Design & Construction Guidelines - Active Level Crossing Warning Systems

W103-600-011

Revision Number 3.00

	Date	Name	Title	Signature
Owner	30/08/2019	Kevin Bulger	Principal Engineer Signalling	
Reviewer	30/08/2019	Jed Sung	Project Lead Signals & Systems	
Approver	30/08/2019	Michael Bourke	Head of Engineering	

Document History

Rev	Date	Amended by	Details of Amendment
1.00	05/01/2005	Signal Manager Projects & Standards	Document was W103-600-001, also revised for changes to predictors, boom operation and general update
1.01	28/04/2005	Level Crossing Project Manager	Issued for Level Crossing Renewal Tender
2.00	12/07/2005	Signal Manager Projects & Standards	Revised for AREMA 2005 and Predictor setting changes
2.01	17/04/2009	Signal Manager Projects & Standards	Review and update of content and format.
2.02	01/05/2014	Signal Manager Projects & Standards	Automatic Drivers Proceed Indicator's, predictor positive start settings and axle counters added
3.00	30/08/2019	Principal Engineer Signalling	Document status changed from Code of Practice to Guideline, reformatted to latest Arc template and general content review and update

Table of Contents

1 Purpose

1.1 Policy

All designs for active level crossing warning systems on Arc infrastructure shall use the functional requirements and design guidance set out in these guidelines. This applies to all Arc personnel, consultants, contractors and external parties, to ensure that minimum safety and functional requirements are met or exceeded.

Any proposed departure from the functional requirements or design and construction guidance set out in these guidelines shall be authorised by the Principal Engineer Signalling.

1.2 Objective

The objective of these guidelines is to provide general functional requirements and guidance for the design of active level crossing warning systems on Arc infrastructure. These guidelines are to be followed by all parties engaged in carrying out design, testing and commissioning of active level crossing systems.

2 Scope

2.1 Application

These guidelines apply to the design of all new or renewed active level crossing warning systems, and also for retrospective alterations to existing level crossing systems where specified by Arc Infrastructure .

This code of practice covers the following types of level crossings:

a) Road crossings with flashing light signals, and;

b) Road crossings with flashing light signals, boom barriers and audible signals, and;

c) Pedestrian crossings with pedestrian signals and audible signals, and;

d) Pedestrian crossings with pedestrian signals, audible signals and automatic gates.

Active level crossing warning systems may be activated either automatically or manually, or by a combination of both.

Cases where the proposed design of an active level crossing warning system falls outside the guidelines set out in this document should be referred to the Principal Engineer Signalling.

3 References

Document Ref	Document Title
W110-600-001	Procedure for Signalling Design
W110-600-008	Procedure for Signal System Testing and Commissioning
W110-600-060	Procedure for Resetting and Restoration of Axle Counters
W190-600-001	Design & Construction Guidelines - Processor Based Interlockings
AS 1742.7:2016	Manual of Uniform Traffic Control Devices, Part 7: Railway Crossings
AS 1743:2018	Road Signs – Specification
AS 2144:2014	Traffic Signal Lanterns
AS 7658:2012	Railway Infrastructure: Railway Level Crossing
Document 9000/01:2017	Main Roads Western Australia: Railway Crossing Control in Western Australia – Policy and Guidelines

4 Definitions

Where used in this document and all other referenced Arc Infrastructure procedures, principles and codes of practice the terms or acronyms listed here have the following specific meaning.

Term or Acronym	Definition
Active Control *(AS1742.7:2016 Section 1.5.1)*	Control of the movement of vehicular or pedestrian traffic across a railway crossing by devices such as flashing signals, gates or barriers, or a combination of these, where the device is activated prior to and during the passage of a train through the crossing.
Active Advance Warning Assembly (RX-11) *(AS1742.7:2016 Section 2.3.7)*	An active device incorporating alternately flashing yellow lights together with the static message “PREPARE TO STOP”, which provide a visual warning to motorists that the flashing light signals at a railway crossing ahead are flashing or about to commence flashing.
Advance Flashing Warning Signals	The flashing yellow light units that form part of an Active Advance Warning Assembly.
Audible Signals	Audible signals are devices designed to audibly warn approaching road users, primarily pedestrians, of the approach of a train.
Boom Barrier Assembly *(AS1742.7:2016 Section 2.3.8)*	An active device that, where provided, automatically lowers across the roadway at a pre-determined time after the flashing lights signals have activated, then raises following the passage of a train. General arrangements are shown in figure 2.3 of AS1742.7:2016.
Clearance Point	The Clearance Point is the distance beyond which a road vehicle or pedestrian passing over a crossing is considered to be safely clear of rail traffic. It is taken to be the point where the edge of either the departing carriageway or centre line, dependent on the crossing angle, is 2 metres from the outside edge of the nearest rail measured at right angles to the rail.

Term or Acronym	Definition
Clearance Distance	The clearance distance is the longest distance, measured parallel to the centre line of the road (or edge of a pathway), between the governing warning device and the clearance point at the far side of the crossing, for each possible entry and exit point.
Control Devices	Any sign, audible or visual signal, maze, locking gate, boom barrier or other device used for the purpose of regulating, warning or guiding motorists, pedestrians, cyclists or wheelchair users at a level crossing.
Drivers Proceed Indicator	A railway indicator that displays a yellow aspect when an active level crossing has been activated for a set time, and red at all other times.
Flashing Signal Assembly (RX-5) *(AS1742.7:2016 Section 2.3.1)*	The complete assembly of red flashing light signals and associated warning signs. Also referred to as Flashing Light Signals.
Level Crossing *(Railway Crossing – AS1742.7:2016 Section 1.5.8)*	Any crossing of a railway at grade, providing for vehicular traffic and/or other road users, including pedestrians. Also known as a railroad crossing, railway crossing or grade crossing.
Level Crossing Sign	A level crossing sign is a warning device provided to advise road users of the existence of a level crossing.
Main Roads Western Australia (MRWA)	The agency of the Western Australian state government responsible for the management of public roads in Western Australia.
Minimum Road Open Time	Minimum road open time is the minimum normally permitted time from when the crossing warning sequence clears for the passage of a previous train to the time the crossing warning sequence commences for the next train. The clearance of the crossing warning sequence is from the time the controls clear and does not include the time required for booms to rise or pedestrian gates to open. The commencement of the crossing warning sequence includes any additional pre-emption time for advance flashing warning signals or road traffic signal interfaces.
Motion Detector	A motion detector is a device used to detect approaching trains whenever the trains are moving. It would typically be used in areas where shunting may take place on the approach to a level crossing.
Passive Control *(AS1742.7:2016 Section 1.5.5)*	Control of the movement of vehicular or pedestrian traffic across a railway crossing by signs and devices, none of which are activated during the approach or passage of a train, and which rely on the road user including pedestrians detecting the approach or presence of a train by direct observation.
Pedestrian	Where used in this document the term pedestrian means any combination of pedestrians, cyclists and wheelchair users.
Pedestrian Crossing	A level crossing provided for the exclusive use of pedestrians.

Term or Acronym	Definition
Pedestrian Signal Assembly (RX-12) *(AS1742.7-2016 Section 6.5.3)*	An active device incorporating a red symbolic standing figure signal to indicate to pedestrians that a train is coming. The figure initially flashes then becomes steady after 15 seconds. The assembly may also incorporate a white or yellow flashing "ANOTHER TRAIN COMING" signal used to indicate the presence of a 2nd train, where there are multiple tracks.
Predictor or Level Crossing Predictor	A predictor is a device used for train detection that calculates the speed of the train's approach to a level crossing so that a constant warning time can be provided, irrespective of the train's speed. Also known as a Grade Crossing Predictor.
Road Crossing	A level crossing provided for vehicular traffic, at which pedestrian facilities may also be provided.
Road Traffic Signal Interface	The interconnection between a railway level crossing system and a road traffic signal system, which is used to interrupt the normal cycle of the road traffic signals when a railway crossing warning sequence is activated.
Visibility Distance	The distance at which operating flashing light signals are clearly visible to an approaching motorist. Approach visibility requirements are stipulated in MRWA's Policy and Guidelines for Railway Crossing Protection in Western Australia.
Warning Distance	The distance at which active level crossing equipment is designed to detect a train's presence in order to provide the required Minimum Warning Time.
Warning Time	The time from when the level crossing warning sequence starts, inclusive of any pre-emption time for advance flashing warning signals or road traffic signal interfaces, to when the front of a train reaches the crossing.

5 General Requirements

5.1 Statutory Requirements

Actively controlled level crossings shall be designed and constructed to be in accordance with AS1742.7:2016 section 4.3 – active control treatments and AS 7658: 2012 – Railway Infrastructure - Railway Level Crossings.

5.1.1 Crossings on Public Roads

Selection of the level of railway crossing protection or warrant on public roads, including pedestrian facilities, shall be in accordance with MRWA's Policy and Guidelines for Railway Crossing Protection in Western Australia and is the responsibility of Main Roads Western Australia.

5.1.2 Crossings Other Than on Public Roads

Selection of the level of railway crossing protection for crossings other than public roads is the responsibility of Arc Infrastructure. While it shall generally be in accordance with MRWA's Policy and Guidelines for Railway Crossing Protection in Western Australia, Arc Infrastructure may determine that special factors such as limited visibility distance or high train speeds dictate a requirement for a higher level of protection.

5.1.3 Pedestrian Crossings

The level of protection provided at pedestrian crossings shall be set by the local authority, Main Roads Western Australia or Arc Infrastructure depending on the location and application of the crossing.

The design of pedestrian crossings shall be in accordance with AS 1742.7:2016, and pedestrian light units shall meet the requirements of AS 2144.

