Australian STANDARD®

Level crossings – rail industry requirements

RISSB
RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Train Control Systems Standard

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This Australian Standard® AS 7658 Level crossings – rail industry requirements was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

ARTC	UGL	Pacific National
ARC Infrastructure	Aurizon	South Australian Government
Siemens	Queensland Rail	PTA WA
KiwiRail	TfNSW	QUT
USC	Wabtec	VicTrack
MTM		

The Standard was approved by the Development Group and the Train Control Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

This standard was issued for public consultation and was independently validated before being approved.

Development of the Standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the Standard

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 comment 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.

Deb Spring
Exec. Chair / CEO
Rail Industry Safety and Standards Board

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This Standard was prepared by the Rail Industry Safety and Standards Board (RISSB) Development Group AS 7658 Level crossings – rail industry requirements. Membership of this Development Group consisted of representatives from the organisations listed on the inside cover of this document

Objective

This standard provides the rail industry with a set of requirements and recommendations to be used to control level crossing risks, and to promote a consistent treatment of level crossings.

The standard is intended to:

(a) provide a uniform basis for compliance with Rail Safety National Law;

(b) complement the requirements of the road rules in each jurisdiction in relation to level crossings;

(c) cover differing rail operations across Australia;

(d) recommend the process and requirements for the application of new technology;

(e) provide a basis for the evaluation of changes to railway operations that affect the risks, and;

(f) identify the hazards and associated risks to be controlled.

This standard applies to new and upgraded level crossings and can be applied by rail infrastructure managers (RIMs) against existing level crossings.

This Standard supersedes AS 7658:2012.

Compliance

There are two types of control contained within Australian Standards developed by RISSB:

1. Requirements.
2. Recommendations.

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 recognise 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.

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.

Controls in RISSB standards address known railway hazards are addressed in Appendix A.

Contents

Appendix Contents

1 Scope and general

1.1 Scope

This standard specifies minimum operational and engineering requirements of the life cycle of a level crossing.

This standard applies to all railways over 600 mm track gauge, including rail freight and passenger networks, heritage and tourist railways and cane railways where appropriate. Whilst not mandated, light rail organisations may adopt this standard if appropriate to do so.

This standard does not apply to level crossings within a restricted access railway yard and used solely by personnel authorized to access the level crossing by the Rail Infrastructure Manager (RIM).

The key level crossing elements addressed in this standard:

(a) Safety practices within the level crossing lifecycle that consist of the following processes.

i. Requirements definition and analysis.

ii. Design.

iii. Construction.

iv. Testing and commissioning.

v. Maintenance.

vi. Degraded mode operation.

vii. Upgrade and renewal.

viii. Decommissioning.

ix. Disposal.

(b) Safety requirements for level crossing infrastructure, which can consist of a combination of these components.

i. Passive traffic control devices.

ii. Active traffic control devices.

iii. Train detection system.

iv. Power supply for level crossing equipment.

v. Monitoring systems.

vi. Warning systems

vii. Railway signals for rail vehicles.

viii. Train control system technology.

1.2 Exclusions

The standard does not address train operation requirements in emergency situations.

1.3 Normative references

The following referenced documents are indispensable for the application of this Standard:

- AS 1428.1 Design for access and mobility - General requirements for access - New building work.
- AS 1742.7 Manual of uniform traffic control devices - Railway crossings.
- AS 2439.1 Perforated plastics drainage and effluent pipe and fittings – Part 1: Perforated drainage pipe and associated fittings
- AS 7470 Human Factors Integration in Engineering Design - General Requirements.
- AS 7635 Railway infrastructure - Track geometry.
- AS 7637 Railway infrastructure - Hydrology and Hydraulics.
- AS 7638 Railway infrastructure - Earthworks.
- AS 7639 Railway infrastructure - Rail support systems.
- AS 7640 Railway infrastructure - Rail Management.
- AS 7770 Rail Cyber Security.
- AS 7717 Signal Testing & Commissioning.
- AS 7718 Signal design process management
- AS/NZS 1158 Lighting for roads and public spaces.
- AS/ISO 31000 Risk management - Guidelines.
- IEC/ISO 31010 Risk management - Risk assessment techniques.
- SA HB 198 Guide to the specification and testing of slip resistance of pedestrian surfaces

1.4 Terms and definitions

For the purposes of this document, the terms and definitions given in RISSB Glossary: https://www.rissb.com.au/products/glossary/ and the following apply:

(a) ***ALCAM (Australian Level Crossing Assessment Model):***
an assessment tool used to identify key potential risks at level crossings and to assist in the prioritization of crossings for upgrades

(b) ***boom barrier horizontal position:***
when the boom barrier is horizontal with a tolerance of ± 5 degrees

(c) ***boom barrier vertical position:***
when the boom barrier is 85° above the horizontal with a tolerance of ± 5°

(d) ***cattle grid (or cattle stop):***
a device set in a roadway across which wheeled traffic may pass and forms a barrier against stock passing

(e) ***island track:***

a short track section that bridges a level crossing whose occupancy causes or maintains an unconditional activation of the crossing warning

(f) ***minimum road open time:***
the minimum permitted time from when the warning devices stop operating after the passage of a previous train to the time the warning devices reactivate for the next train

(g) ***pedestrian refuge:***
a staging area provided for pedestrians to wait when crossing multiple railway tracks

(h) ***predictors (or level crossing predictors):***
this is a level crossing control system that is intended to provide a relatively constant train approach warning time for road users of that level crossing

(i) ***road manager:***

i. in relation to a private road—means the owner, or other person responsible for the care, control and management, of the road; or

ii. in relation to a public road—means an authority, person or body responsible for the care, control or management of the road[1]

(j) ***level crossing user:***
any person or road vehicle that can use a level crossing

(k) ***short stacking:***
when there is insufficient distance between the outer rail and an adjacent intersection to accommodate a road vehicle, resulting in the vehicle fouling the tracks whilst stopped at the adjacent intersection or fouling the intersection whilst stopped at the level crossing.

(l) ***traffic control device:***
any sign, signal, pavement marking, or other installation placed or erected by a public authority or official body having the necessary jurisdiction, for the purpose of regulating, warning or guiding road users;

(m) ***whistle board:***
a trackside sign marking a location where the rail traffic horn or whistle is sounded by rail traffic operators.

2 General information

2.1 General

Level crossings are intended to provide safe at-grade passage of vehicles, pedestrians, cyclists and livestock across railway lines.

Level crossings can also provide rail track access points for road/rail vehicles.

The functions of traffic control devices at a level crossing are to:

[1] Sourced from *Rail Safety National Law (NSW) No 82a*

(a) warn road users of the existence of a level crossing;

(b) alert road users to the likely approach of rail traffic; and

(c) allow for the safe passage of authorized rail and road traffic.

The *Rail Safety National Law* and *Rail Safety National Law Regulations* defines the requirements for RIMs in managing level crossings, including change management and interface agreements. This standard supports RIMs in meeting those requirements.

2.2 Pre-design assessment

Before undertaking the design of a level crossing, a RIM shall evaluate level crossing alternatives to at-grade level crossings such as grade separation or closure in the case of existing level crossings.

2.3 Types of level crossing controls

2.3.1 General

The type of level crossing control and road traffic arrangements to be deployed at a level crossing should consider the typical rail and road traffic arrangements within the vicinity of the level crossing.

Factors that should be evaluated during the assessment process include:

(a) road traffic types;

(b) road traffic volumes;

(c) road surface;

(d) sighting distance;

(e) short stacking;

(f) queuing;

(g) whether rail services are:

i. express passenger;

ii. stopping passenger;

iii. freight.

(h) foreseeable future changes.

2.3.2 Passive control

Passive control is the control of the movement of vehicular or pedestrian traffic across a level crossing by signs and devices only, none of which are activated during the approach or passage of a train, and which rely on the level crossing user detecting the approach or presence of a train by direct observation[2].

Devices may include pedestrian mazes, cattle grids or manually operated gates. Any devices used shall comply with the requirements of AS 1742.7

[2] Source: AS 1742.7:2016 *Manual of uniform traffic devices – railway crossings*

Livestock can be directed across a passive crossing under the guidance of the livestock owner.

Passively controlled level crossings shall be designed and constructed in accordance with AS 1742.7.

2.3.3 Active control

Active control is the control of the movement of vehicular or pedestrian traffic across a level crossing by devices such as level crossing warning lights, gates or barriers, audible warning devices, or a combination of these, where the device is activated prior to and during the passage of a train through the level crossing.

2.4 Access types

2.4.1 Public level crossings

Public level crossings are provided to establish and maintain continuity of a public thoroughfare.

2.4.2 Private (occupation) level crossings

Private level crossings are level crossings that provide access to private properties or between parts of private property.

Private level crossings are for roads that are not gazetted for public access. Control of access shall be responsibility of the property owner in accordance with an interface agreement.

Private level crossings shall be identified, risk assessed by relevant stakeholders and treated with appropriate controls or procedures. Where passive or active controls are installed, they should comply with controls listed in AS 1742.7

If there is a risk of unattended livestock entering the private level crossing lockable gates or appropriate livestock control measures should be provided.

Appropriate signage should be installed to indicate that road access is restricted.

2.4.3 Service and temporary level crossings

Service level crossings are level crossings that provide access only for railway operations by authorized persons.

Service level crossings can be provided at stations, in depots and in field situations.

Temporary level crossings may be installed to facilitate, or support construction works in the rail corridor, or used for derailment or disaster recovery.

2.4.4 Pedestrian level crossings

Pedestrian level crossings are level crossings provided for the exclusive use of pedestrians, who can be people travelling on foot or any device legally allowed on a public pathway.

The minimum control at a pedestrian level crossing shall be as detailed within AS 1742.7.

The requirements for pedestrian enclosures shall comply with requirements in AS 1428.1 and AS 1742.7.

2.5 Records management

The RIM and the road manager shall maintain records of all level crossings. These records shall include:

(a) unique identification of the level crossing;

(b) the level crossing access type (refer section 2.2);

(c) accident and incident report history;

(d) risk assessment reports (including ALCAM reports);

(e) the level crossing controls in place;

(f) engineering drawings; and

(g) maintenance records.

Other records may be kept by RIMs and road managers as required.

2.6 Interface management

RIM's must create and manage interface agreements for level crossings in accordance with *Rail Safety National Law*.

The major stakeholders involved in the management of level crossing safety are the RIM, the road manager and the local council. Other stakeholders may be included in interface agreements as decided by the RIM.

Level crossing risk assessment and design shall be co-ordinated across all relevant engineering disciplines and stakeholders and shall recognize relevant interface agreements.

Changes to the characteristics or controls at a level crossing shall be communicated as defined in the interface agreement for that level crossing.

A RIM should have policies for reporting incidents to relevant stakeholders. These policies should be reflected in any interface agreements.

Although the responsibility for provision and maintenance of various traffic control devices may be split between authorities, there should be coordination of both maintenance and safety audit activities.

2.7 Communication of faults and failures

Active level crossing faults and failures that increase risk to members of the public using the level crossing should be communicated to the RIM in accordance with AS 7705. Faults and failures can include:

(a) failure of either main or backup power supplies;

(b) failure due to damage of the level crossing equipment;

(c) lamp faults;

(d) continuous operation;

(e) out-of-correspondence faults;

(f) advanced warning system faults;

Information regarding level crossing damage and faults, such as missing signage or vandalism, can be provided by members of the public, road managers or railway personnel.

