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Preface

The aim of this Standard is to describe the design principles and technical requirements for lighting and visibility of rolling stock.

All RISSB standards provide controls for hazards contained in RISSB's hazard guideline. In this particular standard, the reference number of the hazard being addressed is identified in an attached appendix. RISSB's hazard guideline can be found on the RISSB website at www.rissb.com.au.

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
- (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.

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Section 1 Scope and general

1.1 Scope

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

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 of both 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.

C1.1 Commentary

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 2700 Colour Standards for General Purposes
- 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 standard 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).
- 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

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

1.3.1

AAR

American Association of Railroads

1.3.2

ADR

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

1.3.3

conspicuity

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

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

ECP

electronically controlled pneumatic – a type of freight car braking system in operation on self-propelled locomotive trains.

1.3.6

EMC

electromagnetic compatibility

1.3.7

emergency lighting

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

1.3.8

EoTM

end of train marker – a device that is fitted to the trailing end of a train or vehicle to denote the end of a train

1.3.9

HEU

head-end unit

1.3.10

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

1.3.11

LED

light emitting diode

1.3.12

luminance

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

1.3.13**maximum illuminance uniformity**

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

1.3.14**PWM**

pulse width modulation

1.3.15**RIM**

rail infrastructure manager

1.3.16**RRV**

road rail vehicle

1.3.17**RTO**

rail transport operator

1.3.18**SBU**

sense and break unit - referring to a type of freight car braking system in operation on self-propelled locomotive trains

1.3.19**visibility light**

common alternative terms to describe visibility lights include "auxiliary lights", "crossing lights", "ditch lights" and "fog lights".

1.3.20**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. Refer to:
<https://www.rissb.com.au/products/glossary/>

Section 2 Lighting and visibility design principles

The RTOs shall ensure the design of rolling stock lighting and visibility adhere to following design 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 safety of rail traffic crew, track workers and interfacing road and pedestrian users shall be a factor.
- (d) 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.

Section 3 Headlights

3.1 General

Locomotive, self-propelled passenger, and infrastructure maintenance rolling stock shall have a headlight arrangement 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 units are fitted, they shall be installed symmetrically from the centreline of the rolling stock profile.

C3.1 Commentary

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

- *interfaces with other rolling stock;*
- *interfaces with parallel roadways; or*
- *user acceptance testing for the introduction of new lighting systems.*
- *Operational requirements when headlights are in a degraded mode of operation.*
- *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 arrangement shall produce light with a colour temperature between 2800 K and 4500 K.

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;

- each headlight unit shall have a high-intensity beam between 200,000 and 260,000 candela luminous intensity when on the brightest setting.
- If more than one headlight unit is 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 with the maximum luminous intensity of 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 on high beam setting shall produce;

- a minimum of 3,000 candela at an angle of 7.5 degrees,
- a minimum of 400 candela at an angle of 22.5 degrees,
- a minimum of 100 candela at an angle of 45 degrees, and
- a range between 10 to 50 candela at an angle of 90 degrees

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 infrastructure maintenance rolling stock 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.

C3.3 Commentary

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 with the maximum luminous intensity of 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 shall be employed when considering LED lighting unit designs.

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.

C3.5 Commentary

If PWM is used by the headlight designer to adjust or control the luminous intensity of the headlight, the switching frequency of pulses needs consideration to avoid causing shutter roll or other interference with digital cameras or video monitors, which could be either on rolling stock or interfacing fixed infrastructure. Typically, this can be avoided in the design of the LED driver circuitry.

*For further information regarding Australian Design rules for road vehicles, visit:
<https://www.infrastructure.gov.au/>*

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

RTO shall demonstrate the following design principles are achieved through effective forward lighting design.

Visibility lights shall:

- (a) 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 to;
 - (i) maximize the visibility of rolling stock from the perspective of a driver of a motor vehicle, or a pedestrian approaching a level crossing;
 - (ii) maximize the visibility of the rolling stock from the perspective of track workers;
 - (iii) effective illumination of turnout components and other trackside installations for rail traffic crew;

Forward visibility light arrangements should be installed on both ends where rolling stock perform reverse propelled movement at speeds greater than 25km/h for a distance greater than 5km.

