility lights shall then be aimed/turned cross-eyed so that they intersect at a point between 4 metres and 12 metres in front of the vehicle.

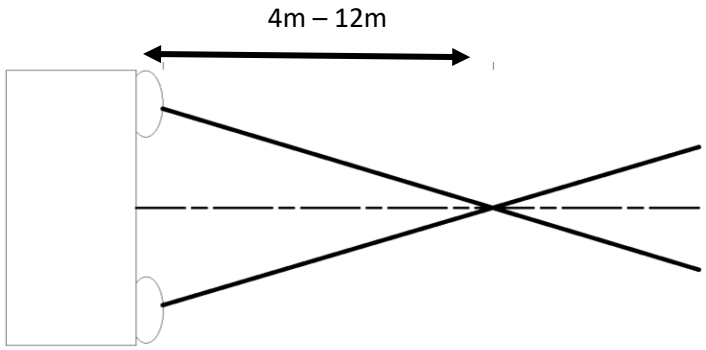

Figure 4-2 Top view of visibility light cross-eyed aiming arrangement

4.4.3 Triangle of light

Where the 'triangle of light' arrangement is applied, visibility light aiming 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.

4.5 Forward visibility lights - flashing

When the horn is sounded, visibility lights shall each flash on and off, such that the visibility lights are illuminated alternately in a wig-wag 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 operation.

The duration of the flashing may 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 of 25 seconds, such that the visibility lights operate in a wig-wag style on the forward-facing end in the direction of travel.

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.

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.

Commentary *C4.5*

Additional functionality may be added within the drivers 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 traffic areas or through locations with a dense volume of level crossings, it is recommended that the duration of flashing is increased from the minimum duration detailed in the Standard.

The rate and duration of flashes can be determined by the likely speed in which the rolling stock is travelling and the position of the whistle boards.

RISSB Code of Practice – Rail Traffic Train Horn Use may provide additional guidance on the duration of the flashing required in specific operational contexts.

4.6 Road rail vehicles (RRV)

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

Where compliance with the visibility requirements of this Standard 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; and

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

(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 Tail and marker lights

New and modified 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 taillight shall have a minimum luminous intensity of 75 candela. If operating in a network where the safeworking system allows permissive working, each taillight shall have a minimum luminous intensity of 100 candela.

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; and

(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 taillights 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 taillight shall have a luminous intensity of a minimum of 100 candela.

Duplicate marker light(s) and taillight(s) should be installed on ADR-compliant RRVs, where reverse propelled movements are performed at speeds greater than 30km/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 visit: https://www.infrastructure.gov.au/

AS 7502 provides additional requirements for RRVs.

5.3 End of train marker (EoTM)

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.

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

The EoTM shall contain a light.

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

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 D CIE chromaticity limits (colour spaces) for colour designation in AS 1906.1.

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 Standard.

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 candela and 250 candela.

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 section 5.3 EoTM.

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 “Back of Train Guards (BOG)” “EoT monitors” and "EoTDs” used interchangeably. For the purpose of this Standard, we have used and defined EoTM and EoTD.

If the EoTD incorporates additional features that support monitoring of brake pressure functionality, additional considerations shall 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 requires that locomotives shall carry spare EoTM/Ds and that it has a means to safely attach to the end of the train. In the case of a failed EoTM/D and where a spare EoTM/D unit is required to be installed in the field, the spare EoTM/D shall be required to perform the minimum functions of lighting and flashing to ensure the integrity of visibility for rail traffic crew approaching other rolling stock. The replacement units shall be lightweight, provide simple connection and battery capability.

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 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 candela.

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 metres, 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*

Amber or orange flashing warning lights are installed to ensure compliance with state legislation covering construction sites. They are primarily intended to reduce risk to workers on or around the track. These legislative requirements apply to self-propelled infrastructure maintenance rolling stock. 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 visit: https://www.sae.org/

Section 8 Stop lights

8.1 Road rail vehicles (RRV)

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

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

Stop lights on new and modified 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 lx.

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 new and modified 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 new and modified passenger rolling stock shall be able to operate for a minimum of 180 minutes after the main power is switched.

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

Emergency lighting on new and modified 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 new and modified passenger 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 new and modified locomotive, passenger rolling stock and track machines shall not be less than 75 lux measured in accordance with EN 13272-1. 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 new and modified 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*
Another method of illuminating emergency exit paths is 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 taillights, marker lights or EoTM/Ds where deemed appropriate in managing risks.