The RIM shall designate the personnel that are notified of level crossing faults or failures. These personnel may include:

(a) network controllers;

(b) signalling maintenance personnel;

(c) operations managers;

(d) road managers.

Procedures shall be put in place so that when the designated personnel are made aware of a level crossing fault or failure that it is communicated to the relevant stakeholders. These stakeholders may include:

(a) signalling maintenance personnel;

(b) network controllers;

(c) rollingstock operators;

(d) local emergency services;

(e) road manager.

3 Risk and change management

3.1 Assess risks to safety at level crossings

3.1.1 General

The risks to safety at each level crossing must be assessed and risk mitigated in accordance with the *Rail Safety National Law*.

Risks to safety at level crossings shall be assessed when there is a change in relation to a level crossing. Risk profiles can be altered when changes are made due to:

(a) new, altered or closed level crossings;

(b) level crossing controls and configuration;

(c) the level crossing environment;

(d) rail traffic;

(e) road traffic;

(f) repeated incidents at level crossing; or

(g) as determined by a RIM's Safety Management System (SMS).

When undertaking a level crossing risk assessment, RIMs should consider including knowledge and information from the following sources.

(a) Appropriately qualified subject matter experts.

(b) All stakeholders.

(c) Road traffic analysis that includes pedestrian numbers where appropriate.

(d) An assessment of the effectiveness of the level crossing's controls using tools such as ALCAM or similar.

(e) Proposed level crossing design.

(f) New level crossing design.

(g) Historical data applicable to the crossing.

(h) Incident investigation recommendations.

  i. The assessed level crossing.

  ii. Other similar level crossings.

(i) Near miss data.

(j) Public consultation outcomes.

(k) Options for risk mitigation strategies.

Four quadrant level crossings have additional risks regarding queuing and trapping of road traffic. These risks shall be assessed as part of any level crossing design risk assessment.

Level crossing risk assessments should comply with AS/ISO 31000 and IEC/ISO 31010.

Outputs and recommendations from these risk assessments shall identify suitable risk mitigation measures that will reduce the risk So Far As Is Reasonably Practical (SFAIRP). These recommendations shall be implemented or reasons for not implementing documented.

Where it is proposed to install, remove or substantially alter a level crossing then a risk assessment comprising of all stakeholders shall be convened to ensure all risks (both actual and perceived) are identified and documented, and then mitigated in accordance with the RIM's risk assessment methodology and the requirements of the RIM's safety management and management of change systems.

3.1.2 Risk assessment process

The risk assessment process shall comply with the policies and procedures of the RIM and based on the requirements of the RSNL.

Where there is a perceived change to the risk profile of a level crossing or for new level crossings the risk assessment process shall reduce safety risks SFAIRP.

3.1.3 Human factors

Human factors risks shall be identified, analysed and mitigated across the level crossing lifecycle.

Safety at level crossings relies on appropriate interactions between level crossing users and elements of the level crossing such as warnings, infrastructure and the train. Formal human factors approaches should be used to understand and optimize these interactions.

Human factors assessment should comply with AS 7470 and the RIM's safety management system (SMS).

3.1.4 Hazards, risk identification and mitigation

The following table of significant risks is not exhaustive however should be considered as part of any risk assessment for a level crossing.

Table 3.1 Risks and mitigations for level crossing interfaces

Hazard	Description	Potential mitigators
Short Stacking	This can occur where a level crossing and road intersection are in proximity to each other. Where a road vehicle is unable to clear the road / rail interface at the level crossing due to traffic or traffic controls at the intersection	The level crossing and intersection should be reviewed and controls put in place in accordance with AS 1742.7
Level crossings in close proximity to a road entry or roundabout	Road users can be faced with multiple competing traffic conditions which can result in a loss of awareness or queuing across the level crossing.	These situations should be managed by undertaking traffic modelling and undertaking a human factors analysis, and considering changes to the physical layout or road speed.
Oversize, over-mass and hazardous vehicles	Slow moving vehicles can result in vehicles still traversing the level crossing when a train is on approach.	Where it is identified that there is a likelihood that vehicles of this type can utilize a level crossing on a regular or semi-regular basis consideration should be given to address whether an alternative route can be provided or whether steps should be taken to alter the level crossing to be better able to cope with these types of vehicles.
Sighting distance (Active)	Insufficient sighting distance can result in road vehicles not stopping prior to the level crossing	The level crossing road lights should be visible from at least the required warning distance at level crossings. Active advance warning assemblies may be required.
Sighting distance (Passive)	Insufficient sighting distance from level crossing of approaching trains due to curvature, vegetation, etc	Consideration should be given to upgrading to active protection or closure of level crossing
Second train coming	Members of the public being unaware that a second train is on approach due to the first train masking the approach of subsequent trains. This can lead to pedestrians and/or road vehicle users assuming the crossing has failed and they cross as the second train approaches.	Boom gates for road crossings or electronic second train coming warning signs for pedestrian crossings may be used to mitigate the risk.
Extended level crossing closure time	This can occur when multiple trains with diverse speeds traverse the level crossing within a short time or where level crossing are in close proximity to railway stations. These situations can lead to non-compliance by level crossing users.	These situations should be managed by undertaking traffic modelling and considering using level crossing predictors whereby there is less variance in warning times. This can reduce the overall level crossing closure time.

SPAD close to level crossing	SPAD by rail traffic results in a road vehicle / rail vehicle collision at level crossing	Consideration should be given to relocating signal to safe distance, second signal protection for level crossing
Failure state of active protection and of power supply	Level crossing booms and lights fail to operate correctly when a rail vehicle approaches	Booms may be set to 'fail safe' to the horizontal position. Battery backups can be used to operate lights until alternative power can be sourced.
Queuing (road users)	Excessive queuing at level crossing can contribute to rear end collisions by road vehicles not aware of level crossing status.	Where excessive queuing considered possible advanced warning lights may be used to provide additional warning distance.
Pedestrians entering pedestrian crossing via emergency exit gates	Pedestrians may undertake this behaviour if they are motivated to catch an approaching train or a connecting transport mode (e.g. bus), become impatient due to long crossing closure times, or do not trust that warnings indicate the imminent approach of a train. This behaviour may be more likely to occur at level crossings adjacent to train stations, those with long crossing closure times, or those that experience failures where warnings activate but no train is approaching.	Design should prevent the emergency gate being opened by pedestrians on the non-rail side. Electromagnetic gate latches can assist in preventing access to the rail corridor. Increased inspections and maintenance to ensure reliability of warning equipment should also be considered.
Pedestrians crossing outside of pedestrian crossing infrastructure	This behaviour is likely to occur where the design of the formal pedestrian pathways requires users to take a longer path. In such cases, some users will take shortcuts, which might include crossing via the road or another point along the rail corridor. This places users at risk if a train approaches, as they may be far from a position of safety and may contribute to road vehicles stopping on the level crossing. This behaviour may be more likely to occur at level crossings adjacent to train stations, with nearby facilities such as car parking and commercial premises including shops and supermarkets.	Design/re-design of approach footpaths and pedestrian crossings to support the shortest route between key points of interest. Fencing and / or obstructive landscaping can be used along the rail corridor, and along the footpath on approach to the crossing, to funnel pedestrians towards the formal crossing point.

3.2 Safety in design requirements

The identification and management of risks associated with installation, testing and ongoing maintenance and operation of the crossing shall be a part of any safety in design process.

The process should consider risks such as:

(a) tripping / entrapment hazards due to flangeway gaps;

(b) obstructions in sighting by location cases;

(c) signage;

(d) crushing injuries from the boom mechanisms, swing gates etc.

Design may also include safe access / egress to the site (safe parking bays, access gates, safe standing areas etc) and other facilities to reduce risk during operation and maintenance.

During the design of an actively controlled level crossing, the designer shall incorporate standard circuit or imbedded software such that the overall control system shall operate safely SFAIRP.

Further guidance is provided in AS 7718.

3.3 Change management

Any change to the operation, use, design or local conditions of a level crossing can change the risk profile of that level crossing. These changes can include:

(a) rail traffic – speed, frequency, length, etc;

(b) road traffic – speed, size of vehicle, adjacent road design, etc;

(c) pedestrian traffic – number of crossings per day, special event pedestrian traffic;

(d) vegetation – installation of gardens, parks, etc;

(e) buildings – erection of new or temporary buildings near a level crossing;

Where changes are proposed at a level crossing, those proposed changes shall be managed in accordance with the RIMs SMS and change management policy.

Councils, road managers and other parties who intend to make such changes shall notify the RIM of these planned changes so that they can be managed in accordance with the RIM's management of change process. These stakeholders shall be listed in interface agreements for each level crossing.

4 Civil requirements

4.1 Delineation of responsibility

The interface agreement between the RIM and the road manager shall clearly define the boundaries for road and level crossing equipment maintenance at a level crossing.

4.2 Road traffic control

RIMs shall have documented processes in place to ensure active and passive level crossings are managed in accordance with AS 1428.1 and AS 1742.7.

Management of level crossings should consider:

(a) signs, devices and assemblies - description and use;

(b) pavement markings;

(c) application of signs and markings to level crossings;

(d) avoidance of traffic queuing on crossings;

(e) management of short stacking risks;

(f) pedestrian and bicycle treatments at level crossings;

(g) illumination and reflectorization of signs;

(h) installation and location of signs;

(i) selection of appropriate sign size.

(j) sight distance provision:

i. road user to level crossing control device;

ii. road user to rear of any stationary queue on the approach to a level crossing;

iii. road user to an approaching train or road/rail vehicle.

(k) active advance warning assembly - guides for use, installation and operation.

4.3 Pedestrian level crossings

4.3.1 Risk

The differing types of pedestrian level crossing users that use the same pedestrian level crossing can increase the risk rating of a particular site. The user types can include, but are not limited to, the following.

(a) Pedestrians:

i. able bodied – including persons pushing a pram / stroller / baby buggy;

ii. non-able bodied – using walking aids such as wheelchairs, frames or walking sticks.

(b) Cyclists:

i. standard cycles;

ii. recumbent cycles;

iii. other styles of cycles.

(c) Pedestrians using mobility devices:

i. two-wheel scooters;

ii. four-wheel devices.

(d) Pedestrians accompanying livestock:

i. horses;

ii. cattle.

4.3.2 Design

Where separate pedestrian and road crossings are provided, physical measures should be included to guide pedestrians to pedestrian crossings and provide sufficient deterrence for pedestrian access to road crossings.

Subject to sight distance considerations, such physical measures may include one or more of the following:

(a) guided pathways;

(b) barriers;

(c) obstructive landscaping;

(d) fencing.

Pedestrian crossings associated with highly skewed road level crossings should be independently located at right angles to the tracks.

Pedestrian crossings may include:

(a) widening of the adjacent road to allow for pedestrian walkways;

(b) separate paths;

(c) path with signs;

(d) crib enclosure, together with pedestrian booms and/or gates equipped with visual and audible warnings.

The pedestrian level crossing should consider the interface with adjacent hazards such as cycleways and other footpaths outside the railway corridor.

Sealed surfaces shall be slip resistant. Slip resistant surfaces should comply with SA HB 198.

4.3.3 Warning time

A RIM shall provide users of the pedestrian level crossing sufficient warning time (by active control or sighting distance) to safely leave the pedestrian crossing.