5.2 Specific Requirements

5.2.1 Levels of Protection

The following minimum levels of protection apply:

a) RX-5 flashing light signals shall be provided at all actively protected road crossings, and;

b) Pedestrian signals shall be provided at all actively protected pedestrian level crossings, except where an adequate visual warning is given by the flashing light signals of an adjacent road crossing, and;

c) Boom barriers shall be provided at all actively protected road crossings with 2 or more tracks, unless the signalling or operational arrangements preclude a second train activating the crossing for a defined time after a first train has activated and cleared the warning, and;

d) Audible signals shall be provided at all actively protected road and pedestrian crossings, except at flashlight crossings with no pedestrian pathway.

5.2.2 Local Conditions

Local conditions at individual level crossings will determine the need to:

a) Provide additional RX-5 flashing light signals above the requirements as set out in AS1742.7:2016, typically in order to meet the visibility criteria where multiple approaches, sharp curves, side roads or other visual impediments exist, and;

b) Provide additional pedestrian signals and/or audible signals at road crossings to cater for pedestrians and ensure adequate visual and/or audible coverage, and;

c) Mute audible signals, typically in order to reduce the impact of noise at night in residential areas. Note that muting is not permitted at pedestrian crossings, and;

d) Provide RX-11 advance flashing warning signals to supplement the level of protection at a level crossing provided by flashing light signals and/or boom barriers, typically where the road speed is high and road trains operate, and;

e) Provide boom barriers where not required by the level of rail traffic or signalling arrangements, typically because of the level of road traffic, and;

f) Increase the time between the commencement of flashing light signal operation and boom barriers lowering at boom barrier crossings, typically where road trains are regularly required to start from rest on entry to the crossing, and;

g) Increase the warning time, typically where long road trains operate at lower speeds and take a longer time to clear the crossing, and;

h) Integrate the level crossing controls with other systems, typically those controlling highway traffic signals, and;

i) Interlock the level crossing controls with railway signalling equipment controlling the passage of trains through the track including the level crossing, and;

j) Increase the warning time to allow for equipment operation times, typically where predictors are used, and;

k) Provide any fencing, barriers, platforms, handrails or other protective measures, and;

l) Provide mid-crossing safety refuges or safe egress routes between pedestrian gates and the track, and;

m) Provide illumination of the crossing and/or surrounding area at night, and;

n) Provide any special treatments for disabled access.

5.3 General Design Concept and Warning System Operation

The general concept of operation of automatically operated level crossings is that an approaching train will automatically activate the level crossing warning sequence when reaching a pre-determined warning distance. There shall be a specific warning distance designed for each possible approach to the crossing. Alternatively, predictor controlled warning systems can be used to provide a fixed warning time for level crossings such that the warning distance varies with the speed of an approaching train. The crossing warning distances shall be designed to provide a guaranteed minimum warning time for road or pedestrian traffic, when trains are travelling at either the maximum permissible track speed, signed permanent speed restriction or signed level crossing speed restriction. The warning distances shall incorporate overspeed and speedometer error allowances as set out in clause 5.4.3.

In cases where provision of an automatic warning is not practical a crossing may be activated manually. Manual activation may apply to all of a crossing's approaches or to specific approaches only. Manual activation may be initiated by the operation of a pushbutton at the crossing or, where Drivers Proceed Indicators are provided, by a pushbutton at an indicator or by UHF radio code. Note that pushbuttons provided for manual activation are in addition to the manual switch provided for the purposes of manual operation, which are provided at all active level crossings (see section 7.2 - Manual Operation).

The provision of crossings with automatic clearing of Drivers Proceed Indicators by an approaching train for some approaches is also permitted in some cases, particularly where a double line boom barrier crossing is required within a station in train order territory. This type of crossing helps to overcome the technical challenge of catering for all possible train movements in the absence of conventional signals, reduces cost and complexity by eliminating the need for

discrete outer warning approach track circuits, and allows through movements to occur without the need for trains to stop and operate the Drivers Proceed Indicators.

A further special type of crossing sequence, known as “Z track” operation, may be provided. Z track crossings allow a crossing warning to be cancelled by a train coming to a stand on the designated Z track, provided that it has not proceeded on to the next track circuit. The crossing warning will be activated again if the train proceeds onto the next track circuit.

The general sequence of operation for each type of actively protected crossing is as set out in the following sections. Note that where a pedestrian crossing is co-located with a road crossing there shall be a common warning system and hence the minimum warning times applicable to the road crossing shall also apply to the pedestrian crossing.

5.3.1 Flashlight Crossings

Flashlight level crossing layouts shall be designed and generally arranged in accordance with drawings W-CE-1054 and W-HE-886.

Duplicated audible signals shall be provided where there is a designated pedestrian crossing at the level crossing. The audible signals shall be mounted on the flashlight masts.

Detection of an approaching train at the warning distance shall automatically illuminate the flashing light signals and start any audible signals sounding. The warning signals shall continue as the train proceeds over the crossing.

Once the train clears the crossing the flashing signal lights shall extinguish and any audible signals shall stop sounding. The last pair of wheels should normally clear the edge of the road and any pedestrian crossing by a minimum of 10 metres and a maximum of 20 metres before the warning signals cease.

5.3.2 Flashlight and Boom Barrier Crossings

Flashlight and Boom Barrier level crossing layouts shall be designed and generally arranged in accordance with drawings W-CE-1053 and W-HE-622.

Boom barrier arms shall be equipped with 3 red lights, two equally spaced along the arm and one at the tip. Whenever the crossing warning is activated or one of the boom barrier arms is out of the vertical by greater than 5° the inner lights shall flash alternately and the tip light shall be illuminated continuously.

Audible signals shall be provided, one on each boom barrier mast. Where muting is provided this shall require the booms to be fully lowered. Muting is not permitted where there is a designated pedestrian crossing at the level crossing.

Detection of an approaching train at the warning distance shall automatically illuminate the flashing light signals and boom barrier arm lights and start the audible signals sounding. 8 seconds later the boom barriers shall start to descend, under power for the first 45°. For some crossings a longer delay may be provided to cater for special conditions such as the need to clear long and/or slow moving vehicles from the crossing. The total boom barrier descent time shall be between 10 and 12 seconds.

Once a boom barrier is detected within 10° of the horizontal the audible signal on that mast shall cease, except where there is a designated pedestrian crossing at the crossing for which it also provides the audible warning, in which case it shall remain sounding.

The boom barriers should be in the horizontal for a minimum of 5 seconds before the train arrives at the crossing.

Once the train clears the crossing both boom barriers shall be driven up, which should take between 8 and 10 seconds. The last pair of wheels should clear the edge of the

road including the road and any pedestrian crossing generally by a minimum of 10 metres and not more than 20m before the ascent commences.

When both boom barriers are detected within 5° of the vertical the flashing light signals and boom barrier arm lights shall extinguish.

5.3.3 Pedestrian Signals and Audible Signal Crossings

Detection of an approaching train at the warning distance shall automatically start the pedestrian signals flashing and audible signals sounding. After 15 seconds of flashing operation the pedestrian signals shall become steady.

Once the train clears the crossing the pedestrian signals shall extinguish and the audible signals shall stop sounding. The last pair of wheels should normally clear the edge of the pedestrian crossing by a minimum of 10 metres and a maximum of 20 metres before the warning signals cease.

An additional flashing “ANOTHER TRAIN COMING” signal shall be provided wherever a 2nd train can approach a crossing during the passage of a 1st, usually where there are multiple tracks. The signal shall illuminate when the presence of a 2nd train is detected and shall extinguish only when the main warning signals cease.

5.3.4 Pedestrian Signals, Automatic Gates and Audible Signal Crossings

Pedestrian crossings with automatic gates shall be fitted with emergency exits from the railway to the pedestrian maze that are only available when the automatic gates are closed. The emergency exit shall be opened by depressing a lever-type handle that is only accessible from the railway side of the maze. When the emergency gate is opened and released, it shall close and lock automatically.

Detection of an approaching train at the designed warning distance shall automatically start the pedestrian signals flashing and audible signals sounding. 6 seconds later the gates shall start to close. For some crossings a longer delay may be provided to allow for wide carriageways etc. The gate closing time shall be between 7 seconds and 9 seconds. Once the gates are both detected as being closed the pedestrian signals shall become steady.

Once the train clears the crossing the gates shall be driven open, which should take between 8 and 10 seconds. The last pair of wheels should normally clear the edge of the pedestrian crossing by a minimum of 10 metres and a maximum of 20 metres before the warning signals cease.

When all the gates are detected in the fully open position pedestrian signals shall extinguish and the audible signals shall stop sounding.

“ANOTHER TRAIN COMING” signals shall not be provided on crossings with automatic gates.

5.3.5 Manually Activated Crossings without Drivers Proceed Indicators

Train Movements over the crossing on all approaches with manual operation shall be protected by a notice board requiring that drivers stop then ensure that the crossing warning is operating before proceeding over it.

Operation of a “Start” pushbutton shall activate the crossing warning sequence, which shall be as set out in sections 5.3.1 to 5.3.4 above. Clearance of the crossing warning shall occur automatically with the passage of a train, also following the same sequence as the preceding sections.

Additionally the crossing warning may be cancelled by operation of a “Stop” pushbutton, provided that a train has not already been detected as having passed the

protecting notice board. Once a “Stop” pushbutton has been operated there shall be a delay of 30 seconds before the crossing warning is cancelled.

The manual operation pushbuttons shall be mounted in a lockable weatherproof housing located such that there is good visibility of the crossing and its rail and road approaches. The housing shall be locked with a Traffic Standard lock or padlock.

5.3.6 Manually Activated Crossings with Drivers Proceed Indicators

Train Movements over the crossing on all approaches with manual operation shall be protected by a Drivers Proceed Indicator, which may display either a red or a yellow aspect. “Start” and “Stop” pushbuttons shall be provided at each indicator. Optionally a UHF radio DTMF data code may be used to activate the crossing warning, in addition to the pushbuttons. Short track circuits shall be provided on the approach to each indicator where radio codes are used, and activation of the crossing by radio code shall only be effective when an approach track circuit is occupied, to ensure that a train is present before the crossing warning can be activated. The radio code applicable to each indicator shall be displayed on a radio call sign mounted under the indicator.