Section 11 Livery

11.1 General livery design requirements

New and modified locomotives and the lead vehicle of a passenger train that is hauled by self-propelled locomotives or has powered cars shall have a high visibility livery design applied to the ends and sides of the vehicle(s).

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 units.

The use of logos that do not comply with the high visibility requirements of this standard shall not be installed in a way that limits compliance with this section.

11.2 High-visibility colour areas

High visibility colours shall be applied to forward facing areas of each leading end of locomotives and self-propelled passenger rolling stock. An area of high visibility colour should be extended down the sides of the rolling stock to a minimum distance of 30% of the length of the vehicle body.

For passenger rolling stock, livery design that extend down the sides of vehicles shall also ensure there is contrast between the livery design and passenger access doors in line with the requirements of DSAPT.

Locomotive and passenger rolling stock shall have livery applied with high visibility colours to a minimum 75% of the total available front facing areas.

Infrastructure maintenance rolling stock shall have livery applied with high visibility colour to a minimum 75% of the available area on the front and sides of the vehicle body above the headstock. This should include boom arms and any articulated component as part of the track machine i.e excavator boom arm.

ADR compliant RRVs should have livery applied with high visibility colours to a minimum 75% of the total available front facing areas.

Forward-facing area of colour may 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 bogey 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 excludes:

(a) Windscreens;

(b) Lighting assemblies' fixtures and fittings;

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

(d) Coupler assemblies and buffer stops; and

(e) Hoses and cocks.

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

The yellow or orange high visibility areas shall have a minimum luminance factor as detailed in Appendix C Colour and Luminance Factor Tests – Fluorescent and non-Fluorescent Sheeting AS/NZS 1906.1.

The livery design may 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 track machines. The size of the pattern shall be designed in accordance with the required sighting distance appropriate to the operational context.

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 from any distance and at any angle that any patterning of colours does not reduce the conspicuity of the vehicle through camouflage effects.

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

11.3 General colour areas

Minimum sectional area sizes for applying general colour on forward-facing areas on all rolling stock shall;

(a) be a minimum of 1 square metre in area with a minimum continuous height or width of 0.6 m.

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

Any application of general colours on front facings area of rolling stock shall not detract from the requirements of section 11.2 of this standard.

RTOs shall not use the colours red and green on the front-facing areas of rolling stock.

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

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.

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

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

Application materials with the capability of glow in the dark colours that do not interfere with the above requirements should 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 wagons.

Reflective delineators shall be mounted between 800 mm and 2,000 mm above the rail.

The colour of reflective delineators shall be white or yellow.

Each reflective delineator shall have a minimum height of 75 mm and a minimum width of 350 mm. On existing rolling stock, reflective delineator dimensions can be adjusted to fit available spaces for installations so long as the same outcome is achieved.

Reflective delineators shall be installed in a location that reflects light at night that is clearly visible from a 180 deg viewing arc on the outer most body area of the rolling stock or wagon.

Reflective delineators shall be mounted on each side within 500mm of each end of the rolling stock and/or wagon 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 containerised 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 or above shall be used.

Applications relating reflective delineators on ADR compliant RRVs shall refer to AS 7502.

Commentary *C12*

While Class 1100 reflective material or above is recommended, higher quality materials with improved reflective technology and applications is also widely available for better reflective outcomes, especially for use on non-self-propelled track equipment and wagons that have no additional visibility measures.

RTOs are also encouraged to consider prismatic style reflectors to improve visibility outcomes on rolling stock and wagons.

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 new and modified passenger rolling stock, or a minimum illumination level of 80 lux for new and modified 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 new and modified locomotives and passenger rolling stock to illuminate the area around couplers that can be separated during service operation.

Lighting should be provided on new and modified 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.

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

Commentary *C15*

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

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 of the illumination and alignment properties of all lighting fixtures and arrangements.

(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 and/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 the following minimum requirements;

(a) Definition of the key roles responsible for all prescribed maintenance activities.

(b) Regular routine inspection activities of all lighting and visibility equipment installed.

(c) Identify & replace components that have reached the end of their service life or show a level of wear and degradation of illumination properties.

(d) Provide specific, scheduled cleaning requirements to remove the build-up of dirt, debris & graffiti contamination on livery or lighting fixtures.

(e) The presence, integrity and cleanliness of reflective delineators.