Where the time taken to safely cross all tracks exceeds the warning time provided the RIM shall either:

(a) close the pedestrian level crossing.

(b) grade separate the pedestrian crossing;

(c) relocate the pedestrian level crossing;

(d) upgrade the level crossing controls (for example passive to active control);

(e) increase the warning times (active level crossings);

(f) reducing the approach speed of trains; or

(g) provide intermediate pedestrian refuges between tracks.

Where an intermediate pedestrian refuge is used, the crossing times on either side of that pedestrian refuge should be considered independently.

4.4 Track-side signage

The use of horns or whistles by rail traffic approaching level crossings provides a level of risk mitigation. RIM's should encourage the use of horns or whistles by installation of whistle boards.

Whistle boards, where provided, shall be located on each approach of a level crossing, at a distance as defined by the RIM.

Other level crossing signage shall be in accordance with the respective operating rules for rail traffic. This signage should be clearly visible to operators of rail vehicles approaching at the

maximum permissible speed. Where text and graphics are used it shall be legible, concise and compliant with the RIMs standards.

4.5 Roads

4.5.1 General requirements

The minimum clear width provided through level crossings shall conform with the road manager's requirements and should be at least equal to the approach road traffic lanes plus shoulders.

Where practical, additional clearances should be considered on each side of the road to avoid unnecessary constraints to traffic, including pedestrians and cyclists.

Where an existing level crossing is narrower than the approach road design width, the taper of the road shall be designed in accordance with the requirements of the road manager.

Vertical curves and changes of grade on the approach road through the level crossing should be minimized and comply with the road authority’s road design standards to the extent possible.

The road approaches to a level crossing should be designed so that road vehicles can safely negotiate the level crossing at the design speed of the road. The design should also consider the road gradient on approach and across the level crossing.

At level crossings, the road curvature and superelevation should be selected with superelevation matching the track grade, so that road cross fall does not reduce in the direction of travel along the curve.

Where applicable, provision shall be made in the level crossing design for adjacent intersections and associated road traffic turning movements in accordance with the road manager's operating requirements and standards.

4.5.2 Road and rail drainage design

At level crossings the design of the surface water drainage runoff should be such that the water runoff is contained, to the extent possible, within the originating corridor. Consideration should be given to managing the extent of any spillage of hazardous chemicals or fuels as the result of an incident in the vicinity of the level crossing.

AS 7637 shall be utilized as a reference for this purpose.

4.5.3 Surface

Level crossing road surfaces should be fit for purpose to suit the type, speed and loading of the road traffic commonly using the site. Road managers should collaborate with RIMs to determine the most appropriate road surface treatment at level crossings so that road user safety is not compromised.

The following level crossing surface types are commonly used.

(a) Gravel.

(b) Crushed rock.

(c) Timber.

(d) Steel panels.

(e) Concrete panels.

(f) Concrete.

(g) Asphalt.

(h) Rubber panels.

Selection of the level crossing surface type shall be based on the following considerations.

(a) Type of crossings.

(b) Track maintenance.

(c) Road maintenance.

(d) Compatibility with the approach road surface.

(e) Road traffic volume, vehicle types, speed and weight.

(f) Use of road by cyclists.

(g) Whether road markings are required.

(h) Presence of impact initiators such as vertical dips in the road.

(i) Horizontal angle of approach of road vehicles and curvature of the road.

(j) Road surface grip under all conditions.

(k) Method of panel fixation.

(l) Surface and sub-surface drainage.

(m) Durability.

(n) Resistance to UV and chemical attack.

(o) Rail traffic volume, speed and axle load.

(p) Track configuration.

(q) Road configuration.

(r) Signalling control and train detection system.

(s) Electrical resistance of level crossing in-fill.

(t) Stray currents induced or conducted through the roadbed into signalling infrastructure or corroding the track components.

(u) Effect of level crossing pavement structure on track components, e.g. wear and corrosion.

(v) Life cycle cost.

The surface type for a level crossing shall be approved by the RIM and the road manager.

The skid resistance value for public level crossings shall be evaluated for suitability. The skid resistance value should be similar to the value for the adjacent road surface.

The level crossing surface shall be flush with the top of rail, planar between the two rails and flush with the approach roads and footpaths.

For multiple tracks, as far as practicable, a uniform road surface plane should be provided through the entire railway corridor width of the level crossing.

The surface of the approach road, including the shoulder area should be sealed for sufficient distance that vehicles can safely stop prior to the level crossing if required.

The minimum standard for all public level crossings shall be a formed gravel road surface extending for a sufficient distance that vehicles can safely use the level crossing.

4.5.4 Road and pedestrian street lighting system

Adequacy of street lighting at a level crossing shall be assessed against the requirements in AS 1158 during a level crossing risk assessment.

Street lighting provided for level crossings shall comply with AS 1158 and impacts on train drivers, road users and pedestrians shall be evaluated and outcomes documented.

4.5.5 Safe stopping distance

The relevant road manager is responsible for determining the road surface requirements to ensure a sufficient distance for approaching road traffic to safely stop. These calculations may demonstrate that advanced warning lights are required.

4.6 Track

Track geometry should be designed in accordance with AS 7635.

Track shall be designed and constructed in accordance with AS 7638, AS 7639 and AS 7640. If a road crosses two or more tracks, the tracks should be kept on the same plane.

The amount of track cant should be optimized consistent with safe rail and road geometry through the level crossing.

Where the track cant is still incompatible with the level crossing the road geometry may be modified to provide safe road conditions.

The tracks across the surface of a level crossing should be clear of turnouts and insulated rail joints.

Resilient fastenings should be used through the level crossing.

Geofabrics should be used to provide a separation layer between the sub-ballast and the track formation and should extend up to the interface between the road pavement subbase layers and the ballast.

4.6.1 Track structure

The track structure should comply with the relevant Australian Standards.

The track formation and ballast structure should be suitable to support the level crossing, with consideration to the likely road and pedestrian traffic.

The rails within the level crossing should be protected from corrosion by the application of a suitable surface treatment to both sides of the rail web and foot. Track fastenings should be corrosion resistant.

Where track guard rails are installed, they should be continuous through the road, shoulders and (where present) pedestrian footpaths, with appropriate tapered run-in.

Suitable sleepers should be used through the road / rail interface of level crossings to minimize level crossing maintenance demands.

Suitable transitions in the track structure should be provided on the approaches to level crossings by changing the sleeper spacing and/or sleeper type to accommodate the stiffness of the track structure through the level crossing.

4.6.2 Drainage

Track drainage should be maintained through or appropriately deviated around level crossings.

The road manager and RIM should contain water within their own reserves. Drainage should be provided to avoid damming of water at road / rail interfaces.

Subsurface water, where identified, should have subsurface drains provided within the sub-ballast near the road interfaces to intercept and drain subsurface water from the level crossing area to a suitable outlet.

Where sub-soil drainage materials are utilized they should be installed in accordance with the manufacturer's specifications and guidelines.

RIMs may use perforated pipes filled with aggregate for level crossing drainage and where used those pipes shall be in accordance with AS 2439.1.

4.6.3 Flangeway gaps

Flangeway gaps shall be provided, taking into account the following.

(a) Maximum size of wheel flanges of trains allowed through the level crossing.

(b) Clearance between track gauge and wheel-set gauge.

(c) Track radius through the level crossing.

(d) Entrapment hazard for wheeled vehicles.

The depth and width of flangeway gaps should be sufficient to allow a worn train wheel to traverse without damaging the road surface.

Flangeway gaps for pedestrian crossings shall comply with the requirements of AS 1742.7.

Flangeway fillers should be considered where a risk to level crossing users has been identified. The surface of the gap filler could introduce slippage risks that should be considered.

4.7 Identification and contact details

All level crossings shall be individually identified in each RIM's network. This is to allow level crossing users to have full details at each site should there be an accident, incident or defect that requires attention. The identification plate should contain the contact details for the network control centre, the line section and kilometrage of the level crossing and the level crossing's unique identification number.

At active installations multiple plates should be located on the equipment enclosure and on each RX-5 light assembly (facing away from the rail corridor). At passive sites, plates should be installed on each STOP or GIVE WAY signpost – facing away from the rail corridor.

5 Active control

5.1 Performance requirements

5.1.1 General requirements

The purpose of an active level crossing warning system is to alert level crossing users of approaching trains.

The design, construction, testing and commissioning of active level crossings shall be in accordance with AS 7717 and the standards and procedures of the RIM.

An actively controlled level crossing is a complex engineered system, the safety integrity relies on the processes applied to it through every stage of its lifecycle.

Actively controlled level crossings are safety critical and they shall meet the following requirements.

(a) The system shall minimize the probability of insufficient warning being provided due to the failure of any single level crossing component.

(b) The presence of a failure in the system shall be evident.

(c) The system shall be designed such that if it fails, it shall revert to its fail-safe condition.

Methods shall be used to alert the RTO and/or RIM of a failure in the level crossing system.

Such methods, in combination or separately, may include:

(a) control circuit design;

(b) remote monitoring;

(c) periodic site inspections;

(d) indication of failure to the crew of an approaching train;

(e) indication of failure to road users; and

(f) a means for the road user to report a failure to the rail authority, a sign with crossing identification and a telephone number to report the fault.

An actively controlled level crossing should comply with quality management conditions, safety management conditions, technical safety conditions and quantified safety targets.

An actively controlled level crossing shall be designed and maintained to operate reliably within its environmental conditions and in accordance with the requirements of the rail authority.

The major subsystems of an actively controlled level crossing are:

(a) passive traffic control devices;

(b) active traffic control devices;

(c) train detection system;

(d) power supply;

(e) monitoring system.

An actively controlled level crossing may also include interlocking between the level crossing controls and railway signal controls or interlocking between the level crossing controls and road traffic signal controls.

The requirements for passive and active level crossing traffic control devices for road users in this standard are intended to supplement details already prescribed in AS 1742.7.

Passive and active level crossing traffic control devices for road users shall comply with AS 1742.7 and any additional state and rail transport operator standards.

5.1.2 Level crossing design process requirements

Prior to the design of an actively controlled level crossing, an initial risk assessment shall be conducted to determine the applicable level crossing controls, including consideration of consequential impacts and possible mitigation measures.

Further risk assessment may be conducted at any stage during the design process in compliance with the risk management requirements.

With the results of a risk assessment, the scope of works and preliminary design of a level crossing shall produce the required characteristics of the major level crossing subsystems covering all relevant design considerations and risks, including control measures.

The design process should address reliability, availability, maintainability and safety (RAMS) requirements.

The detailed design shall produce design drawings and documentation which incorporate the characteristics of the level crossing subsystems as described in the scope of works and preliminary design documentation.

The detailed design drawings and documentation of a level crossing shall be verified and validated for compliance with relevant standards and the functional design requirements.

5.2 Active control devices

5.2.1 General information

Active control devices provide alerts and/or physical barriers to vehicle and pedestrian movements across the rail corridor upon activation by approaching trains.

At actively controlled level crossings, a combination of one or more of the following protection methods shall be activated by approaching trains.

(a) Visual warning; provided primarily by level crossing warning lights or flashing and/or steady pedestrian lights.

(b) Physical barriers; provided primarily by boom barriers or pedestrian gates or barriers.

(c) Audible warning; provided primarily by audible warning devices.

The sequence of operations that these methods shall follow are detailed in Appendix C.

The actively controlled level crossing system shall be capable of manual operation by authorized persons.