Drivers may only proceed over the crossing when the indicators are displaying yellow. Note that Drivers Proceed Indicators only provide an indication that the crossing warning is operating and do not provide a movement authority, and hence all the indicators applicable to a crossing can clear to yellow at the same time.

Operation of a “Start” pushbutton or the correct UHF radio DTMF data code for a crossing with an approach track circuit occupied shall activate the crossing warning sequence, which shall be as set out in sections 5.3.1 to 5.3.4 above. Once the crossing warning has been proved to be operational for the required approach warning time (AWT) the indicators shall change from red to yellow aspects.

Once the front of a train has been detected as having passed an indicator the indicators shall revert to red. Clearance of the crossing warning shall occur automatically with the passage of a train, also following the same sequence as the preceding sections.

Additionally the crossing warning may be cancelled by operation of a “Stop” pushbutton, provided that a train has not already been detected to have passed an indicator. Once a “Stop” pushbutton has been operated the indicators shall revert to red. There shall then be a delay of nominally 30 seconds before the crossing warning is cancelled.

5.3.7 Automatically Activated Crossing with Drivers Proceed Indicators

Train movements over designated approaches of an otherwise manually operated crossing may be designed to automatically operate the crossing and clear the Drivers Proceed Indicators without the need for UHF radio DTMF data code or pushbutton operation. Detection of an approaching train will activate the crossing warning and the crossing operating will allow the Drivers Proceed Indicator in the applicable direction to clear without any time delay. UHF Radio and pushbutton operation shall also be provided to cater for stopping and shunting operations.

Automatic operation shall only occur if both approaches on the applicable line are clear. If the approaches are occupied, or there is a track circuit failure, the train will be required to stop at the indicator and use radio or pushbutton operation to operate the crossing warning.

Automatic operation shall only clear the indicator on the line and direction to which the occupied approach applies, to preclude a short warning time on another line.

If there is a shorter alternative approach to an automatically operated indicator a train could reach the crossing before the required AWT. To prevent this one of the following shall apply: -

a) A lower level crossing speed restriction shall be applied to the shorter approach to ensure that the required AWT is provided, or;

b) A means shall be provided to inhibit automatic operation for trains on the shorter approach.

If an approach occurs immediately following the controls clearing after a previous activation a delay in the crossing warning re-activation shall be imposed to ensure that the Minimum Road Open Time is provided (refer to section 5.5 for requirements). In this event clearance of the applicable Drivers Proceed Indicator is also delayed until the crossing re-activates.

To ensure that trains are able to stop at a Drivers Proceed Indicator in the event of encountering it at red the speed on the approach shall be limited to suit sighting conditions, generally to not more than 50km/h, and the speed set so that the train would be able to stop at the indicator from the sighting point in the event of it remaining at red. In general the combination of approach warning distance and speed set shall provide for an additional 10 seconds of warning time; this allows drivers adequate time to comprehend and act upon the Drivers Proceed Indicator aspect, and additional time for the crossing to clear to compensate for the lower MROT provided at this type of crossing.

In the event of the stop pushbutton being used following the automatic clearance of a Drivers Proceed Indicator a 60 second cancellation timer shall be provided to prevent the cancellation of the crossing warning until a train has safely come to a stand at the indicator.

The specific arrangements for all crossings for which automatically operated Drivers Proceed Indicators are proposed must be agreed with the Principal Engineer Signalling.

5.3.8 Z Track Operation

Z tracks are provided within the normal approach warning distance of a level crossing in unsignalled areas to cater for cases where a train is likely to come to a stand for some time at a nearby station or stopping place. The limits of a Z track circuit shall be defined by two yellow notice boards with the text “Z track” in black letters as shown on drawing W-HE-977.

The Z track is a short track circuit, typically about 25 to 50 metres in length, which may form part of longer track circuit on which trains are permitted to stand. There must also be at least one other track circuit between these track circuits and the level crossing, which must remain clear for Z track operation to be effective, the boundary between the two being denoted as the inner warning point.

When a train on the approach to the crossing has been detected as occupying the Z track for a set period, typically 60 seconds, the level crossing warning will clear. The level crossing warning sequence shall be re-activated when the train starts towards the crossing from the Z track and passes the inner warning point.

Local operating instructions are required to set out any requirements for train crew when starting from rest from the Z track towards a crossing, typically requiring rail traffic to proceed at a restricted speed until it can be established that the warning devices are operating and any road traffic has come to a stand at the crossing.

5.4 Approach Warning Times and Distances

All automatically operated level crossings require the crossing warning to be activated for a set minimum time on all possible approaches to the crossing. The warning will normally be activated when a train reaches a set point on the approach to the crossing, the position of which is dependent on the applicable line speed, permanent speed restriction or a specific crossing speed restriction. Consequently trains travelling at lower than the permissible speed will provide a warning time longer than the minimum.

On some crossings a constant warning time may be provided by the use of a level crossing predictor rather than a fixed warning point.

5.4.1 Minimum Warning Time (MWT) Requirements

For all new and renewed actively protected level crossings the minimum warning time (MWT) for road and pedestrian crossings shall be not less than:

a) 25 seconds for road crossings and combined road/pedestrian crossings, or;

b) 21 seconds for pedestrian crossings.

The times above incorporate an allowance of up to 1 second for equipment operation. This may need to be increased for some types of detection systems, which is covered by the following section.

5.4.2 Approach Warning Time (AWT) Requirements

The approach warning time (AWT) for any crossing is the MWT plus allowances for specific site conditions and equipment operation considerations. The following table shall be used to calculate the AWT.

Minimum Warning Time *(MWT)*	The absolute minimum warning time for users of the type of crossing under consideration.
Pre-Emption Time *(PT)*	Allowance for interfacing with road traffic signals or advance flashing warning signals, which need to be activated before the standard crossing warning sequence commences. Refer to sections 7.4 - Advance Flashing Warning Signals and 7.5 - Interfacing with Road Traffic Signals for details.
Clearance Time *(CT)*	An additional time period of one second for every 3 metres, or part thereof, for the clearance distance minus 15 metres. For pedestrian crossings an additional time period of 1.25 seconds for every 1 metre shall be allowed (based on a walking speed of 0.8m/sec), for the clearance distance minus 10 metres.
Adjustment Time *(AT)*	Adjustments may be made to provide for: a) Equipment response time, typically to allow for relay and track circuit operating times where these may be longer than the 1 second already allowed in the MWT. b) Motion sensing or predictor systems. Specifically 4 seconds shall be added to the minimum warning time for the equipment response time of level crossing predictors, unless otherwise specified by the manufacturer. c) For Automatically Activated Crossings with Drivers Proceed Indicators, an additional time of 10 seconds shall be added for approaches with automatic clearing.
Buffer Time *(BT)*	An additional allowance for the clearance of very long or slow vehicles, typically where road trains are permitted to operate and regularly start from a stationary position or turn onto the crossing from adjacent side roads.

The PT, CT, AT and BT applicable to each crossing will be decided by a site assessment at the design stage and shall be detailed in the crossing records.

Once the allowances have been calculated the AWT for sites which require additional allowances can be calculated using the following formula:

Approach Warning Time (AWT) = MWT + PT + CT + AT + BT

5.4.3 Determination of Approach Warning Distance (AWD)

The Approach Warning Distance (AWD) is calculated as the distance travelled over the AWT by a train travelling at 3km/h above the maximum permissible line speed, plus an allowance of 6% to allow for speedometer error. The value of AWD for any crossing approach shall be calculated using the following formula, rounding up to the nearest integer:

AWD = AWT × (Maximum Permissible Speed in km/h + 3) × 1.06 × 1000/3600

A comprehensive table of distance values calculated using the above formula for a range of speeds and warning times is given in Appendix 1.

The actual AWD used may be increased in order to make use of existing insulated rail joint (IRJ) positions, provided that excessive warning times do not result. All such cases must be agreed with the Principal Engineer Signalling.

5.5 Road Open Times and Outer Warning Distances

Once a level crossing warning has cleared there needs to be a minimum time before the warning is re-activated by a second train in order that any waiting stationary road traffic has time to start moving, pass over and clear the crossing. For most crossings on single line areas there is no possibility of a second train arriving within the minimum time, but this can occur on double lines and near crossing loops or junctions on single lines.

In these cases outer warning controls are provided to prevent the minimum time being compromised by inhibiting the initial crossing warning from clearing until the second train passes over the crossing or is otherwise detected at a stand at an intervening signal.

5.5.1 Minimum Road Open Time (MROT) Requirements

For all new and renewed actively protected level crossings the minimum road open time (MROT) for road and pedestrian crossings shall be not less than:

a) 20 seconds – for flashlight, boom barrier crossings associated with automatically activated crossings with drivers proceed indicators, and pedestrian crossings without gates, or;

b) 30 seconds – for boom barriers and pedestrian crossings with gates.

Boom barrier and gated pedestrian crossings require the additional time because the barriers need to fully rise or the gates need to fully open before the visual/audible warnings cease. Boom barrier crossings associated with automatically activated crossings with drivers proceed indicators are excepted as part of an overall acceptance of a very low generic probability of a 2nd train arrival immediately following any 1st activation.

The times above incorporate an allowance of up to 1 second for equipment operation. This may need to be increased for some types of detection systems, which is covered by the following section.

5.5.2 Road Open Time (ROT) Requirements

The road open time (ROT) for any crossing is the MROT plus allowances for specific site conditions. The following table shall be used to calculate the ROT.