Appendix A ARRM Risk Table (Informative)

Publishable	Hazardous event
Collision between train and projectile	Non-passenger-train collision with projectile
Collision between train and projectile	Passenger-train collision with projectile
Collision in yard between train and member of public/trespasser	Non-passenger-train collision with member of public/trespasser in yard (not including suicides)
Collision on running line between train and member of public/trespasser	Non-passenger-train collision with member of public/trespasser on running line not at a level crossing not at a station platform (not including suicides)
Collision on running line between rain and member of public/trespasser	Passenger-train collision with member of public/trespasser on running Line not at a level crossing not at a station platform (not including suicides)
Maintenance vehicle collision with other train/MV on running line (where the collision was caused by other train/MV)	Maintenance vehicle collision with other train/MV on running line (where the collision was caused by other train/MV)
Maintenance vehicle collision with a worker on running line not at a level crossing	Maintenance vehicle collision with a worker on running line not at a level crossing
Rolling stock collision with buffer stop in yard including gates and other stops but not including derailers	Rolling Stock collision with buffer stop in yard including gates and other stops but not including derailers
Rolling stock derailment in the yard	Rolling stock derailment in yard
Train collision with buffer stop in yard	Non-passenger-train collision with buffer stop in yard including gates and other stops but not including derailers
Train collision with buffer stop on running line	Non-passenger-train collision with buffer stop on running line
Train collision with buffer stop on running line	Passenger-train collision with buffer stop on running line
Train collision with infrastructure on running line	Non-passenger-train collision with infrastructure on running Line (permanent structures like platforms, signs, loaders) not including obstructions (e.g. temporary signs and other temporary equipment)
Train collision with infrastructure on running line	Passenger-Train collision with infrastructure on Running Line (permanent structures like platforms, signs, loaders) not including obstructions (e.g. temporary signs and other temporary equipment)

Publishable	Hazardous event
Train collision with Road User at Public Road Level crossing	Train collision with Road User at Public Road Level crossing
Train collision with Rolling stock in Yard	Non-Passenger-Train collision with Rolling Stock in Yard
Train collision with an animal in Yard	Non-Passenger-Train collision with an animal in Yard
Train collision with an animal on the running line	Non-passenger-train collision with an animal on running-line
Train collision with an animal on the running line	Passenger-train collision with an animal on running-line
Train collision with derailed other train/MV on running line	Non-passenger-train collision with derailed other train/MV on running line
Train collision with derailed other train/MV on running line	Passenger-train collision with derailed other train/MV on running line
Train collision with infrastructure in yard	Non-passenger-train collision with infrastructure in yard not including obstructions, i.e. permanent structures like platforms, signs, loaders however not including temporary signs and other equipment
Train collision with obstruction at Level Crossing	Non-Passenger-Train collision with obstruction at Level Crossing of any type (Not Road User or Pedestrian)
Train collision with obstruction at a level crossing	Passenger-train collision with obstruction at level crossing of any type (not road user or pedestrian)
Train collision with obstruction in yard	Non-passenger-train collision with obstruction in yard not at a level crossing
Train collision with obstruction on running line	Non-passenger-train collision with obstruction on running line not at a level crossing
Train collision with obstruction on running line	Passenger-train collision with obstruction on running line not at a level crossing
Train collision with other train in yard	Non-passenger-train collision with other train/MV in yard
Train collision with other train on running line	Non-passenger-train collision with other train/MV on running-line
Train collision with other train on running line	Passenger-train collision with other train/MV on running line
Train collision with other train/MV on running line (where the collision was caused by other train/MV)	Non-passenger-train collision with other train/MV on running line (where the collision was caused by other train/MV)
Train collision with other train/MV on running line (where the collision was caused by other train/MV)	Passenger-train collision with other train/MV on running line (where the collision was caused by other train/MV)

Publishable	Hazardous event
Train collision with passenger/member of public at a platform/station	Non-passenger-train collision with passenger/member of public at a platform/station not due to slip, trip, or fall (not including suicide attempts)
Train collision with passenger/member of public at a platform/station	Passenger-train collision with passenger/member of public at a platform/station not due to slip, trip, or fall (not including suicide attempts)
Train collision with worker in yard not at a level crossing	Non-passenger-train collision with worker in yard not at a level crossing
Train collision with worker on running line not at a level crossing	Non-passenger-train collision with worker on running line not at a level crossing
Train collision with worker on running line not at a level crossing	Passenger-train collision with worker on running Line not at a level crossing
Train derailed or load dropped at loader/unloader in yard	Non-passenger-train derailment or load dropped in yard while loading/unloading
Train derailment in yard	Non-passenger-train derailment in yard
Train derailment on running line	Non-passenger-train derailment on running-line
Train derailment on running line	Passenger-train derailment on running-line