A local test switch secured in a locked equipment cabinet should be provided to achieve the requirements of individual RIMs.

5.2.2 Level crossing warning lights

Level crossing warning lights in RX-5 assemblies, as defined in AS 1742.7, provide level crossing users with a visual warning of approaching trains.

Site specific focussing diagrams should be prepared to optimize the visibility of level crossing warning lights at level crossings. Suggested arrangements are shown in Appendix E.

Level crossing warning lights shall be focussed to provide level crossing users with sighting of the stop indication in accordance with the requirements of the road manager and their determination of a safe stopping distance. For the purpose of this paragraph level crossing users include users:

(a) stopped at the level crossing;

(b) approaching the level crossing on the normal side of the road;

(c) approaching the level crossing on the wrong side of the road e.g. emergency vehicles.

Each light module in a pair of level crossing warning lights shall flash alternately with the other when activated.

Pedestrian crossing warning lights associated with level crossings with boom gates may flash individually at the same rate as the flashing road traffic lights during the warning phase of a level crossing's activation when fitted with road boom barriers. The pedestrian lights then shall remain constantly illuminated 15 seconds after commencing flashing.

Pedestrian crossing warning lights associated with level crossings without boom gates shall be constantly illuminated when activated.

The warning lights for level crossings shall conform to the following functional requirements.

(a) The lights shall be clearly viewable at the required sighting distance for each individual level crossing under bright sunlight conditions[3], with the hood and background fitted against a bright sky.

(b) The lights shall have a minimum horizontal viewing range of as per the table at Appendix D.

(c) The red colour shall comply with the envelope specified in AS 2144.

(d) The operating voltage range shall be compatible with the power supply arrangements of the installation.

(e) Shall be capable of operating in an environment of –10 to +50 °C ambient and 0-95 % relative humidity.

(f) For LED technology, the cover over the LED's shall be clear or neutral grey in colour. Red lenses shall not be used.

(g) For LED technology where side lights are included, they shall not be illuminated until the main aspect is proven alight.

(h) The mounting arrangement shall allow for aiming through a wide range in both the horizontal and vertical planes.

[3] Low sun (backlit or front lit) can affect the ability for level crossing users to sight warning lights when active and should be considered.

(i) Shall be at least IP65 rated.

(j) The lights shall have a minimum nominal diameter of 200 mm.

(k) The lights shall have a flashing rate of between 35 and 65 flashes per minute.

5.2.3 Boom barriers

5.2.3.1 General

When activated by the approach of train(s), boom barriers augment level crossing warning lights and provide a physical barrier to the progress of level crossing users as well as active visual warning via boom lights.

Boom barriers shall be installed at multiple track active control level crossings to prevent level crossing users entering the level crossing when there is hazard caused by subsequent trains approach from either direction. RIMs should install boom barriers at single track level crossings where the risk profile of the level crossing suggests they are required.

The risks associated with all overhead wiring shall be assessed with regard to the position of any boom barrier arm and mechanism. Risk mitigation may include:

(a) greater set back from the rail;

(b) enhanced traction bonding;

(c) shortened booms;

(d) use of a composite material boom.

5.2.3.2 Boom barrier mechanism

The boom mechanism shall be designed so that the mechanism can raise and lower the boom at a reasonable speed.

Boom barrier mechanisms shall conform to the following functional requirements.

(a) They shall retain the barrier arm in the raised position under control power.

(b) The power down drive shall be set to the OEM specifications.

(c) Descent time – 13 seconds maximum when the barrier arm and counterweight arrangement is set as per the original equipment manufacturers (OEMs) requirements.

(d) Raise time – 10 seconds maximum when the barrier arm and counterweight arrangement is set as per the OEM's requirements.

(e) The boom barrier mechanism shall:

i. be capable of the control function of raising and lowering of the barrier arm;

ii. enforce the operation of the level crossing warning lights when the barrier is not fully raised;

iii. provide an indication of the barrier in the lowered position. Other indications may be provided.

In the event of a power or equipment failure, the boom should lower by gravity alone.

5.2.3.3 Boom arms

Boom arms shall conform to the following functional requirements.

(a) The maximum length of timber and aluminium boom barriers shall be in accordance with OEM recommendations.

(b) Aluminium booms shall be fitted with breakaway mechanisms and incorporate shear pins where attached to the gate arm support. A tether cable can be fitted between the post and the boom.

(c) Each side of the boom shall be finished in retro-reflective red and white diagonal stripes in accordance with AS 1742.7.

In areas where high winds can reasonably be expected brackets for supporting the boom barrier whilst in the vertical position should be considered for longer boom barrier arms.

5.2.3.4 Boom barrier lights

Boom barrier lights shall conform to the following functional requirements.

(a) The boom barrier shall have boom lights arranged in accordance with AS 1742.7. The tip boom light shall be steady illuminated whilst the two inner boom lights shall flash alternatively.

(b) The boom barrier shall have three boom lights viewable from each side of the boom barrier. They shall be positioned on the boom barrier such that each traffic lane has at least one boom light in it.

5.2.4 Boom barriers – four quadrant

Four quadrant boom barrier installations provide boom barriers at the entry and exit to a level crossing for both lanes of traffic. Four quadrant boom barrier installations have the additional hazards of traffic being caught on the level crossing and being unable to exit due to the exit side boom barrier. This hazard shall be included in any design risk assessment.

To reduce the risk of a train / vehicle collision due to a vehicle being trapped between the entry and exit boom barriers the exit boom barrier shall not start to lower into the horizontal position until after the entry boom barrier is detected in the horizontal position. The exit boom barrier shall be in the horizontal position at least 5 seconds prior to the train crossing the level crossing.

To achieve the level crossing sequence and timing a RIM may need to increase the warning time by allowing for additional clearance time.

The approach side boom barriers shall not start to rise into the vertical position until the departure side boom barriers have been detected in the vertical position.

5.2.5 Pedestrian swing gates

5.2.5.1 General

When activated by the approach of train(s) pedestrian swing gates augment activated pedestrian warning signs and provide a physical barrier to the progress of pedestrians across the pedestrian level crossing.

The swing gate mechanism shall be designed so that the gate opening and closing time is within 10 seconds. In the event of a power failure, the gate should close via spring or other energy storage device.

5.2.5.2 Functional requirements

Pedestrian swing gate shall conform to the following functional requirements.

(a) Swing gates shall be of a constructed so as not to distort or sag with a vertical load of 150 kg applied at the tip of the gate.

(b) Gate supports shall not bend, twist or distort with similar loads applied or with a load of 250 kg applied to the top of the gate support in any direction.

Pedestrian swing gate mechanism shall conform to the following functional requirements:

(a) The swing gate motor-mechanism shall be capable of operating swing gates of at least 1.5 metres in width.

(b) The operating voltage range shall be compatible with the power supply arrangements of the installation.

(c) Designed such that hazards to persons associated with the swinging gate leaf and crank arms are minimized and the gate leaf not capable of causing crush injuries to pedestrians.

(d) Capable of closing the gate (through 95°) in 10 seconds or less.

(e) Capable of tolerating the gate being restrained part way through its arc for an indefinite period without detriment to the motor or mechanism for an indefinite period.

(f) Capable of resuming movement in the intended direction when restraint is removed.

(g) Fitted with a minimum of two independent volt free contacts when the gate is closed and a minimum of 2 independent volt free contacts when the gate is open.

(h) Contacts shall be rated at a minimum 10 A at 240 V ac and 1 A at 24 V dc.

(i) Capable of tolerating being forced from the closed or open position without detriment to motor or mechanism.

(j) Capable of returning to the correct position when the force is removed.

(k) Capable of closing the gate on loss of power.

Emergency exit swing gate and magnetic release (where fitted) shall conform to the following functional requirements.

(a) Be of galvanized steel construction, provided with a self-closing mechanism usually taking the form of spring close hinges that apply sufficient torque to hold the gate closed and do not restrict any operation to open the gate when the latch is not operating. The automatic latch shall have a local release. The gate design shall comply with the requirements defined in AS 1742.7.

(b) The operating voltage range be compatible with the power supply arrangements of the installation.

(c) The magnetic release is fitted with a position status switch which, when wired up to a monitoring system allows the closed or otherwise position status of a gate to be detected.

(d) Only permit level crossing users to open the gate from the rail side e.g. users leaving the rail corridor.

Latches should be:

(a) robust in nature;

(b) capable of being released by all user types;

(c) reliable in operation.

5.2.6 Pedestrian enclosures

Pedestrian enclosures shall comply with the requirements in AS 1742.7 and AS 1428.1

Design should consider, as a minimum:

(a) the likely volume of traffic;

(b) mobility devices;

(c) human factors;

(d) the interface between the swing path of the gates and other paths or structures;

(e) step and touch potential under normal and fault conditions.

5.2.7 Audible warning devices

5.2.7.1 General

Audible warning devices provide level crossing users with an active audible warning of approaching trains.

Where there is a pedestrian crossing associated with an active level crossing, audible warning device(s) shall be provided for the pedestrian crossing. The audible warning devices may be fitted to the adjacent level crossing.

Where audible warning devices are not fitted to the level crossing, or the volume does not meet the requirements of this section separate audible warning devices shall be provided at the pedestrian crossing.

Audible warning devices should be located and directed such that upon activation, an audible warning is heard by pedestrian crossing users approaching or crossing the railway tracks.

5.2.7.2 Volume

The sound from an audible warning device should be at least 10 dBA above ambient noise level to ensure that the warning is heard by pedestrians. The audible warning device sound level shall be measured 3 m away from the gate or pedestrian holding point in the direction of the approaching pedestrian traffic.

The maximum volume of an audible warning device shall comply with local standards and legislation that minimize the risk of noise induced hearing loss and shall take into consideration the proximity of residential and commercial property to the audible warning devices.

A RIM may provide a means to vary the volume of the audible warning devices at pedestrian crossings where a high variance in ambient noise levels exists, for example in urban areas with high daytime traffic and low night time traffic.

Audible warning devices should minimize the sound level being presented to nearby residential properties.

As an alternative the RIM may require that four low power electronic audible warning devices be provided at the four quadrants of the crossing and that these remain operating during the warning cycle of the level crossing.

5.2.7.3 Bells

Audible warning devices with bells shall conform to the following functional requirements.

(a) It shall contain at least 2 devices where pedestrian facilities are provided at the same location.

(b) The electronic version shall have adjustments to volume and the impulse rate shall be able to be set between 150 to 200 strikes per minute.

(c) It shall be designed to mount directly on the top of a 125 nominal bore heavy steel tube (140 mm outside diameter) and on top of a 100 mm nominal bore heavy steel tube (114 mm outside diameter) – or be provided with an adaptor where required.

(d) The operating voltage range shall be compatible with the power supply arrangements of the installation.

5.2.8 Standing pedestrian signal assemblies (RX-12)

Illuminated pedestrian symbols and signs shall comply with the requirements of AS 1742.7

The illuminated pedestrian signs shall conform to the following functional requirements.

(a) They shall be ‘Red Person’ lights using symbolic indications detailed in AS 2144. Where ‘Green Person’ lights are used they shall also comply with AS 2144;

(b) The operating voltage range shall be compatible with the power supply arrangements of the installation;

(c) They shall be at least IP65 rated.

5.2.9 Illuminated another train coming signs

Another train coming illuminated signs may be used for multi-track level crossings. The another train coming sign will remain illuminated while the active level crossing remains activated for subsequent trains

When designing the location of another train coming signs consideration should be given to the sighting requirements of pedestrians, such as from both sides of the crossing or within the holding area.