Minimum Road Open Time *(MROT)*	The absolute minimum road open time for users of the type of crossing under consideration.
Outer Adjustment Time *(OAT)*	Adjustments may be made to provide for: a) Equipment response time, typically to allow for relay and track circuit operating times where these may be longer than the 1 second already allowed in the MROT. b) Motion sensing or constant warning time systems. Specifically 4 seconds shall be added to the minimum warning time for the equipment response time of level crossing predictors, unless otherwise specified by the manufacturer. The outer adjustment time may be dependent on different equipment to the adjustment time for the normal warning and hence may be a different value.
Buffer Time *(BT)*	An additional allowance for the clearance of very long or slow vehicles, typically where road trains are permitted to operate and regularly start from a stationary position or turn onto the crossing from adjacent side roads. The buffer time is the same value as that used for the AWT calculation.

Once the allowances have been calculated the ROT for sites which require additional allowances can be calculated using the following formula:

$$\text{Road Open Time (ROT)} = \text{MROT} + \text{OAT} + \text{BT}$$

5.5.3 Determination of Outer Warning Distance (OWD)

The Road Open Distance (ROD) is calculated as the distance travelled over the ROT by a train travelling at 3km/h above line speed plus an allowance of 6% to allow for speedometer error. The value of ROD for any crossing outer approach shall be calculated using the following formula, rounding up to the nearest integer:

$$\text{ROD} = \text{ROT} \times (\text{Maximum Permissible Speed in km/h} + 3) \times 1.06 \times 1000/3600$$

A comprehensive table of distance values calculated using the above formula for a range of speeds and warning tines is given in Appendix 1.

The Outer Warning Distance (OWD) is calculated as follows:

$$\text{OWD} = \text{AWD} + \text{ROD}$$

The actual OWD used may be increased in order to make use of existing IRJ positions provided that excessive warning times do not result. All such cases must be agreed with the Principal Engineer Signalling.

5.6 Avoidance of Excessive Warning Times

5.6.1 General

Care shall be taken when calculating the required approach and outer warning times, and hence approach and outer warning distances, to avoid excessive warning times that may result from regular slow or stopping train movements. It is generally desirable that, for regular train movements, the maximum warning times do not exceed:

a) 60 seconds for the arrival of a 1st train, and;

b) 120 seconds for the arrival of a 2nd train.

The time allowed for the 1st train does not include any pre-emption time for a crossing.

The time allowed for the 2nd train arrival covers the worst case where the 1st train is just about to clear the crossing when the 2nd train passes the OWD.

Where excessive warning times are likely to occur regularly consideration shall be given to alternative means of operation or special controls. These include, but are not limited to, the use of the following:

- Drivers Proceed Indicators;
- Z track Operation;
- Signal Controls;
- Grade Crossing Predictors;
- Speed Controls;
- Stopping/Express Selection.

5.6.2 Permanent Speed Restrictions

The existence of speed restrictions within and on either side of the approach and/or outer warning distances of level crossings will increase the warning times if the warning is calculated based on the maximum line speed in isolation. Where this occurs the applicable warning distances should be re-assessed, taking into account deceleration and acceleration as required. If the assessment shows that an excessive warning would result, the warning distance(s) should be revised.

5.6.3 Level Crossing Speed Restrictions

In cases where excessive warning times may result from regular stopping patterns, or where the required AWD cannot be achieved, a specific level crossing speed restriction may be applied, subject to the approval of Arc Infrastructure's Head of Operations.

Level crossing speed restrictions shall be signed using a standard speed board together with a "XING" board, positioned below the speed board. This requires drivers to maintain the signed speed up to the crossing, after which they may accelerate.

5.7 Signal Controls

The following signal controls shall apply wherever signals that control movements towards a crossing are positioned within the approach or outer warning distances, to ensure that the protecting equipment will always operate for the required AWT and that the ROT is always maintained.

5.7.1 Signals Located Within Approach Warning Distances

The following controls apply to signals located within approach warning distances: -

Condition	Requirement
a) A signal is displaying a proceed aspect or is approach locked.	The level crossing warning shall be activated by an approaching train, unless protection is provided by another signal nearer to the crossing.
b) A signal is 200m or less from the level crossing, is at stop and not approach locked, and a train overrunning the signal would be routed over the crossing.	The level crossing warning shall be activated by an approaching train. The warning shall be cancelled once the train has been timed to a stand at the signal. Standard release times for given approach distances are given in Appendix 2. Alternatively a device such as a predictor may be used to ensure that the required warning time is achieved in the event of a train running at excessive speed towards the signal.
c) A signal is more than 200m from the level crossing, is at stop and not approach locked.	The level crossing warning shall not be activated by an approaching train. However, if the crossing is controlled by a device such as a predictor this may activate the crossing independently if the approach speed is excessive.
d) A signal at any distance from the crossing is at stop and not approach locked, and an approaching train passes the signal.	The normal level crossing warning sequence shall immediately be activated, if it is not active already. If the signal is within 460m of the crossing the level crossing warning signals and associated sequence shall immediately be activated irrespective of any normal pre-emptive sequence associated with road traffic devices. Alternatively a device such as a predictor may be used to ensure that the required warning time is achieved in the event of an overrunning train.
e) A signal is displaying a proceed aspect and the level crossing warning has been activated by an approaching train, when the signal is replaced to stop before the train reaches the signal.	The level crossing warning shall be maintained until the train either proceeds over the crossing or has been timed to a stand at the signal. Standard release times for given approach distances are given in Appendix 2. Alternatively a device such as a predictor may be used to ensure that the warning is maintained for as long as required.
f) A signal is at stop and not approach locked and there is an approaching train within the approach distance, when the signal attempts to clear to a proceed aspect.	The level crossing warning shall immediately be activated and, after any required time delay as set out in Appendix 3 has elapsed, the signal can be cleared. If the crossing warning has already been activated by another train the time delay may be calculated from the initial warning's activation. If the level crossing warning has been extinguished shortly before the signal is set it shall additionally be prevented from attempting to clear until the required ROT has elapsed.

5.7.2 Signals Located Within Outer Approach Warning Distances

The following controls apply to signals located between the outer and inner approach warning distances, when the level crossing warning has already been activated by a first train: -

Condition	Requirement
a) A signal is displaying a proceed aspect or is approach locked.	The level crossing outer warning shall be activated by a train approaching the signal, unless protection is provided by another signal nearer to the crossing.
b) A signal is at stop and not approach locked.	The level crossing outer warning shall not be activated by a train approaching the signal.
c) A signal is at stop and not approach locked, and an approaching train passes the signal.	The level crossing outer warning shall be activated, unless protection is provided by another signal nearer to the crossing.
d) A signal is displaying a proceed aspect and the level crossing outer warning has been activated by an approaching train, when the signal is replaced to stop before the train reaches the signal.	The level crossing outer warning shall be maintained until the train either proceeds over the crossing or has been timed to a stand at the signal, unless protection is provided by another signal nearer to the crossing. Standard release times for given approach distances are given in Appendix 2.
e) A signal is at stop and not approach locked and there is an approaching train within the outer approach distance, when the signal attempts to clear to a proceed aspect.	If the level crossing warning is already active the level crossing outer warning shall be activated and the signal may clear immediately. If the level crossing warning has been extinguished shortly before the signal is set it shall additionally be prevented from attempting to clear until a required time delay as set out in Appendix 3 has elapsed, to ensure that the required ROT is always maintained.

The effect of activating the level crossing outer warning is to prevent the initial level crossing warning from clearing until the 2nd train has passed over the crossing, or has otherwise come to a stand at an intervening signal. Note that the controls equally apply to the case where the 2nd train is already within the outer warning distance when the 1st train activates the level crossing warning.

6 Train Detection Requirements

6.1 General

The reliable detection of trains on and within the approach to a level crossing is vital to its safe operation, requiring a level of integrity at least equal to that of the signalling system. Accordingly all train detection systems used on active level crossing systems shall use track circuit types approved for use on the signalling system or specifically approved for use for active level crossing systems. This section identifies the types approved for use and any special requirements that apply.

Other forms of train detection may be considered but require type approval by Arc Infrastructure before use.

6.2 Track Circuits

6.2.1 General

The following types of track circuit are in use on Arc Infrastructure's CTC signalled areas: -

a) dc relay – various types are in use, and;

b) GEC ac RT Reed, and;

c) GETS ("Harmon") Electrocode coded, and;

d) US&S Microtrax coded, and;

e) Jeumont Schneider High Voltage Impulse.

Other types of track circuit are identified in the sections below.

6.2.2 Westrak Diode Track Circuits

Westrak diode track circuits may be used in non-signalled areas. Use of this type of track circuit eliminates the need for remote track circuit feed locations.

GETS ("Harmon") SCX controllers, which incorporate a similar diode track circuit, are also approved for use.

6.2.3 Audio Frequency Overlay Track Circuits

The following types of audio frequency overlay (AFO) track circuit are in use on Arc Infrastructure's signalled areas: -

a) GETS ("Harmon") AFTAC and AFTAC II, and;

b) US&S AFO, and;

c) Westinghouse/Siemens PSO.

Care must be exercised when selecting frequencies to ensure that overlay track circuits do not interfere with the underlying signalling track circuits or other detection systems, and vice versa.

6.3 Motion Detectors

Motion detectors are similar to AFO track circuits in that they provide a frequency overlay to standard types. However their function is different in that they only detect a train when it is in motion, i.e. they do not detect stationary trains. This feature may be useful in situations where the detection of a train at a stand can allow the release of a crossing warning.

The following types of motion detector are in use on Arc Infrastructure's signalled areas: -

a) GETS ("Harmon") PMD.

Care must be exercised when selecting frequencies to ensure that overlay track circuits do not interfere with the underlying signalling track circuits or other detection systems, and vice versa.