Appendix B Typical forward facing lighting arrangement (Informative)

B.1 Local suburban passenger rolling stock

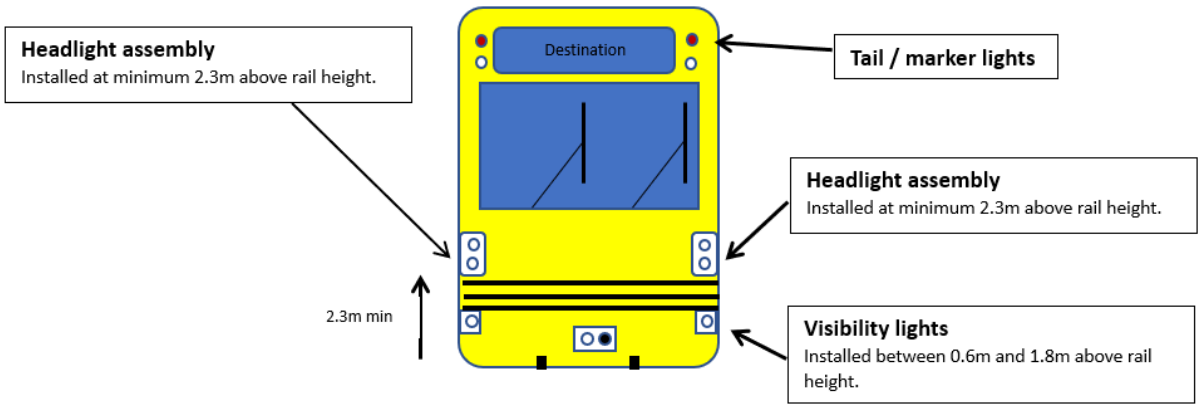

Figure B-2 Suburban passenger rolling stock with 2 headlight arrangements

Suburban passenger rolling stock with 2 headlight arrangements located equidistant from the centre line below the windscreen, typically each arrangement contains separate fixtures (halogen bulbs or LED globes) with high and low intensity settings. A 2-headlight arrangement is common on suburban passenger rolling stock where a single headlight arrangement above the windscreen is not possible due to the destination indication board.

B.2 Locomotive rolling stock

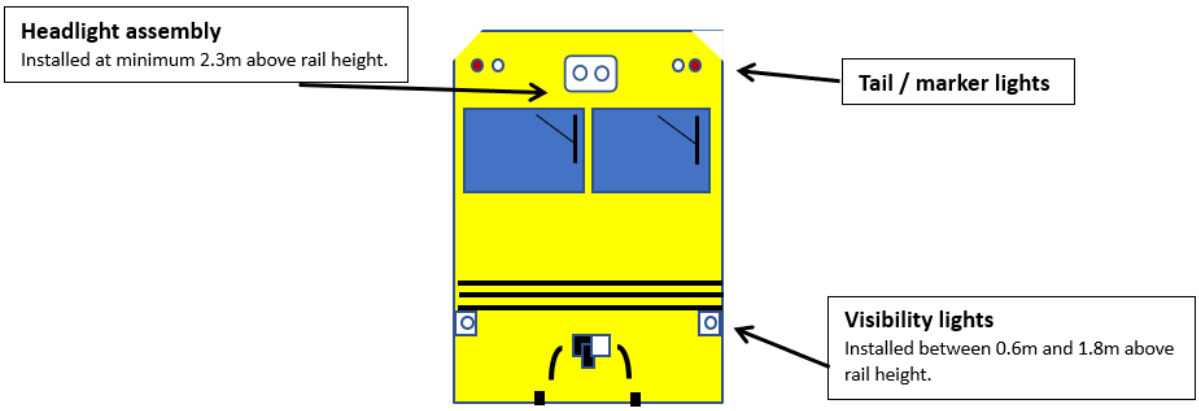

Figure B-2 Locomotive rolling stock with single headlight arrangement

Locomotive rolling stock with single headlight arrangement located on the centre line above the windscreen, the arrangement contains 2 separate fixtures (either halogen bulbs or LED globes) with each fixture capable of operation at high or low intensity settings. A single head light arrangement is common on locomotives and infrastructure maintenance vehicles.