The illuminated another train coming signs shall conform to the following functional requirements.

(a) The operating voltage range shall be compatible with the power supply arrangements of the installation.

(b) They shall be at least IP65 rated.

5.3 Train detection system

5.3.1 General

The train detection system of an actively controlled level crossing detects the approach of a train or rail mounted vehicle. This input contributes to the operation of active level crossing warning equipment.

Primary train detection technologies shall be appropriate for the type of rail traffic pattern. These may at include:

(a) track circuits;

(b) axle counters; and

(c) predictors.

Treadles are a secondary train detection system that may be used to supplement a primary train detection system.

The extent of the length of the train detection system on the approach of an actively controlled level crossing shall be sufficient to provide the calculated warning time at the maximum permissible line speed from each approach direction. Guidance for the calculation of the required warning time is provided in Appendix B.

Where an island track is included within the train detection system of a level crossing, it shall encompass the level crossing surface plus a distance on each side of the level crossing to ensure that the active traffic control devices will not deactivate before all portions of all the trains that use the level crossing have cleared the road/rail interface of the level crossing.

Where variable train speeds can occur due to complex characteristics on the approach to a level crossing (e.g. signals or turnouts near a level crossing), a number of train detection sections used in different configurations may be used to provide an appropriate approach timing for differing approach routes.

5.3.2 Bi-directional movements

Wherever bi-directional movements can take place over a level crossing on the same track directional controls shall be provided to prevent the continued operation of the level crossing warning when the rear of a train clears the crossing island track section but remains within the opposing crossing approach. Level crossing predictors normally provide this feature as part of their basic operation but other systems typically require directional circuits to achieve this functionality. The provision of such circuitry gives rise to the risk that a departure side track circuit remaining occupied after the passage of a train will leave the stick circuit effective and hence render the crossing unprotected for movements towards it in the opposite direction to the first train.

In order to guard against this one of the following forms of control shall be applied.

(a) The crossing track section shall be proved clear, and the directional feature proved ineffective, in all signals reading over the track section. In addition, the setting of a signal route may itself be used to disengage any directional control, typically so that permissive shunt movements are not prevented from clearing.

(b) The directional feature shall be disengaged, and the crossing warning reactivated after a set period of time if a track section remains occupied on the

departure side of a level crossing. The time selected shall be such that the crossing would not be reactivated by a train remaining on the departure side during normal operations, typically whilst stopping at a station or awaiting onward routing, but would reactivate prior to the possible arrival of a second train in the opposite direction.

Option 1 should normally be used in signalled territory and option 2 on non-signalled lines where proving is not possible. However, option 2 may also be used where level crossing predictors, audio frequency overlay or axle counters are used on signalled lines but not proved clear in the signalling system

5.4 Predictors

A predictor is a level crossing control system that incorporates an audio frequency track circuit for train detection. The control system monitors the track circuit's operational parameters and uses an algorithm to calculate the speed of a train approaching a level crossing. This allows for trains approaching at different speeds to provide a constant warning time (except for very low speeds).

Predictors shall be configured in accordance with the OEM recommendations and then with the RIM's signal design standards taking into consideration rail traffic patterns and tonnage that operate over the particular level crossing. Predictors should be selected to be compatible with the traction system and any other equipment on the network.

When a train is approaching a level crossing controlled by a predictor, an output can be given prior to the active level crossing controls being activated. This is known as a pre-emptive output and can be used where interfacing to other control systems such as road traffic light controllers or active advance warning assemblies.

All predictor systems should be configured with a "positive start" that activates the level crossing warning equipment at a fixed distance from the level crossing or the predictor can switch to "motion sense" mode at a fixed distance from the crossing.

RIMs should install a unique sign on the approach to a predictor controlled level crossing to alert train drivers not to increase their approach speed to the next level crossing. If a change in train speed occurs on the approach to the level crossing, the actual warning time provided can differ from the warning time configured in the predictor.

Appropriate controls for managing this change in warning time, including network rules, should be implemented.

5.5 Logging and alerting

Active level crossings shall, so far as reasonably practical, be fitted with an active logging and fault reporting system. This system shall report to a nominated control point – so that should a predetermined warning or alarm occur at the level crossing, that control point shall be immediately alerted so that the appropriate response from the operator can be implemented.

The detailed arrangements for these types of monitoring and logging systems is contained within AS7705.

5.6 Rail cyber security and cyber security

Rail and general cyber security is a risk to the safety and integrity of both railway signalling and control systems. Where level crossings are likely to be at risk of cyber-attack, a risk assessment should be undertaken to mitigate and minimize the risk of cyber-attack.

Systems and equipment design should reference to AS 7770.

5.7 Healthy state detection

A local healthy state indicator may be provided that is only viewable by approaching rail mounted vehicles and not level crossing users.

Information relating to this type of indicator can be found in AS 7705.

5.8 Degraded operations

All active level crossing installations should include emergency and manual controls so that during times of accident or incident, qualified workers can operate these controls to assist with both rail and road traffic movements. The controls, where provided, shall be located on or near the level crossing control equipment enclosure and be clearly marked.

5.8.1 Emergency controls for active installations

Emergency controls, where provided, shall disable the normal operation of individual level crossing hardware items such as level crossing warning lights, road boom barriers or pedestrian gates in accordance with the applicable network rules.

5.8.2 Manual controls for active installations

Manual controls for the operation of a level crossing should be provided where approach track circuits or other automated level crossing activation technologies are not suitable. This will commonly occur where a level crossing is provided at a siding where trains are expected to stand for extended periods of time.

The manual control device shall begin the normal operation of the level crossing equipment in accordance with the applicable network rules.

5.9 Road-rail vehicles and track machine operation of level crossings

The operation of road-rail vehicles and track maintenance machinery through a level crossing should be carried out in accordance with each RIMs individual requirements.

Where active warning equipment is installed, the RIM shall determine whether the passage of such rail vehicles will reliably operate the active warning equipment or whether special arrangements shall be put in place.

5.10 Electrified railway interface

Where level crossings are located within an electrified railway steps shall be taken to ensure that there is sufficient immunity between the traction system and the level crossing equipment, such that the safety integrity of the level crossing is not adversely effected by normal operation or transient events in the traction system.

EN50122-1 should be referenced for interfacing arrangements.

5.11 CCTV

CCTV systems may be installed at level crossings to improve the safety and data capturing arrangements at selected sites. CCTV systems may be stand-alone whereby they only record and store the video data locally or be remotely monitored and recorded.

Refer to AS 7705 for further detail.

5.12 Construction, testing and commissioning requirements

A program shall be developed for the works in accordance with individual RIM requirements and shall identify all the necessary level crossing works and interface management requirements to safely complete the construction, testing and commissioning activities.

5.13 Configuration management of application data

Where level crossings are controlled by systems that utilize either application data or a form of software coding, the application data or software coding shall be managed in accordance with AS 7718 or as per RIM standards.

5.14 Signalling interface requirements

5.14.1 Interlocked with the signalling system

The requirements of AS 7711 shall be applied when interfacing level crossing control systems to a local signalling control system.

Level crossings may be interlocked with the signalling system to provide level crossing users with compatible warning for stopping trains.

Level crossing system design should consider the probability that a train will stop on approach to a level crossing. Availability of signals between the stopping point and the level crossing that could safely be used to mask the approach of the train and thereby enhance the availably of the level crossing to road users should also be considered.

5.14.2 Interfaced with the road traffic system

Where an active level crossing is located adjacent to a traffic light controlled road junction and there is a risk of road traffic queuing across the level crossing the level crossing control system shall interface with the traffic light control system so that the overall installation shall operate as a single system. The overarching system requirement is to ensure that road users are given sufficient time to clear the rail corridor when a rail vehicle is detected approaching the level crossing.

In these situations, the amount of railway infrastructure required can increase due to the requirement to detect the approaching rail vehicle further from the level crossing to allow a control to be sent to the traffic light control system so that road traffic signals can change to allow free exit of road traffic from the level crossing/road interface.

Traffic light pre-emption requires that a control output be passed from the level crossing control equipment to the traffic lights controller in advance of when the level crossing active warning equipment operates.

This control shall modify the normal cycle of the traffic lights controller on the approach of a train, in order to provide a sufficient clearance phase and allow the road traffic at the level crossing to clear before the normal level crossing warning sequence is activated.

The pre-emptive timing required and traffic light phases shall be defined by the road manager for the level crossing. Interface control circuits between the level crossing and road crossing shall be agreed between the RIM and road manager.

Where reasonably practicable, the road traffic light system and the interface may be designed so that if the traffic lights have not changed to the specified “railway phase” by the required time, then the road traffic lights will be forced into flashing yellow.

Events shall be logged by the level crossing control equipment in accordance with AS 7705 and may be logged in the traffic lights controller.

5.14.3 Level crossing active control technology

Where a computer-based technology is used for the active control then any communications of functions between separate computer card files shall ensure that all null functions are actively confirmed and are not a default value with sub-system failure.

This should be implemented by using a communications healthy state function in association with the null state. For example, train detection occupied = "0" data state. Otherwise a loss of a sub-system may cause a different function to be activated by the "0"data state.

5.15 Power supply

The power supply for actively controlled level crossings shall be derived from one of the following sources and shall take the form of a ‘no break’ supply with sufficient back up time coverage.

(a) Railway power supply.

(b) Power supply utility or other third-party source.

(c) Alternative off-grid power supply (e.g. solar panels, generators).

The power supply shall include backup power source to maintain normal operation in the event of a power failure. This may include a battery and battery charger or UPS system.

The back-up power supply shall be able to maintain normal operation for a period of time in excess of the response time of maintenance staff to attend the site.

6 Operations

6.1 Managing alarms and warnings

Where active level crossings are monitored and remotely connected to a Network Control Centre, the RIM shall have a documented process that details how operational personnel are to respond to system warnings and alarms at level crossings. This process shall be developed in consultation with the RIM so that it meets the requirements of the SMS and other standards and processes.

6.2 Resetting of axle counters

Where a level crossing utilizes axle counters for the train detection system, the RIM in consultation with the RTO shall agree the axle counter reset method/s. These methods shall be clearly defined and following a risk assessment shall have the appropriate controls implemented to control the risk of an axle counter system being restored whilst rail traffic remains within the limits of the axle counter system.

Level crossings can be a convenient location for road rail vehicles to on or off track. These can cause a miscount of axle counter train detection systems. The RIM shall establish whether an axle counter controlled level crossing can be used for entry and departure of road rail vehicles. Where an axle counter controlled level crossing is used for road rail vehicles provision shall be made for resetting the axle counters.

6.3 Manual operation and emergency switches

6.3.1 General

Where manual operation and/or emergency switch functionality is installed at an active level crossing, only suitably trained and competent personnel shall utilize these functionalities.

Manual operation and emergency switches shall be secured to prevent unauthorized operation.

Prior to these functions being utilized, the RIM's safeworking and/or possession processes to protect the level crossing shall be fully implemented along with any RTO requirements to protect any train or rail mounted vehicle movements.

6.3.2 Manual operation switches

At locations where it is reasonably expected that trains will approach a level crossing but will not proceed over the level crossing manual operation switches should be provided. This can occur at:

(a) sidings and yards where trains shunt but do not proceed across a level crossing;

(b) locations where trains are loading / unloading for extended periods adjacent to a level crossing.