6.4 Level Crossing Predictors

6.4.1 General

Level crossing predictors (predictors) provide a constant warning time solution for level crossings. They generally consist of a short high frequency island track circuit and a lower frequency approach track circuit terminated by a hard wire or other frequency dependent shunting device at the warning distance applicable to the highest design speed, although various configurations are available for single and double lines.

Predictors work by calculating the speed of an approaching train based on the rate of change of the signal received by the predictor. Various user programmable settings are available to adjust the warning time and other parameters, as set out in the following sections.

Predictors shall only be used where regular train movements exceed 25 trains per week.

6.4.2 Predictor Signs

Predictor signs are provided at some predictor controlled crossings to indicate to train drivers that they must limit the acceleration of their train as set out in the Network Safeworking Rules and Procedures. The signs shall be provided at each of the outer limits of the control area, except where the following applies: -

a) There is an intervening predictor controlled crossing – the predictor sign shall be placed 10-20 metres after the intervening crossing, or;

b) There is an intervening non-predictor controlled crossing – an additional predictor sign shall be placed 10-20 metres after the intervening crossing.

Predictor signs are not required where the design of an installation conforms to the following sections, which ensure that accelerating trains cannot reach a crossing under the required AWT.

6.4.3 Predictor Settings

For Arc Infrastructure applications predictors shall normally be set as follows: -

a) Warning Time – The AWT for the crossing + 10 seconds, and;

b) Positive Start – To be set according to the tables of Appendix 4.

These settings ensure that an accelerating train cannot reach the crossing under the required approach warning time.

6.4.4 Termination Shunts

Termination shunts for predictors shall be positioned as follows: -

a) At the AWD for each crossing approach, where outer warnings are not required, or;

b) At the OWD for each crossing approach, where outer warnings are required.

Where outer warnings are required the predictor circuit needs to be configured to switch to motion detect once the crossing has been activated. This ensures that any train within the outer approach is detected, regardless of its speed or position.

6.4.5 Predictor Marker Signs

Predictor marker signs, as shown on drawing W-HE-973, shall be installed at the 50%, 100% and Positive Start positions for each crossing approach.

6.4.6 Stopping Points on Crossing Approaches

Where predictors are used it is necessary to ensure that regular stopping places such as passenger platforms and signals are outside the positive start distance, to ensure that an excessive warning time does not result. In exceptional cases where a stopping place is within the normal positive start distance Arc Infrastructure will specify the arrangements to be applied, which may include: -

a) Shortening the positive start distance to allow the crossing warning to clear and enabling motion detect for the remaining approach length, and;

b) Provision of special signage to limit stopping train speeds until the level crossing is reached.

6.4.7 Compatibility Requirements

In order to avoid interference with signalling track circuits and other predictors the following general restrictions/conditions apply: -

a) Predictor frequencies below 200Hz are not normally used in conjunction with dc coded track circuits, and;

b) Narrow band termination shunts and joint bypass couplers must be used with dc coded, Reed and audio frequency track circuits, and within overlapping predictor approaches, and;

c) Predictor frequencies in the range 360 to 390Hz are not to be used in conjunction with Reed track circuits, and;

d) Predictor and Reed/audio frequency track circuit frequencies and their harmonics shall be separated by greater than 10%, and;

e) Battery chokes shall be installed in the feed end of any dc track circuit where the feed end lies within a predictor approach, and;

f) Wide band shunts shall be installed across the output of dc track feed sets where the feed end lies within a predictor approach, to eliminate 100Hz ripple.

6.5 Axle Counters

6.5.1 General

Axle counting systems may be used in place of track circuits where authorised by Arc Infrastructure. This generally applies to level crossings on non-signalled lines where it may not be economic to insulate both steel sleepered track and provide insulated rail joints, and/or where poor rail contact conditions may lead to a loss of train detection if track circuits are used.

Axle counter sections may be directional, eliminating the need for directional sticks, or non-directional.

The following types of axle counter are in use on Arc Infrastructure's network: -

a) Frauscher ACS2000, and;

b) Frauscher FAdC.

6.5.2 Axle Counter Signage

An axle counter sign shall be provided at the beginning and end of the axle counter sections.

6.5.3 Island Sections

The island section of an axle counter controlled crossing may utilise an individual axle counter section, overlapping axle counter sections, a jointed track circuit or a short non-jointed audio frequency overlay track circuit.

6.5.4 Axle Counter Heads

The following requirements apply to the positioning of axle counter heads: -

a) The location of axle counter heads shall be identified by painting two sleepers either side of the head yellow, and;

b) Where an axle counter head is required to be placed on a curve then the head shall be placed on the inside of the curve.

6.5.5 Resetting and Restoration.

The resetting and restoration requirements for individual level crossings will be dependent upon the arrangement/type of approach and island sections and the access and egress requirements for road/rail vehicles at the crossing and any other crossings within the approaches. The design and operation of the reset and restoration facilities for all axle counter sections shall comply with the requirements of procedure W110-600-060 - Procedure for Resetting and Restoration of Axle Counters.

6.6 Bonding Requirements

6.6.1 Dual Gauge Track Circuits

In areas with dual gauge track circuits cross-bonding is required between the standard and narrow gauge rails at intervals of not more than 50 metres.

6.6.2 Jointed Rails

In areas with rails which are mechanically jointed the rail head bond shall be a Thermit type generally in accordance with drawing W-HE-873. Predictor and AFO track circuits shall have 10 mm^2 copper cable in the bond lead.

6.6.3 Predictors

Wherever predictor circuits run through turnouts the bonding arrangements must be such that a step change in rail impedance will not occur as a train passes over an insulated rail joint. If necessary point track circuits should be changed to 2 track relay type to accommodate this requirement.

6.7 Special Requirements

6.7.1 Island Track Circuits

Island track circuits are short track circuits between the clearance points on either side of a level crossing. Occupation of an island track circuit shall always activate and

maintain the level crossing warning. All tracks across an actively protected level crossing shall have an island track circuit, which may be combined with the island track circuit of one or more other tracks.

Level crossing predictors have a high frequency island track circuit built in to their detection system. Audio frequency jointless track circuits may be overlapped across the crossing, such that the occupation of both approach track circuits provides for the same functionality as a separate island track circuit.

6.7.2 Bi-Directional Operation

Wherever bi-directional movements take place over a crossing directional controls shall be provided to prevent the continued operation of the level crossing warning when the rear of a train clears the crossing but remains within the opposing approach warning distance.

Level crossing predictors automatically provide this feature but relay and processor based interlocking systems require directional stick circuits to provide this functionality. The provision of such circuitry gives rise to the risk that a track circuit remaining occupied after the passage of a train will leave the stick circuit effective and hence the crossing unprotected for movements in the opposite direction to the first train. In order to mitigate this risk the following shall apply: -

a) In signalled areas, wherever practical, the stick circuit(s) for the opposing direction shall be back proved in the aspects of all signal routes leading over the crossing(s) to which the stick circuit(s) apply, the setting of any signal shall drop opposing stick circuits and opposing stick circuits shall be cross proved, or;

b) In non-signalled areas, and wherever opposing stick circuit back proving is not practical in signalled areas, a timed cancellation of the stick feature shall be provided together with a power off restoration stick circuit to ensure that no directional stick relays can pick until all track circuits have first been proven clear. The timed cancellation shall cause the level crossing warning to re-activate at a set time after the level crossing island track circuit clears, in the event of a track circuit remaining occupied after the passage of a train. The time before re-activation shall normally be 300 seconds unless an opposing train could arrive in less than this time, in which case a reduced time may be used, and;

c) In all cases, wherever practical, stick circuits shall be energised by the occupation of 2 track circuits, to minimise the risk arising from individual track failures.

6.7.3 Overlay Track Circuits

Where overlay track circuits are used in signalled areas care must be taken to ensure that an early release of any signal approach clearance controls cannot occur due to the undetected right side failure of the overlay track circuit. This may be achieved in a number of ways, including: -

a) Proving the overlay track circuit clear in the main track circuit, or;

b) Proving the overlay track circuit clear in the aspects of signals reading over it, or;

c) Using the main track circuit for the approach clearance controls.

6.7.4 Z Track Circuits

The use of Z track circuits presents a risk of reduced warning times as a right side failure may bridge out one or more of the track circuits on the approach to a crossing. This is exacerbated by the lack of any signals to prove the Z track circuit in. To mitigate this risk all Z track circuits shall utilise a composite track/rail circuit that positively detects both the absence and presence of a train.

7 Safety and Miscellaneous Requirements

7.1 Safety

Active level crossing warning systems are safety critical, with a safety integrity requirement equal to that of the signalling system. Systems shall therefore be designed using the same procedures as signalling, and to ensure that: -

a) Any individual component failure will not prevent a warning being given to the road user, and;

b) The presence of a critical failure becomes evident within adequate time to allow appropriate corrective or protective action to be taken before an unprotected approach could occur. The corrective or protective action may be automatic or manual.

7.1.1 Design Techniques

The following techniques may be used, in combination or separately, to achieve the safety integrity requirements: -

a) Fail safe circuit design, and;

b) Proven and/or type approved railway signalling and level crossing equipment, and;

c) Remote monitoring and critical alarm generation, and;

d) Periodic maintenance site inspections and testing, and;

e) Indication of failure to train drivers, and;

f) A means for the road user to report a failure to Arc Infrastructure. This requirement can be satisfied by providing a telephone at the crossing or by providing a sign indicating a telephone number to report the fault and details for identifying the level crossing: e.g. the crossing number, and;

g) Redundancy: e.g. duplicated equipment and/or wiring.

7.1.2 Remote Monitoring and Data Logging

Remote monitoring and data logging shall be provided for all active level crossings. The data logger shall be interfaced to the Arc Infrastructure SCADA system. The SCADA system shall communicate with the remote data loggers by means of a dial-up communications link, via GSM (Next G), PSTN or satellite phone systems.