4.2 Forward visibility lights - colour temperature and luminous intensity

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

Each visibility light shall produce a minimum peak intensity of 20,000 candela.

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

- a minimum of 3,000 candela at an angle of 7.5 degrees,
- a minimum of 400 candela at an angle of 22.5 degrees,
- a minimum of 100 candela at an angle of 45 degrees, and
- a range between 10 - 50 candela at an angle of 90 degrees.

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

C4.2 Commentary

The peak intensity of 20,000 candela is well below the US 49 CFR 229.133 requirements of 200,000 candela for ditch or crossing lights. The lower output allows the lights to remain illuminated throughout 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 1800 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 1500 mm below the headlights.

A minimum of 1500 mm shall laterally separate visibility lights if they are mounted less than 1500 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.

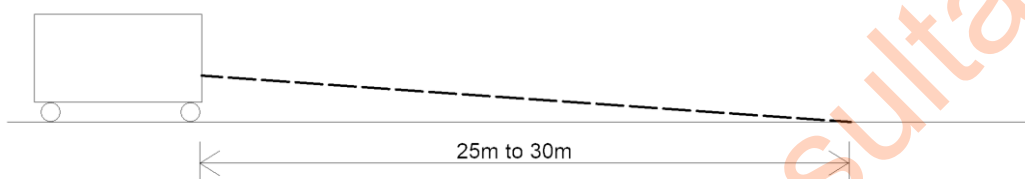


Figure 5:1 – Side view of visibility light cross-eyed aiming arrangement

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.

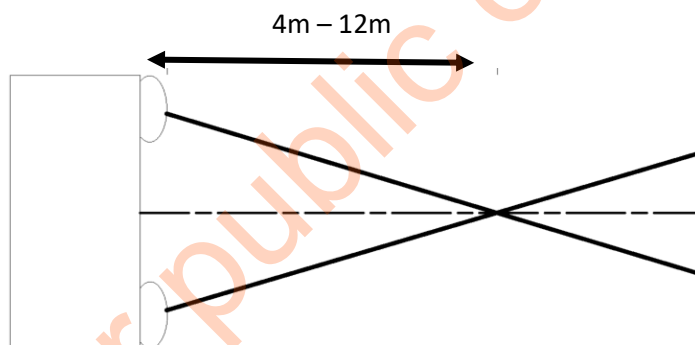


Figure 5:2 – Top view of visibility light cross-eyed aiming arrangement

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 20 seconds after the horn has been sounded.

Where rolling stock traverses a level crossing or pedestrian crossing, the duration of the flashing function after the horn has sounded shall meet or exceed the required warning time for the

pedestrian or level crossing by active control or sighting distance in accordance with Appendix B
Operational timing of active traffic control devices in AS 7658.

When the vehicle changes direction, visibility lights shall each flash on and off, such that the visibility lights operate in a wig-wag style.

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.

C4.5 Commentary

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.

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 when using the road 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 installation shall not:

- (a) impede ADR regulations;
- (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.

Hauled infrastructure maintenance rolling stock 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.

Infrastructure maintenance rolling stock 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:

- degraded modes of lighting while in operation;
- visibility of rolling stock units lying dormant in sidings for other rail traffic crew; and;
- in field maintenance requirements where rolling stock units with failed tail, marker or EoTM lighted units 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 operational constraints give rise to any likelihood of travelling a distance in reverse of the normal direction of operation.

C5.2 Commentary

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 mm² and 12,000 mm².

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 mm² and a minimum dimension of 90 mm.

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

EoTMs connected to ECP or Air turbine and SBU brake systems shall automatically activate in low light conditions, including movement through tunnels.

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

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

C5.3 Commentary

If the EoTM 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 EoTM chosen for installation.

AS 7523.1 requires that locomotives shall carry spare EoTMs and that it has a means to safely attach to the end of the train. In the case of a failed EoTM and where a spare EoTM unit is required to be installed in the field, the spare EoTM 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 B details the typical arrangement of different styles of EoTMs 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 beacons

Amber or orange flashing beacon(s) shall be fitted to self-propelled infrastructure maintenance rolling stock and RRVs that operate within a construction zone.