Manual operation switches may also be provided to active a level crossing where the approaching rail vehicle could fail to active the level crossing, such as track machines and /or hi-rail vehicles.

The level crossing may be activated by:

(a) a manual switch;

(b) radio control.

Signage reminding train crews to operate the manual switch prior to proceeding should be provided in advance of the level crossing. Level crossing indicator lights may be provided to advise train crews that the level crossing has been operated.

Level crossing operation may be cancelled by either:

(c) returning the switch to its normal position;

(d) through track circuits detecting all rail vehicles are clear of the level crossing.

6.3.3 Emergency switches

Emergency switches shall be provided to enable emergency operation of the level crossing, in accordance with RIM polies and procedures.

6.4 Suspended railway operations

Where rail traffic has been suspended on a section of railway line, level crossings shall be managed in accordance with the RIMs SMS and maintenance procedures following consultation with the road manager.

The interface agreement(s) for the affected crossing(s) shall be reviewed with the road manager to reflect the new risk profile and outline responsibilities of each party in managing the identified risks SFAIRP.

Where is it unlikely that rail traffic will resume operations through these level crossings the traffic control devices should be reviewed and be addressed in accordance with AS 1742.7.

6.5 Reactivation of deactivated level crossings

A deactivated level crossing being brought back into service shall be recommissioned in accordance the individual RIMs maintenance and operational requirements. The level crossing shall be risk assessed to ensure the controls in place are suitable for the recommenced rail traffic.

The road manager shall be advised when a deactivated level crossing is re-activated.

Railway operations shall not recommence until the reactivation and certification of active level crossings has been completed.

Where a level crossing has had signage and/or active control devices removed additional signage shall be installed at the level crossing to indicate that train running is to recommence. Other strategies for public notification should be investigated and implemented as deemed necessary.

6.6 Train driver and road user reporting

RIMs shall have a reporting system in place such that train drivers and road users have a mechanism to report faults within that network – including alleged defects or faults at level crossings – that result in the appropriate escalation of personnel to investigate and take further action as necessary.

Signage shall be provided at active level crossings in accordance with section 7.2 of this standard to enable adherence to this clause.

6.7 Degraded conditions

RIM’s shall have in place a documented process for the operation of rail traffic whilst an active level crossing is in a degraded condition.

Consideration should be given to (but not limited to) the following.

(a) Requirements to control risks at degraded level crossings with regards to:

i. road traffic;

ii. rail traffic;

iii. pedestrian traffic.

(b) Safeworking requirements.

(c) Movement of road and rail traffic through the crossing.

(d) Risk management.

(e) Notification to stakeholders and emergency services.

6.8 Abnormal road vehicles – oversize, over-mass and hazardous goods

In accordance with the *Heavy Vehicle (Mass, Dimension and Loading) National Regulations*, before a class 1 heavy vehicle is driven along any route, its driver and operator shall be satisfied that the route has been assessed and that the vehicle can be driven along it without likely causing damage to a road (including a bridge), structure or level crossing.

Before a class 1 heavy vehicle that can cause damage to a level crossing can traverse the route, the operator of the vehicle shall receive the written authority of the relevant RIM. This requirement should be included in interface agreements between the RIM and road manager where class 1 vehicles can be reasonably expected.

Each RIM shall have a documented process in place to manage applications from 'oversize' and 'over-mass' vehicles that wish to traverse level crossings within their network. The process should not be overly onerous and should be efficient in application turn-around time such that heavy vehicle haulage operators have sufficient time to plan their journeys with full approval to do so.

7 Maintenance, renewal and upgrade

7.1 General maintenance requirements

Procedures shall be established and maintained by the RTO/RIM in accordance with the requirements of their accreditation for the rail portion of the level crossing. There shall be an interface agreement with the road manager to ensure that all facets of the monitoring and maintenance of level crossings is undertaken in accordance maintenance plans and procedures. These procedures shall include:

(a) inspection and testing;

(b) assessment of serviceability;

(c) carrying out of preventative or corrective action, including the use of appropriate maintenance practices and procedures, adjustment of equipment, and repair and replacement of faulty equipment;

(d) maintenance of road and pedestrian walkway surfaces;

(e) monitoring and maintaining the engineering equipment and systems used in maintenance, including:

i. adjustment of equipment;

ii. in-situ and operational testing of safety-related equipment and systems; and

iii. fault rectification.

(f) recording details of maintenance and repairs carried out;

(g) liaison with the relevant road manager that railway maintenance work is to be carried out at the level crossing;

(h) vegetation management.

Inspection and testing procedures for level crossings shall define the location, method, level of detail and frequency of inspection and testing.

Frequency of inspection and testing shall consider operational criteria, rate of deterioration, consequences of failure and frequency of occurrences.

Inspection and test records shall be established and maintained to provide evidence of the condition of all elements critical to level crossing safety and shall comply with the document and data control requirements in AS 4292.1

Corrective action shall be taken when the assessed safety condition of any elements of the level crossing:

(a) will cause the organisation's safety standards to be infringed;

(b) has reached prescribed intervention levels; or

(c) will cause the risk to exceed acceptable levels.

Procedures shall be in place to receive and assess feedback from level crossing users and take appropriate action on identified safety risks or operational enhancements.

7.2 Track and civil maintenance

The preventative maintenance program developed by the RIM should prioritize the maintenance of level crossing safety elements.

Removal of plant growth shall be required to ensure retention of sight distance.

The preventative maintenance of track and civil infrastructure at level crossings should be undertaken in accordance with AS 7639, AS 7640 and RIM maintenance programs.

7.3 Rail signalling maintenance

Active level crossing maintenance shall be carried out in accordance with individual RIM technical maintenance plan requirements.

Other inspections and investigations shall be carried out in accordance with safety management systems and other RIM processes and procedures.

7.4 Level crossing renewal

Where components of a level crossing are life expired or obsolete a RIM should renew those components. To enable timely renewals the RIM shall maintain a record of the life expectancy of level crossing components.

Level crossings should be assessed for renewal at least every 15 years.

Where it has been identified that part or all of a level crossing is to be renewed, all stakeholders shall engage to ensure that the project is adequately managed within the RIM's project management framework.

Where a component of a level crossing is replaced due to obsolescence the RIMs type approval processes shall be followed prior to installation of the new component.

7.5 Level crossing upgrade

Where it has been determined that an upgrade is needed (as per section 3.1.1) the level crossing should be upgraded in accordance with this Standard.

7.6 Decommissioning requirements

Where it has been identified that a level crossing is to be decommissioned or closed, all stakeholders shall engage to ensure that all requirements are identified and addressed so that the project can be adequately managed within the RIM's project management framework – including interaction with local communities where there could be an impact upon their established travel patterns.

7.7 Disposal of level crossing equipment

When level crossing equipment is removed from a level crossing the equipment shall be disposed of in accordance with OEM requirements, RIM policies and any relevant legislation.

A RIM should consider environmentally acceptable options when disposing of any redundant level crossing equipment.

8 Future technology

New technologies shall be developed in accordance with existing standards (where applicable) and design philosophies so that they fulfil the same functional requirements as existing systems and equipment for level crossings. Where there are no directly applicable standards to support new or novel technology, new standards shall be developed in parallel to support any type approval process so that upon deployment there is adequate documentation for RIMs and RTOs to appropriately manage the ongoing maintenance and repair of such systems and equipment.

Some examples of new and emerging systems include;

(a) wireless connected warning systems;

(b) intelligent transportation systems;

(c) obstruction detection;

(d) vehicles with high levels of automation.

Appendix A Hazard register

A.1 Hazard register requirements

Each RIM shall have their own hazard register that is managed in accordance with their own SMS. The following is list gives some examples of what should be considered in respect of level crossings but is not an exhaustive list.

At private level crossings, the RIM should consider the following.

(a) Issuing a detailed procedure to the property owner or occupier regarding safe operation for the level crossing.

(b) Contacting each property owner or occupier periodically to ascertain if the property ownership or occupancy has changed and if so, issuing a notice outlining the authority's requirements to the new property owner or occupier.

(c) Requiring property owners to make sure that when third party users, such as contractors, visitors or other parties, use the private level crossing, they shall use the safety procedures relating to that level crossing.

(d) Periodically contacting property owners to review their use of the safety procedures.

(e) Defining the responsibilities for the operation and maintenance of the private level crossing.

Special consideration should be given to the type of control to be provided at pedestrian crossings where:

(a) the pedestrian crossing provides the only access to a platform or platforms for which there are regularly scheduled rail services, particularly to those crossing two or more tracks;

(b) the pedestrian crossing is used by school children; or

(c) the pedestrian crossing is identified as high risk, e.g. has experienced a high number of accidents or near misses.

Where a physical barrier is required as an active control at a pedestrian level crossing, preference should be given to gates (desirably fitted with electromagnetic latches) over boom barriers on the premise that gates provide added safety.

Appendix B Operational timing of active traffic control devices

B.1 Calculation of level crossing warning time

The design of an active level crossing shall use a calculated warning time that evaluates the following timing factors at the particular level crossing.

(a) The minimum warning time between the commencement of the level or pedestrian level crossing activation and arrival at the level or pedestrian crossing of the fastest train shall be at least 20 seconds.

(b) For level crossings wider than 15 m an allowance of 1 second for every additional 3 m, or part thereof, of width shall be included.

(c) Additional time provided to accommodate:

i. equipment response time;

ii. boom barriers;

iii. four quadrant boom barriers;

iv. motion sensitive systems or constant warning time system;

v. high risk of short stacking and queuing on the level crossing;

vi. long road vehicles such as B-doubles or road trains;

vii. road traffic speed, including possible reduced speed due to vehicles negotiating nearby intersections.

(d) Buffer time can need to be provided to accommodate minor variations in train handling, track circuit variability and risk assessment requirements.

Pre-emption time may be provided for integration with road traffic devices, such as road traffic signals or active advance warning assemblies.

Where reasonably practicable, the design warning time should not exceed 50 seconds.

Level crossings with characteristics that introduce the risk of excessive, sub-minimum or volatile timing of operation shall be risk-assessed. Special controls may be used as controls to mitigate the identified risks.

Appendix C Sequence of operation of active traffic control devices

C.1 Level crossing warning lights

At an actively controlled level crossing with level crossing warning lights (without boom barriers), the following sequence of operation shall apply.

(a) If no train is approaching the level crossing, then the level crossing warning lights shall be extinguished, and the audible warning devices (where fitted)shall be silent.

(b) If a train is approaching the level crossing then the level crossing warning lightsshall commence and continue to flash alternately, and the audible warning devices (where fitted) shall commence and continue to sound.

(c) After a predetermined period, the front of the approaching train will reach the level crossing.

(d) When the rear of the train passes clear of the level crossing then the level crossing warning lights shall become extinguished and the audible warning devices (where fitted) shall be silenced.

C.2 Level crossing warning lights, boom barriers and audible warning device

At an actively controlled level crossing with level crossing warning lights and boom barriers, the following sequence of operation shall apply.

(a) If no train is approaching the level crossing, then the level crossing warning lights shall be extinguished, the boom barriers shall be in the vertical position and the audible warning devices shall be silent.

(b) If a train is detected to be approaching the level crossing, then the level crossing warning lights shall commence and continue to flash alternately, and the audible warning devices shall commence and continue to sound. Where pedestrian devices are installed, the illuminated pedestrian sign commence and continue to flash the ‘red person’.