All events in the data logger shall be capable of being remotely interrogated and downloaded. Interrogation of the data logger shall be password protected.

The data logger shall be capable of recording both digital and analogue inputs, and shall also be capable of providing digital output functions. Complex crossings with large numbers of additional control functions and/or flashlight units may require more logger inputs than available on a single data logger. In such case a data logger expansion module shall be provided for the additional digital and/or analogue functions.

The events recorded on the digital inputs shall include, where applicable: -

a) Island and approach track circuits, and;

b) Directional stick relays and timers, and;

c) Crossing control relays, and;

d) Battery charger health, and;

e) Location door switches, and;

f) Manual operation controls, and;

g) Individual boom barrier down proving.

Other inputs may be specified by Arc Infrastructure for complex and unusual level crossings.

The events recorded on the analogue inputs shall include, where applicable: -

h) Train detection/control and flashlight battery voltages, and

i) Flashlight lamp current.

At some sites Arc Infrastructure may additionally require the installation and monitoring of their Rail Ambient Temperature System (RATS).

Data loggers shall provide facilities for the generation of critical alarms. Alarms typically include flashing for greater than 30 minutes and low battery voltage. The data logger shall be configured to dial-up and notify the central SCADA system when it detects an alarm condition.

7.2 Manual Operation

A manual operation switch shall be provided at all level crossings irrespective of their normal method of operation. Operation of the switch, via an intermediate control relay (the CR), shall immediately activate the normal level crossing warning sequence, including any pre-emptive warnings.

The level crossing warning shall remain active until the manual operation switch is restored to the normal position. The level crossing warning shall immediately cancel upon restoration unless a train has initiated the normal warning sequence or an outer warning has been activated, in which case the warning will cancel after the train has passed over the crossing or otherwise come to a stand at an intervening signal.

Manual operation switches shall normally be mounted in a lockable weatherproof housing mounted on the side of the location case nearest to the crossing, from which there must be good visibility of the crossing and its rail and road approaches. The housing shall be locked with a Traffic Standard lock or padlock. At some crossings Arc Infrastructure may require additional switches to be provided.

7.3 Radio Remote Control Operation

At some crossings radio remote control operation may be specified by Arc Infrastructure, for use by road-rail patrol vehicles. Radio remote control operation consists of a coded transmitter, built into the patrol vehicles control system or hand-held for testing purposes, and a receiver unit in the crossing's control case. Operation of the transmitter with the correct code will cause the receiver to energise a control relay (the (RC)R), which in turn de-energises the manual operation CR relay.

The receiver maintains the (RC)R energised for a time period, normally set to the crossing's AWT plus 5 seconds, which allows road traffic to come to a stand and the patrol vehicle to cross safely before the (RC)R de-energises cancelling the crossing warning. Note that the radio remote control circuit is designed to fail in a manner that won't cause the crossing warning to activate.

The radio remote control system operates over a restricted range, generally less than 300m, and the operating instructions and interlocks on the patrol vehicles require that patrol vehicles come to a stand at a crossing before operating the remote control transmitter. However, to reduce the risk of the inadvertent operation of a closely spaced adjacent crossing, two channel codes are available so that closely spaced crossings use different codes. The code for each crossing is recorded on the crossing records, and is shown on labels attached to the crossing flashlight or boomgate masts, as per drawing W-HE-990.

7.4 Advance Flashing Warning Signals

Requirements for advanced flashing warning signals at level crossings shall be determined by the road authority using the criteria set out in MRWA's Policy and Guidelines for Railway Crossing Protection in Western Australia. This includes the positioning of the signs relative to the crossing and the time that the signs should be activated prior to activation of the normal crossing warning sequence, i.e. the pre-emption time.

Advance flashing warning signals consist of two horizontal yellow lamp units that, when activated, shall flash at the same rate as the flashing light signals at the crossing. Advance flashing warning signals shall be illuminated during the pre-emption time and whenever the level crossing warning is active.

The lamp units of advance flashing warning signals shall be driven directly from the level crossing location by a failsafe flasher unit. A method of detecting the operation of the advance flashing warning signals lamp units shall be provided. In the event that any one lamp unit of an advance flashing warning signal has failed to illuminate during the pre-emption time the flashing light signals at the crossing shall additionally be illuminated.

A separate battery supply shall be installed to support the operation of advance flashing warning signals. The capacity of the supply and its charger shall be sufficient to allow the advance flashing warning signals to function for at least the same minimum times for normal and failed operation provided for the main crossing under power supply failure conditions.

7.5 Interfacing with Road Traffic Signals

Where road traffic signals controlling an intersection are situated less than 100 metres from an active level crossing it may be necessary to provide interfacing between the two systems. Generally any requirement for such an interface will be decided by MRWA or the local road authority. The design of the interface shall be such that the road user shall at no time observe a conflict of indications between road and rail systems.

Interfacing shall be used to interrupt the normal cycle of the traffic light controller on the approach of a train, in order to provide a clearance phase to allow the crossing to clear road traffic before the normal level crossing warning sequence is activated. This requires the earlier detection of a train on the approach to a crossing, in order to provide a signal (*known as an early call*) to the road traffic signal system, i.e. the pre-emption time. The early call shall normally be between 14 and 22 seconds before the main normal warning is activated, but may need to be increased to take account of the worst case road traffic clearance time. A timer shall be provided to ensure that the normal crossing warning is always activated after the pre-emption time has elapsed, irrespective of the speed of the approaching train. The pre-emption time applicable to individual level crossings will be specified by MRWA or the responsible local road authority.

Interfaces to road traffic signal systems shall be in accordance with drawing W-HC-2980, which generally requires: -

a) An early call output – The level crossing system shall provide an early call output to the road traffic light system for a period as agreed with the responsible traffic authority, and;

b) A late call output – The late call output indicates that the normal level crossing warning is active, and;

c) An early call accepted input – This confirms that the road traffic signal system has accepted the early call, and;

d) A late call accepted input – This confirms that the road traffic signal system has accepted the late call.

7.6 Documentation of Special Cases

Any active level crossing system that requires any special working instructions in addition to those set out in the Network Safeworking Rules and Procedures shall be documented as follows: -

a) The special working instructions shall be set out in the Special Train Notice (STN) issued at the time that the crossing is commissioned, and;

b) The special working instructions shall be set out in the Local Instructions section of the General Operational Instructions.

8 Equipment Requirements

This section sets out requirements for the warning equipment to be provided for the active control of road and pedestrian level crossings, whether separate or combined.

8.1 Road and Pedestrian Crossing Signs

All signs used at or on the approach to an active level crossing shall comply with AS 1742.7:2016 and AS 1743:2018.

8.2 Road Crossing Equipment

8.2.1 Flashing Light Signal and Boom Barrier Masts

Flashing Light Signal and Boom Barrier Masts shall normally be positioned such that the centre of the mast is positioned: -

a) at a minimum of 3.5 metres from the nearest edge of rail, and;

b) at a minimum of 2 metres from the nearest edge of road on unkerbed roads, or;

c) at a minimum of 1.5 metres from the nearest kerb on kerbed roads.

In addition to requirement a) above the point halfway across the road carriageway perpendicular to the centre of the mast must also be at a minimum of 3.5 metres from the nearest edge of rail.

Masts shall normally be connected to their foundations by a frangible cast alloy type base, to enable the mast to break away in the event of any significant impact by a road vehicle. As far as is practical a level and compacted surface should be provided for a minimum of 2 metres around masts (road kerb excepted), and a minimum working clearance of 1 metre should be provided around boom counterweights when in the lowered position. Special arrangements, e.g. a lockable access gate, may be required to allow this to be provided, typically where an adjacent fenced pedestrian crossing exists.

8.2.2 Flashing Light Signal Assemblies

Flashing light signal assemblies shall use the RX-5 assembly as defined in AS 1742.7:2016. The light units shall be fixed, at approximately 760 mm horizontal centres, to a cross arm assembly.

In some circumstances additional flashing light assemblies on high masts and/or cantilever signals may be required in order to provide adequate sighting for all approaches.

The light units shall be fitted with hoods and the assemblies with rectangular backgrounds (target boards) that meet the requirements of Arc Infrastructure drawings W-CE-637, W-CE-638 or W-CE-653.

Assemblies shall be available in two-light (one-way) and four-light (two-way) back to back form, mounted as shown in drawings W-CE-1053 or W-CE-1054.

The number of flashes per minute shall be between 40 and 50 (normally 45). While flashing, one lamp unit of the pair of signals shall be illuminated at any time the other is not illuminated. Each unit of the signal shall be illuminated for approximately the same length of time.

At least two assemblies shall face each main approach to the controlled area. Additional assemblies shall be provided as required for secondary approaches from side roads.

Light units shall be aligned according to the requirements of AS 1742 Part 7 (Manual of Uniform Traffic Control Devices – Railway Crossings), MRWA's Policy and Guidelines for Railway Crossing Protection in Western Australia and the requirements of Arc Infrastructure drawings W-FY-101, W-FY-102, W-FY-103, W-FY-108, W-FY-111, W-FY-121, W-FY-122, and W-FY-123.

Where the road is aligned from East to West and the track North to South, consideration shall be given to the influence of the sun at low elevations upon the visibility of the warning signals. This influence may be mitigated, for example by the use of larger target boards, hoods or additional assemblies.

8.2.3 Flashing Light Signals

Flashing light signal lamp units shall be of a type approved 200mm diameter 12V d.c. LED type. The signal lamp units shall incorporate a white "side-light" to provide an indication to rail traffic crew that the lights are flashing.

8.2.4 Audible Warning Signals

Audible warning signals shall be provided by a type approved 12V d.c. operated bell or other suitable electronic device. The audible signal device shall be designed to mount directly on the top of a flashing light warning signal mast, or on an offset bracket at the same height as a standard mast where an extended mast is used.