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.

Table C-1

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 flashes and 180 flashes per minute with typical value of 120 per minute and flash duration 25 ms.	Between 40 and 180 flashes per minute	Between 40 and 180 flashes per minute
Brightness	100 candela measured at the centre of the beam	100 candela measured at the centre of the beam	100 candela measured at the centre of the beam
Service interval	Each unit is inspected on a roll by to determine functionality.	12 to 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 monitoring and inspection program	Servicing completed in accordance with AAR specifications by OEM. LED lights are checked for functionality and flashing frequency while in service.	Service, maintenance, and calibration is completed by OEM in accordance with AAR 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 vehicle non-compliance mitigations (informative)

This appendix provides guidance to heritage operators in identifying typical non-conformances to AS 7531 commonly associated with heritage rolling stock and suggests risks that require further consideration or assessment. Controls for each of these risks may be found with an RTOs safety management system. Any potential control will need to be negotiated with the RIM before acceptance.

In principle heritage vehicles can apply a derogation process as per AS7501 to ensure an appropriate level of compliance suitable for their operation. The following table is not an exhaustive list, however, is intended to assist operations in identifying potential issues that these vehicles present for consideration in the application of operational risk controls. Non-compliance with this Standard should be managed through the derogation process outlined in AS 7501.

Table D-1

Reference	Non-conformance description	Abnormal operating risk
1	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.
2	Ditch lights not fitted.	Ability to judge distance to the vehicle at appropriate distances for lookout working is significantly reduced. Ability for track workers and members of the public 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.
3	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.
4	Vehicle not fitted with direction indicating end marker lights.	Can be confusing for other rail traffic crew and rail workers to direction of travel.
5	Vehicle not fitted with compliant direction indicating end marker lights.	Marker light indications can confuse other rail traffic crew and rail workers, leading to miscommunication of intent.

6	Leading end(s) painted black, dark or non-contrasting color.	Ability for track workers and members of the public 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.
7	Leading end(s) painted with high visibility paint but, insufficient area.	Ability to judge distance to the vehicle at appropriate distances for lookout working is significantly reduced. Ability for track workers and members of the public 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.
8	Leading end(s) painted with high visibility paint but, areas are broken with non-compliant colors.	Ability to judge distance to the vehicle at appropriate distances for lookout working is significantly reduced. Ability for track workers and members of the public 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.

Appendix E Lighting Arrangement Overview (Informative)

Table E-1

Lighting Type	Luminous Intensity Requirement (candela)	Key Notes
Headlight Locomotive and passenger rolling stock	**High beam** Between 200,000 – 520,000 **Low beam** Maximum 80,000	Color temperature between 2,800 k – 4,500 k Maximum aggregate candela across all headlight assemblies is 520,000
Headlight Infrastructure maintenance rollingstock	**Speeds > 60 km/h** **High beam** Between 200,000 – 260,000 **Low beam** Maximum 80,000 **Speeds < 60 km/h** **High beam** Maximum 100,000 **Low beam** Maximum 80,000	Color 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 EoTM/Ds	
Visibility Lights	Between 20,000 – 30,000	Color 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 color Flash rates between 40 and 180 flashes per minute. Flashing across all lighting to be synchronized

Appendix F Bibliography (Informative)

The following referenced documents are used by this Standard 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
- RISSB Code of Practice – Rail Traffic Train Horn Use
- AAR Standard S-5515 – Led lighting for locomotives.
- AAR Standard S-5516 – Led headlights and auxiliary lighting for locomotives.
- BN EN 15153 Part 1 Railway Applications – External Visible and Audible Warning Devices – Head, Marker and Tail Lamps for Heavy Rail
- UK RSSB Standard GM/RT 2483 Visibility requirements for trains.
- US Code of Federal Regulations 49 CFR 221.14 Rear end marking device – Passenger, commuter & freight trains.
- US Code of Federal Regulations 49 CFR 229.133 Interim locomotive conspicuity measures - Auxiliary external lights.
- 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 2023
- ONRSR Briefing Note (ONRSR - 1984096326-3241) Monash Report ONRSR Overview (17/03/2023)
- Rail Industry Safety Standards Board (RISSB) Guideline – Consolidation of Public Level Crossings 2022

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