(c) After a minimum of 6 seconds after the level crossing warning lights activate the boom barriers shall start to lower and, where installed, the pedestrian swing gates shall commence to close.

(d) Where installed the pedestrian illuminated sign shall display a steady ‘red person’ 15 seconds after activating;

(e) Within 13 seconds of starting to lower the boom barriers shall reach the horizontal position and where installed the pedestrian swing gates or lifting barriers shall be closed / reach the horizontal position. The boom barriers and/or pedestrian gates shall be in the horizontal or closed position a minimum of 5 seconds prior to the train arrival.

(f) From this stage onwards, the audible warning devices not associated with pedestrian warning may be muted and/or some of the audible warning devices may be silenced.

(g) At this stage the front of the approaching train will reach the level crossing.

(h) When the rear of the train passes clear of the level crossing, both the boom barriers shall commence to rise, and all audible warning devices shall be silenced and where installed the pedestrian swing gates or lifting barriers will begin to open / rise.

(i) Within 10 seconds of deactivation of the level and/or pedestrian crossing both boom barriers shall reach the vertical position, and the level crossing warning lights shall become extinguished. Where installed the pedestrian swing gates and lifting barrier shall become open / raised and the illuminated pedestrian sign shall be extinguished.

At an actively controlled level crossing consisting of two or more tracks equipped with level crossing warning lights and boom barriers (and where fitted pedestrian swing gates), if a second train is approaching the level crossing within a predetermined period of the first train clearing the level crossing, the boom barriers and pedestrian swing gates shall be held in the horizontal or closed position, the level crossing warning lights shall continue to flash alternately and the illuminated pedestrian signs (where fitted) continue to display a steady 'red person' and the audible warning devices shall continue to operate in the same mode until the second train has cleared through the level crossing. Where fitted, the illuminated another train coming sign shall be illuminated. Guidance for calculation of the minimum crossing opening time is provided in AS 7711.

C.3 Active advance warning assemblies (AAWA) – RX11

Active advance warning assemblies may be provided in advance of a level crossing to supplement level crossing warning lights. These provide a visual advance warning to road users of a requirement to stop at an active level crossing. The design of the operation and requirements for AAWAs is detailed in AS 1742.7. The AAWA's begin flashing a predetermined time interval before the active level crossing equipment is activated.

C.4 Pedestrian only with lights and audible warning device

At an actively controlled pedestrian crossing the following sequence of operation shall apply.

(a) If no train is approaching the level crossing, then the illuminated pedestrian signs shall be extinguished, and the audible warning devices shall be silent.

(b) If a train is detected to be approaching the level crossing, then the illuminated pedestrian sign commence and continue to flash the 'red person'. After 15 seconds the pedestrian sign displays a steady 'red person'. The audible warning devices shall commence and continue to sound.

(c) After a predetermined period, the front of the approaching train will reach the level crossing.

(d) When the rear of the train passes clear of the level crossing, the illuminated pedestrian sign shall become extinguished and all audible warning devices shall be silenced.

At an actively controlled pedestrian level crossing consisting of two or more tracks equipped with illuminated pedestrian signs only, if a second train is approaching the pedestrian level crossing within a predetermined period of the first train clearing the level crossing, the illuminated pedestrian sign shall continue to display a steady 'red person' and the audible warning devices shall continue to operate in the same mode until the second train has cleared

through the level crossing. Where fitted, the illuminated another train coming sign shall be illuminated. AS 7711 describes this as the minimum opening time for a level crossing on a multi-track level crossing.

C.5 Pedestrian only lights, barriers and audible warning device

At an actively controlled level crossing with active pedestrian facilities only, the following sequence of operation shall apply.

(a) If no train is approaching the level crossing, then the illuminated pedestrian signs shall be extinguished, the barriers shall be open and the audible warning devices shall be silent.

(b) If a train is detected to be approaching the level crossing, then the illuminated pedestrian sign commence and continue to flash the ‘red person’ and the audible warning devices shall commence and continue to sound.

(c) After a predetermined period, the barriers shall commence to close and 15 seconds after the ‘red person’ commenced to flash the illuminated pedestrian sign will display a steady ‘red person’.

(d) After a predetermined period, the barriers shall reach the closed position.

(e) From this stage onwards, the audible warning devices shall continue to be sounded.

(f) After a predetermined period, the front of the approaching train will reach the level crossing.

(g) When the rear of the train passes clear of the level crossing, the barriers shall commence to open or rise and all audible warning devices shall be silenced.

(h) After a predetermined period, the barriers shall reach the open or vertical position, and the illuminated pedestrian sign shall become extinguished.

(i) Where green person lights are installed, these lights may be illuminated once the barriers and / or booms have commenced opening or rising and the red person lights have been extinguished.

At an actively controlled pedestrian level crossing consisting of two or more tracks equipped with illuminated pedestrian signs and barriers, if a second train is approaching the pedestrian level crossing within a predetermined period of the first train clearing the level crossing:

(a) the barriers shall be held in the closed or horizontal position;

(b) the illuminated pedestrian sign shall continue to display a steady ‘red person’; and

(c) the audible warning devices shall continue to operate in the same mode until the second train has cleared through the level crossing.

Where fitted the illuminated another train coming sign shall be illuminated.

AS 7711 describes this as the ‘minimum opening time’ for a level crossing on a multi-track level crossing.

Appendix D Horizontal and vertical viewing distances

Degree off Axis (Horizontal)	35	30	25	20	15	10	5	0	5	10	15	20	25	30	35
LED	10	10	10	15	40	160	400	500	400	160	40	15	10	10	10

D1: Minimum horizontal alignment sighting distances (metres)[4]

Degree off Axis (Downward)	0	5	10	15	20	30
LED	500	315	155	65		

D1: Minimum downward alignment sighting distances (metres)[5]

[4] Sourced from AREMA Standards 2005, amended to metric
[5] Sourced from AREMA Standards 2005, amended to metric

Appendix E LED level crossing warning lights alignment

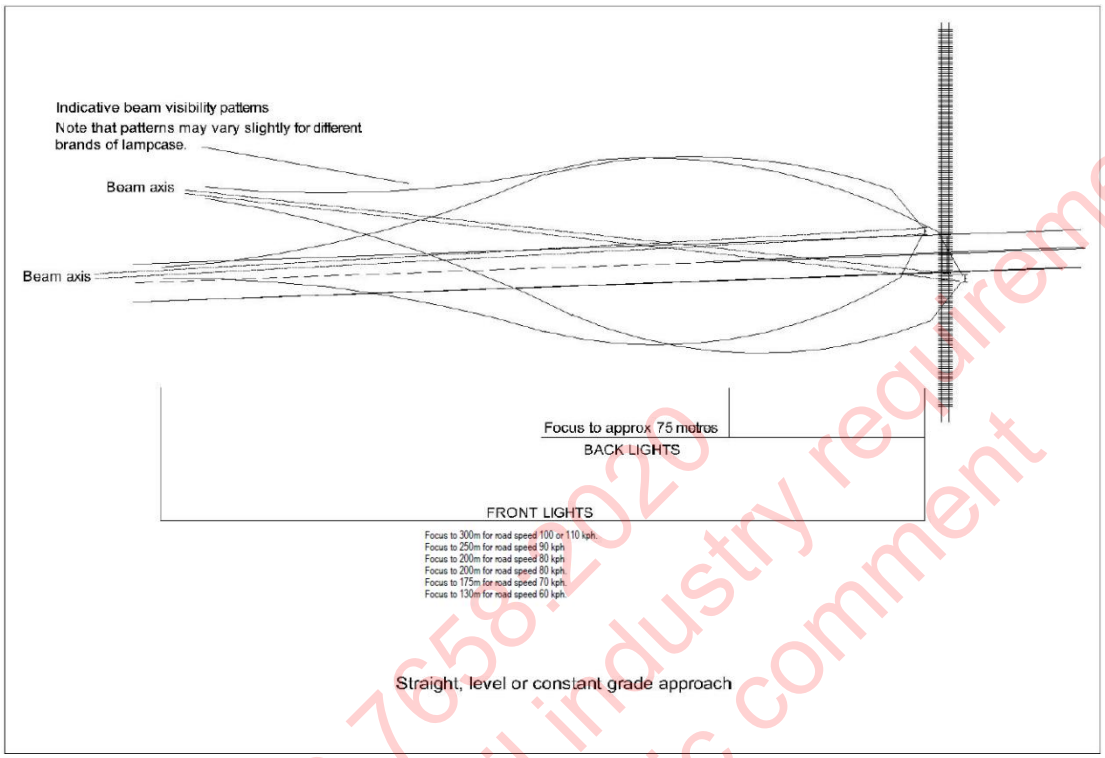

Figure E:1 - Level crossing warning lights alignment - straight, level or constant grade approach

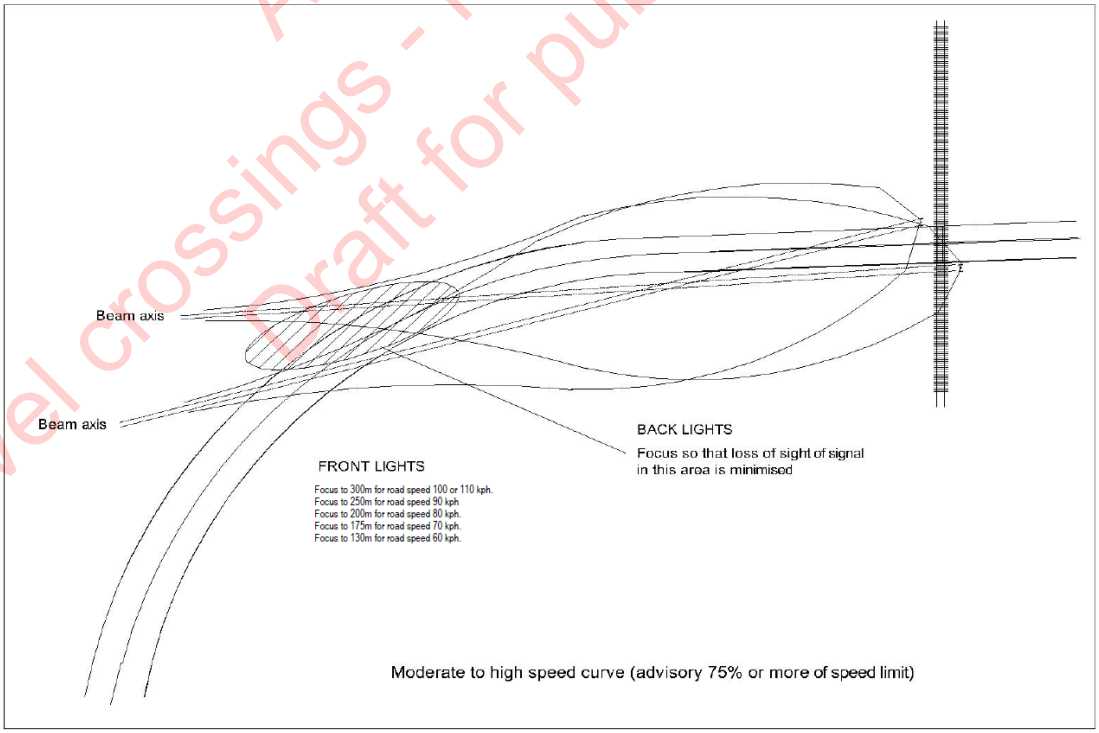

Figure E:2 - Level crossing warning lights focusing - moderate to high speed curve (advisory 75% of speed limit or greater)