Audible signals shall be designed to be at least 10 dBA above ambient noise levels, at the predominant frequency of the audible signal, measured at 3m from the signal. Electronically generated audible warning signals should mimic the sound of a bell or shall be such that it shall be obvious that the audible warning signal applies to the crossing.

8.2.5 Boom Barrier Mechanisms

Boom barrier mechanisms shall be of a type approved 12V d.c. type. Aluminium boom barrier arms shall be provided for all new and renewed installations.

Boom barrier arms shall be equipped with red retro-reflective stripes on a white background. The tip of the boom should not extend closer than 300 mm from the centre line of the carriageway for undivided roads and not beyond the near edge of the median strip on divided roads.

A light shall be provided at the boom tip and a minimum of two further lights shall be provided equally spaced along the boom. The tip light shall display a steady red when operated. The others shall flash red alternately, in synchronisation with the main flashing lights. The lights shall be visible to road traffic on both sides of the level crossing but no indication is required for the train driver.

The boom lights shall operate whenever the boom arms are moved out of the vertical position by greater than 5°.

When activated boom barriers shall descend initially using powered operation until the boom arms reach 45 degrees, followed by gravity descent and snubbing until the boom arm is horizontal. Ascent shall be by powered operation.

Wind guards shall be provided on boom barrier masts to prevent excessive movement of the boom barrier arms when in the raised position. For boom arms in excess of 7 metres an extended boom barrier mast and additional wind guard shall be provided.

Mechanical latches shall be provided at boom barriers to allow them to be latched up during failure. These shall be able to be padlocked in either position, and shall be clearly labelled to indicate whether they are in the latched or unlatched position.

8.3 Pedestrian Crossing Equipment

8.3.1 Pedestrian Signals

Pedestrian signals for crossings with or without gates shall be AS 2144 "Don't Walk" lights (with symbolic “standing man” indications). As a minimum, one light unit shall face oncoming pedestrians and one shall face across the railway track on each side of the crossing, normally in a back-to-back arrangement on the same mast. LED light units shall be used.

Another Train Coming (ATC) signals shall be white LED units.

8.3.2 Pedestrian Gates

Pedestrian gate mechanisms shall be electric motor driven at 110V ac. They shall be stall and condensation resistant with a built in thermal overload (100°C).

Pedestrian gates shall be at least 1.2 metres high and shall normally be held open under power allowing access to the crossing, whilst blocking the emergency exit. The closed gate shall be designed to present a firm pressure against forced opening, whilst not being strong enough to cause injury to a pedestrian caught between a closing gate and end post.

The mechanism shall be arranged such that there is no possibility of the gate failing to close under wind conditions likely to be encountered in the region. Under power failure conditions the gate shall close to pedestrian traffic.

8.3.3 Audible Warning Signals

Audible warning signals shall be an adjustable volume audible warble alarm, designed for: -

a) Low current consumption (>300 mA at 110 v AC), and;

b) High sound output (90 dB (A) at 1 metre), and;

c) A frequency range of 800 Hz to 1 kHz.

Unless otherwise specified, one alarm shall be fitted on each side of the crossing, facing oncoming pedestrians. The alarms may be mounted within pedestrian signal units, under the pedestrian signal mast top dome or within pedestrian gate mechanisms, provided that adequate coverage of the pedestrian crossing and its approaches is provided.

8.4 Drivers Proceed Indicators

The design and construction of drivers proceed indicators shall generally be in accordance with drawing W-CE-1701.

8.5 Power Supplies

Primary power for active level crossing warning systems shall be derived from the following sources: -

a) An Arc Infrastructure signalling power supply, or;

b) A power supply utility or other third party source, or;

c) A solar power installation.

Options a) and b) are known as mains power supplies. The options are to be selected in order of preference from a) to b) to c), with the next option only being selected where it is impractical and/or uneconomic to provide the preferred supply. Existing mains power supplies shall only be used where they have adequate capacity for the additional load, or where their capacity can be upgraded.

In all cases the primary power supply shall be supported by a battery backup as set out in sections 8.5.1 and 8.5.2 below.

8.5.1 Mains Power Supplies

Mains powered sites shall normally be provided with the following mains backed battery supplies: -

a) A train detection/control battery – a 12V supply for the crossing control circuits and train detection system. The battery shall be adequate for 3 days of normal operation in the event of a mains power failure and;

b) A flashlight battery – a 12V supply for the flashing light signals, audible signals and boom barriers. The battery shall be adequate for 3 days of normal operation, plus 12 hours of continuous operation (18 or 24 hours for crossings in remote areas, refer to section 8.5.3) once normal operation has failed.

Battery temperature compensation shall be provided for the battery chargers.

Exceptionally a train detection/control battery need not be provided where the crossing is controlled from another location (e.g. a signalling interlocking) and there would be no other load required on the train detection/control battery other than that required for controlling the level crossing sequence.

8.5.2 Solar Power Supplies

Solar powered sites shall normally be provided with solar arrays and regulator supplies supporting the following battery supplies: -

a) A train detection/control battery – a 12V supply for the crossing control circuits and train detection system. The solar system shall be designed so that there is sufficient battery capacity to support normal crossing operation for seven days of no sun, and so that a battery discharged to 20% of its rated capacity will return to fully charged operation after two days of normal sun at any time of the year, and;

b) A flashlight battery – a 12V supply for the flashing light signals, audible signals and boom barriers. The solar system shall be designed so that there is sufficient battery capacity for 7 days of normal operation, plus 12 hours of continuous operation (18 or 24 hours for crossings in remote areas, refer to section 8.5.3) once normal operation has failed, and so that a battery discharged to 20% of its rated capacity will return to fully charged operation after two days of normal sun at any time of the year.

The sizing of solar power systems shall allow for normal seasonal variations in sun hours and possible reductions in sun hours due to shadows from local topographic features and structures.

Battery temperature compensation shall be provided for the solar regulators.

Exceptionally a train detection/control battery need not be provided where the crossing is controlled from another location (e.g. a signalling interlocking) and there would be no other load required on the train detection/control battery other than that required for controlling the level crossing sequence.

8.5.3 Crossings in Remote Areas

A crossing is defined as being in a remote area if it is more than 2 hours travelling time by road, at the designated speed limits, from the Arc maintenance depot responsible for the crossing. Arc maintenance depots are situated at: -

- Kalgoorlie,
- Merredin,
- Northam,
- Midland,
- Narngulu,
- Kwinana,
- Pinjarra and
- Picton.

Note that, whilst there may be a maintenance depot closer to a crossing than that responsible for its maintenance, it is the distance from the maintaining depot that defines its remote status as attendance in the event of a fault will be from that depot.

The flashlight battery capacity for continuous operation is to be increased for crossings in remote areas from the normal 12 hours to either 18 or 24 hours in accordance with the following: -

a) Crossings between 2 and 4 hours travelling time – 18 hours, and;

b) Crossings greater than 4 hours travelling time – 24 hours.

8.5.4 Associated Supplies

The power supplies for all equipment in locations and equipment rooms providing train detection and/or controls for the crossing shall provide the same autonomy as specified for the train detection/control battery, except where the crossing is controlled from a signalling interlocking which provides protection to the crossing via signals.

8.5.5 Miscellaneous

The design of batteries and battery housings shall comply with the following: -

a) Fixed voltmeters shall be provided for all battery supplies, and;

b) Individual batteries shall be capable of being lifted and carried by a maximum of 2 people, and;

c) Batteries shall be housed such that any individual battery can be removed without the need to move other batteries or fixed equipment, and;

d) Spillage trays shall be provided.

Appendices

Appendix 1 – Table of Values for AWD & ROD

The following table give a comprehensive list of values for Approach Warning Distances (AWD) and Road Open Distances (ROD), which have been derived using the following formula:

AWD/ROD = AWT/ROT × (Line Speed in km/h + 3) × 1.06 × 1000/3600

	AWD or ROD (Seconds)									
Line Speed (km/h) ↓	20	21	22	23	24	25	26	27	28	29
5	48	50	52	55	57	59	62	64	66	69
8	65	69	72	75	78	81	85	88	91	94
10	77	81	85	89	92	96	100	104	108	112
15	106	112	117	122	128	133	138	144	149	154
20	136	143	149	156	163	170	177	183	190	197
25	165	174	182	190	198	207	215	223	231	240
30	195	205	214	224	234	243	253	263	273	282
35	224	235	247	258	269	280	291	303	314	325
40	254	266	279	292	304	317	330	342	355	368
45	283	297	311	326	340	354	368	382	396	410
50	313	328	344	359	375	391	406	422	437	453
55	342	359	376	393	410	427	445	462	479	496
60	371	390	409	427	446	464	483	501	520	538
65	401	421	441	461	481	501	521	541	561	581
70	430	452	473	495	516	538	559	581	602	624
75	460	483	506	529	552	575	598	621	644	667
80	489	514	538	563	587	611	636	660	685	709
85	519	545	571	596	622	648	674	700	726	752
90	548	576	603	630	658	685	712	740	767	795
95	578	606	635	664	693	722	751	780	808	837
100	607	637	668	698	728	759	789	819	850	880
105	636	668	700	732	764	795	827	859	891	923
110	666	699	732	766	799	832	866	899	932	965
115	695	730	765	800	834	869	904	939	973	1008
120	725	761	797	833	870	906	942	978	1015	1051
125	754	792	830	867	905	943	980	1018	1056	1093
130	784	823	862	901	940	980	1019	1058	1097	1136
135	813	854	894	935	976	1016	1057	1098	1138	1179
140	843	885	927	969	1011	1053	1095	1137	1179	1222
145	872	916	959	1003	1046	1090	1134	1177	1221	1264
150	901	947	992	1037	1082	1127	1172	1217	1262	1307
155	931	977	1024	1071	1117	1164	1210	1257	1303	1350
160	960	1008	1056	1104	1152	1200	1248	1296	1344	1392