Each beacon shall have a minimum luminous intensity of 18,000 candela.

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

Construction beacon(s) shall incorporate the following functionality;

- be interlocked with the operation of the horn and breaks.
- operate when the rolling stock is performing a forward or backward movement; and

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

The flash rate of beacons 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.

C7.2 Commentary

Amber or orange flashing beacons are installed to ensure compliance with state and federal legislation covering construction sites. They are primarily intended to reduce risk to infrastructure workers on or around the track.

These legislative requirements apply to self-propelled infrastructure maintenance rolling stock. Flashing beacons 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 beacons 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 25km/h for a distance greater than 5km.

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.

8.2 Infrastructure maintenance rolling stock

Self-propelled infrastructure maintenance rolling stock 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 infrastructure maintenance rolling stock shall have a luminous intensity of a minimum 60 candela per light.

Stop lights on new and modified infrastructure maintenance rolling stock 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.

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

Section 9 Normal (non-emergency) interior lights

Normal (non-emergency) lighting levels inside the locomotive cab should comply with the following:

- Drivers' cab - general: Minimum 50 lux (illuminance uniformity 0.5 to 2.5).
- Rail traffic crew workstation: Minimum 75 lux at desk level (illuminance uniformity 0.7 to 1.3).
- Timetable light: Minimum 160 Lux at 150mm (illuminance uniformity 0.7 to 1.3).
- Rail traffic crew reading light: Minimum 150 lux (illuminance uniformity 0.7 to 1.3).

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

Normal (non-emergency) lighting levels inside the passenger car cab should comply with the following:

- Drivers' cab - general: Minimum 50 lux (illuminance uniformity 0.5 to 2.5).
- Rail traffic crew workstation: Minimum 75 lux at desk level (illuminance uniformity 0.7 to 1.3).
- Rail traffic crew reading light: Minimum 150 lux (illuminance uniformity 0.7 to 1.3).
- Kitchen and other working areas: Minimum 300 lux (illuminance uniformity 0.7 to 1.3).

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 infrastructure maintenance rolling stock 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 etc.) on locomotives, passenger rolling stock, and infrastructure maintenance rolling stock where people can be enclosed in during operation, shall have emergency lighting.

Emergency lighting on new and modified locomotives and infrastructure maintenance rolling stock 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 infrastructure maintenance rolling stock 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.

Emergency lighting on new and modified locomotives and passenger rolling stock shall provide a minimum of 20 lux illuminance at floor level at emergency exit doors.

Emergency lighting on new and modified locomotives, passenger and infrastructure maintenance rolling stock shall provide a minimum of 20 lux illuminance on any equipment necessary to provide emergency egress.

On new and modified passenger rolling stock where emergency lighting is powered by the trains normal battery supply or mounted near the ceiling, the vehicle shall have in passenger-accessible areas another method of illuminating emergency exit paths and exit equipment that is crash-tolerant and mounted near the vehicle floor.

C10 Commentary

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 EoTMs where deemed appropriate in managing risks.

APTA Standards can be accessed via the website: <https://www.apta.com/>

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 luminous 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.

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.

Infrastructure maintenance rolling stock shall have livery applied with high visibility colour to a minimum 50% of the available area on the front and sides of the vehicle.

The forward-facing areas of colour on all rolling stock shall;

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

Forward-facing area of colour should be divided by the features of the front of the rolling stock.

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 and dimensions.

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 Table 2.6 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 Table 2.6 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.

11.3 General colour areas

Minimum sectional area sizes for applying general colour shall comply with section 11.2 Hi-visibility colour areas as described in this standard.

RTOs shall eliminate the use of red and green colours on the front-facing areas of rolling stock units.

Fluorescent colours compliant with AS/NZS 1906.2 should be used to improve daytime visibility while considering the environment in which the rolling stock operates.

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.

C11 Commentary

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. Using colours or patterns that do not occur in the natural or built environment could improve conspicuity, for example, using diagonal zebra stripes that utilise colours.

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.

Section 12 Reflective delineators

Reflective delineators shall be fitted to vertical surfaces on each side of all rolling stock.

Reflective delineators should be mounted between 800 mm and 2000 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 180deg viewing arc.