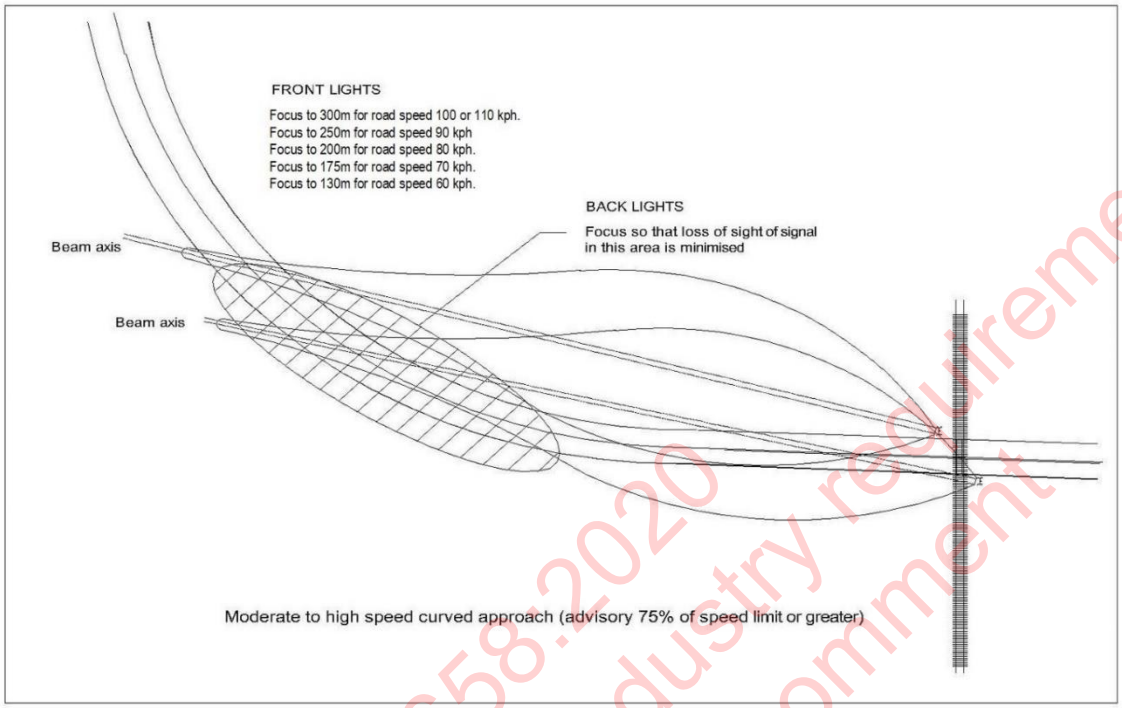

Figure E:3 - Level crossing warning lights- moderate to high speed curved approach (advisory 75% of speed limit or greater)

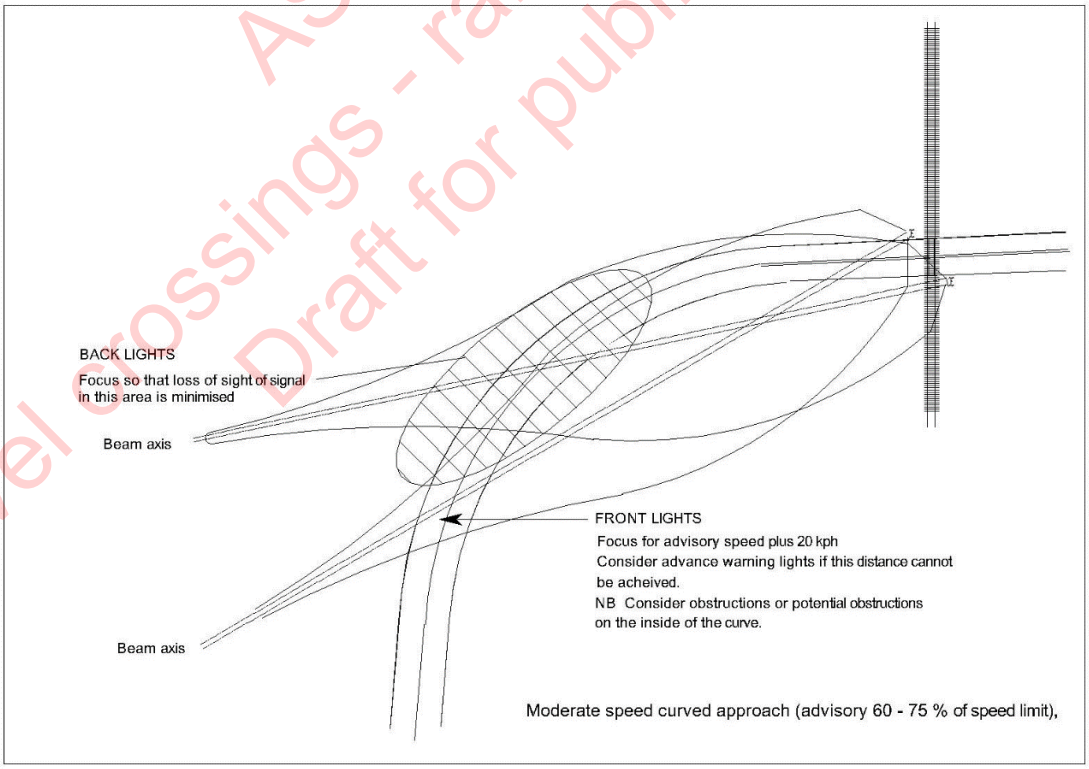

Figure E:4 - Level crossing warning lights focusing - moderate speed curved approach (advisory60 - 75% of speed limit)

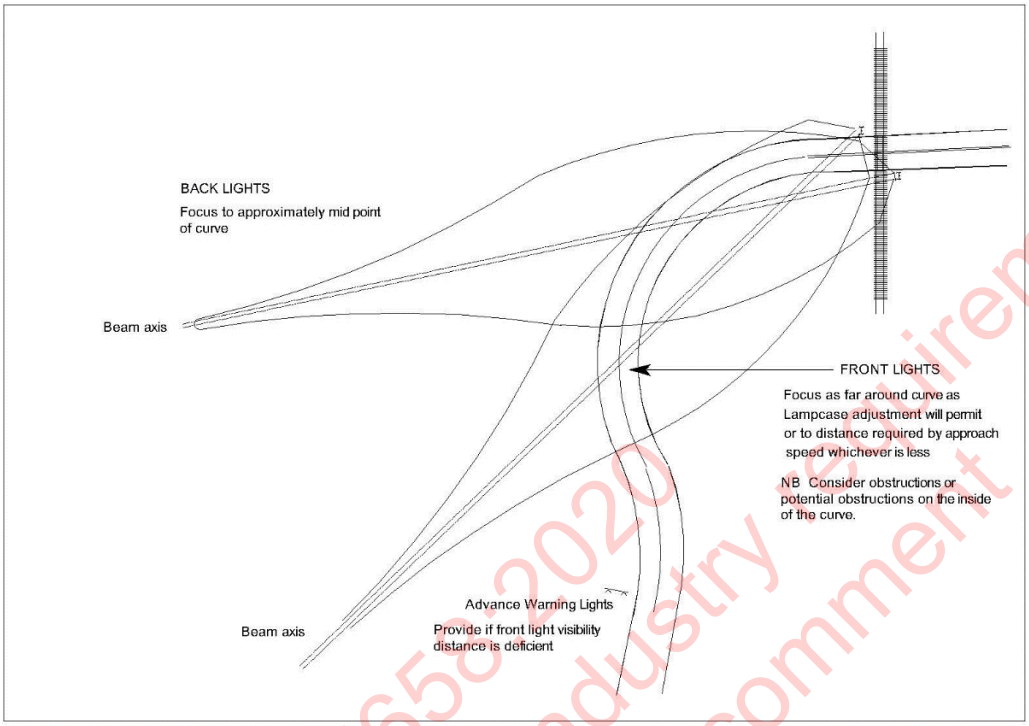

Figure E:5 - Level crossing warning lights focusing example

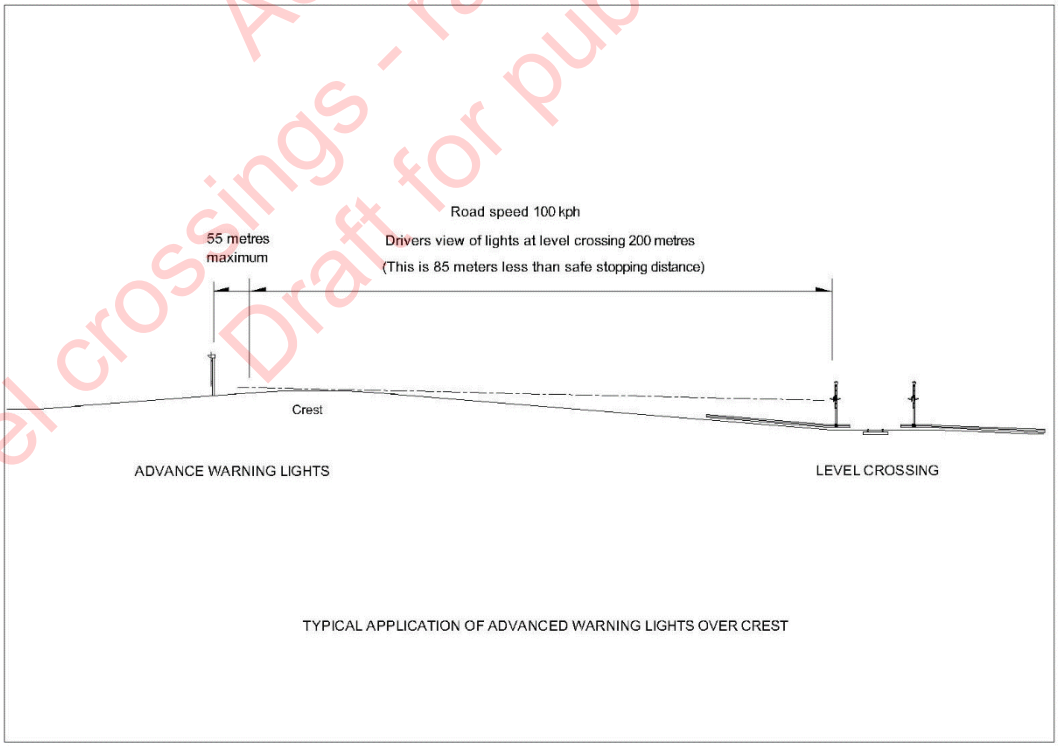

Figure E:6 - Advance warning light application over crest example

Appendix F Bibliography

The following referenced documents are used by this Standard for information only.

- AS 1743 Road signs – specifications.
- AS 4292.4 Railway safety management Part 4: Signalling and telecommunications systems and equipment.
- AS 15288 Systems engineering - system life cycle processes.
- AS 7705 Level crossing monitoring systems
- AS 7718 Signal design process management.
- Austroads Guide to road design - Part 3: Geometric design.
- Austroads Guide to road design - Part 4: Intersections and crossings – general.
- ALCAM in detail
- AREMA Communications and Signals Manual, Volume 1, Section 3 - Highway-Rail Grade Crossing Warning System

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