A minimum of two reflective delineators per side shall be fitted, with one mounted within 500mm of each end of the rolling stock unit and/or wagon consist or in a location close to that distance that allows clear visibility at the road user level.

Additional reflective delineators should be fitted every 2500 mm to 5000 mm between the end-mounted delineators for locomotives, freight and passenger rolling stock, and infrastructure maintenance rolling stock.

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 400 reflective material compliant with AS/NZS 1906.2 or Class 1100 reflective material compliant with AS/NZS 1906.1 shall be used as a minimum.

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

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.

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

C15 Commentary

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 have an asset management plan that defines maintenance activities for all rolling stock types that ensure;

- the preservation the illumination and alignment properties of all lighting fixtures and arrangements.
- conspicuity levels of high visibility colour areas and livery designs are maintained.

Where any lighting design or configuration on rolling stock is changed through 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.

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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 train 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 derailleurs	Rolling Stock collision with buffer stop in yard including gates and other stops but not including derailleurs
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 derailleurs
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)
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

Publishable	Hazardous event
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)
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

Publishable	Hazardous event
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

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Appendix B Typical Arrangements for EoTMs (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	Portable tail lamp	Air turbine and SBU EoTM	ECP EoTM
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 EoTM 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 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 - 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 EoTM is also cleaned, and a full functional test is completed. Spare EoTMs are kept on charging racks ready for use at most depots.

Appendix C Heritage vehicle non-compliance mitigations for consideration (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 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.

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.	<p>Ability to judge distance to the vehicle at appropriate distances for lookout working is significantly reduced.</p> <p>Ability for track workers and members of the public to identify the vehicle as a rail vehicle in poor visibility conditions is impaired.</p> <p>Ability for rail traffic crew to visually confirm setting of the roads in poor visibility conditions is impaired.</p>
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 colour.	<p>Ability for track workers and members of the public to identify the vehicle as a rail vehicle in poor visibility conditions is impaired.</p> <p>Ability for rail traffic crew to visually confirm setting of the roads in poor visibility conditions is impaired.</p>
7	Leading end(s) painted with high visibility paint but, insufficient area.	<p>Ability to judge distance to the vehicle at appropriate distances for lookout working is significantly reduced.</p> <p>Ability for track workers and members of the public to identify the vehicle as a rail vehicle in poor visibility conditions is impaired.</p>

8	Leading end(s) painted with high visibility paint but, areas are broken with non-compliant colours.	Ability for rail traffic crew to visually confirm setting of the roads in poor visibility conditions is impaired.
		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.

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Appendix D Lighting Arrangement Overview (Informative)

Lighting Type	Luminous Intensity Requirement (candela)	Key Notes
Headlight Locomotive and passenger rolling stock	High beam 200,000 – 260,000 Low beam Maximum 80,000	Color temperature between 2800k – 4800k Maximum aggregate candela across all headlight fittings 520,000
Headlight Infrastructure maintenance rollingstock	Speeds > 60km/h High beam 200,000 – 260,000 Low beam Maximum 80,000 Speeds < 60km/h High beam 100,000 Low beam 80,000	Color temperature between 2800k – 4800k Units with driving stations at each end to have headlight arrangements fitted at both ends.
EoTM	See Appendix B – Typical Arrangements for EoTMs	
Visibility Lights	Minimum 20,000	Color temperature between 2800k – 4800k Each visibility light fitting to produce a peak intensity of a minimum 20,000 candela
Road Rail Vehicles		To comply with all ADR regulations
Tail, Marker and EoTMs	100 – 250	White marker lights at leading end Red marker lights at the trailing end Hauled infrastructure maintenance rolling stock to have both red and white marker lights fitted at each terminal end
Visibility beacon lights	Minimum 75	White in color Minimum visible distance of 1000m Flash rates between 40 and 180 flashes per minute
Construction Beacon 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 E Bibliography

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 7502 Road Rail Vehicles.
- AS 7523.1 Railway Rolling Stock Emergency Equipment Part 1 - Locomotive Rolling Stock
- AS 7705:2019 Level Crossing Monitoring Systems
- 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
- BS EN 13272 Railway applications — Electrical lighting for rolling stock in public transport systems.
- 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