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	30	31	32	33	34	35	36	37	38	39
5	71	74	76	78	81	83	85	88	90	92
8	98	101	104	107	111	114	117	120	124	127
10	115	119	123	127	131	134	138	142	146	150
15	159	165	170	175	181	186	191	197	202	207
20	204	210	217	224	231	238	244	251	258	265
25	248	256	264	273	281	289	297	306	314	322
30	292	302	311	321	331	341	350	360	370	379
35	336	347	359	370	381	392	403	414	426	437
40	380	393	406	418	431	444	456	469	482	494
45	424	439	453	467	481	495	509	523	538	552
50	469	484	500	515	531	547	562	578	594	609
55	513	530	547	564	581	598	615	632	649	667
60	557	576	594	613	631	650	668	687	705	724
65	601	621	641	661	681	701	721	741	761	781
70	645	667	688	710	731	753	774	796	817	839
75	689	712	735	758	781	804	827	850	873	896
80	734	758	783	807	831	856	880	905	929	954
85	778	804	830	856	881	907	933	959	985	1011
90	822	849	877	904	932	959	986	1014	1041	1068
95	866	895	924	953	982	1010	1039	1068	1097	1126
100	910	941	971	1001	1032	1062	1092	1123	1153	1183
105	954	986	1018	1050	1082	1113	1145	1177	1209	1241
110	999	1032	1065	1098	1132	1165	1198	1232	1265	1298
115	1043	1078	1112	1147	1182	1217	1251	1286	1321	1356
120	1087	1123	1159	1196	1232	1268	1304	1341	1377	1413
125	1131	1169	1207	1244	1282	1320	1357	1395	1433	1470
130	1175	1214	1254	1293	1332	1371	1410	1449	1489	1528
135	1219	1260	1301	1341	1382	1423	1463	1504	1545	1585
140	1264	1306	1348	1390	1432	1474	1516	1558	1601	1643
145	1308	1351	1395	1439	1482	1526	1569	1613	1656	1700
150	1352	1397	1442	1487	1532	1577	1622	1667	1712	1757
155	1396	1443	1489	1536	1582	1629	1675	1722	1768	1815
160	1440	1488	1536	1584	1632	1680	1728	1776	1824	1872

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	40	41	42	43	44	45	46	47	48	49
5	95	97	99	102	104	106	109	111	114	116
8	130	133	137	140	143	146	149	153	156	159
10	154	157	161	165	169	173	177	180	184	188
15	212	218	223	228	234	239	244	250	255	260
20	271	278	285	292	298	305	312	319	326	332
25	330	339	347	355	363	371	380	388	396	404
30	389	399	409	418	428	438	447	457	467	477
35	448	459	470	482	493	504	515	526	538	549
40	507	520	532	545	558	570	583	596	608	621
45	566	580	594	608	622	636	651	665	679	693
50	625	640	656	672	687	703	718	734	750	765
55	684	701	718	735	752	769	786	803	820	837
60	742	761	780	798	817	835	854	872	891	909
65	801	821	841	861	881	901	922	942	962	982
70	860	882	903	925	946	968	989	1011	1032	1054
75	919	942	965	988	1011	1034	1057	1080	1103	1126
80	978	1002	1027	1051	1076	1100	1125	1149	1174	1198
85	1037	1063	1089	1115	1141	1166	1192	1218	1244	1270
90	1096	1123	1151	1178	1205	1233	1260	1288	1315	1342
95	1155	1184	1212	1241	1270	1299	1328	1357	1386	1414
100	1214	1244	1274	1305	1335	1365	1396	1426	1456	1487
105	1272	1304	1336	1368	1400	1431	1463	1495	1527	1559
110	1331	1365	1398	1431	1464	1498	1531	1564	1598	1631
115	1390	1425	1460	1495	1529	1564	1599	1633	1668	1703
120	1449	1485	1522	1558	1594	1630	1666	1703	1739	1775
125	1508	1546	1583	1621	1659	1696	1734	1772	1810	1847
130	1567	1606	1645	1684	1724	1763	1802	1841	1880	1919
135	1626	1666	1707	1748	1788	1829	1870	1910	1951	1992
140	1685	1727	1769	1811	1853	1895	1937	1979	2022	2064
145	1744	1787	1831	1874	1918	1961	2005	2049	2092	2136
150	1802	1848	1893	1938	1983	2028	2073	2118	2163	2208
155	1861	1908	1954	2001	2047	2094	2141	2187	2234	2280
160	1920	1968	2016	2064	2112	2160	2208	2256	2304	2352

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	50	51	52	53	54	55	56	57	58	59
5	118	121	123	125	128	130	132	135	137	139
8	162	166	169	172	175	179	182	185	188	192
10	192	196	200	203	207	211	215	219	223	226
15	265	271	276	281	287	292	297	303	308	313
20	339	346	353	359	366	373	380	387	393	400
25	413	421	429	437	446	454	462	470	479	487
30	486	496	506	515	525	535	545	554	564	574
35	560	571	582	594	605	616	627	638	649	661
40	634	646	659	672	684	697	710	722	735	748
45	707	721	735	750	764	778	792	806	820	834
50	781	796	812	828	843	859	874	890	906	921
55	854	871	889	906	923	940	957	974	991	1008
60	928	947	965	984	1002	1021	1039	1058	1076	1095
65	1002	1022	1042	1062	1082	1102	1122	1142	1162	1182
70	1075	1097	1118	1140	1161	1183	1204	1226	1247	1269
75	1149	1172	1195	1218	1241	1264	1287	1310	1333	1356
80	1222	1247	1271	1296	1320	1345	1369	1394	1418	1442
85	1296	1322	1348	1374	1400	1426	1452	1477	1503	1529
90	1370	1397	1424	1452	1479	1507	1534	1561	1589	1616
95	1443	1472	1501	1530	1559	1588	1616	1645	1674	1703
100	1517	1547	1578	1608	1638	1669	1699	1729	1760	1790
105	1590	1622	1654	1686	1718	1749	1781	1813	1845	1877
110	1664	1697	1731	1764	1797	1830	1864	1897	1930	1964
115	1738	1772	1807	1842	1877	1911	1946	1981	2016	2050
120	1811	1848	1884	1920	1956	1992	2029	2065	2101	2137
125	1885	1923	1960	1998	2036	2073	2111	2149	2186	2224
130	1959	1998	2037	2076	2115	2154	2194	2233	2272	2311
135	2032	2073	2113	2154	2195	2235	2276	2317	2357	2398
140	2106	2148	2190	2232	2274	2316	2358	2401	2443	2485
145	2179	2223	2267	2310	2354	2397	2441	2484	2528	2572
150	2253	2298	2343	2388	2433	2478	2523	2568	2613	2658
155	2327	2373	2420	2466	2513	2559	2606	2652	2699	2745
160	2400	2448	2496	2544	2592	2640	2688	2736	2784	2832

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	60	61	62	63	64	65	66	67	68	69
5	142	144	147	149	151	154	156	158	161	163
8	195	198	201	205	208	211	214	218	221	224
10	230	234	238	242	245	249	253	257	261	265
15	318	324	329	334	340	345	350	356	361	366
20	407	414	420	427	434	441	447	454	461	468
25	495	503	512	520	528	536	545	553	561	569
30	583	593	603	613	622	632	642	652	661	671
35	672	683	694	705	717	728	739	750	761	773
40	760	773	785	798	811	823	836	849	861	874
45	848	863	877	891	905	919	933	947	962	976
50	937	952	968	984	999	1015	1030	1046	1062	1077
55	1025	1042	1059	1076	1093	1111	1128	1145	1162	1179
60	1113	1132	1151	1169	1188	1206	1225	1243	1262	1280
65	1202	1222	1242	1262	1282	1302	1322	1342	1362	1382
70	1290	1312	1333	1355	1376	1398	1419	1441	1462	1484
75	1378	1401	1424	1447	1470	1493	1516	1539	1562	1585
80	1467	1491	1516	1540	1565	1589	1613	1638	1662	1687
85	1555	1581	1607	1633	1659	1685	1711	1737	1762	1788
90	1643	1671	1698	1726	1753	1780	1808	1835	1863	1890
95	1732	1761	1790	1818	1847	1876	1905	1934	1963	1992
100	1820	1850	1881	1911	1941	1972	2002	2032	2063	2093
105	1908	1940	1972	2004	2036	2067	2099	2131	2163	2195
110	1997	2030	2063	2097	2130	2163	2196	2230	2263	2296
115	2085	2120	2155	2189	2224	2259	2294	2328	2363	2398
120	2173	2210	2246	2282	2318	2355	2391	2427	2463	2499
125	2262	2300	2337	2375	2413	2450	2488	2526	2563	2601
130	2350	2389	2428	2468	2507	2546	2585	2624	2663	2703
135	2438	2479	2520	2560	2601	2642	2682	2723	2764	2804
140	2527	2569	2611	2653	2695	2737	2779	2822	2864	2906
145	2615	2659	2702	2746	2789	2833	2877	2920	2964	3007
150	2703	2749	2794	2839	2884	2929	2974	3019	3064	3109
155	2792	2838	2885	2931	2978	3024	3071	3117	3164	3211
160	2880	2928	2976	3024	3072	3120	3168	3216	3264	3312

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	70	71	72	73	74	75	76	77	78	79
5	165	168	170	172	175	177	180	182	184	187
8	227	230	234	237	240	243	247	250	253	256
10	268	272	276	280	284	288	291	295	299	303
15	371	377	382	387	393	398	403	409	414	419
20	475	481	488	495	502	508	515	522	529	536
25	578	586	594	602	611	619	627	635	644	652
30	681	690	700	710	720	729	739	749	758	768
35	784	795	806	817	828	840	851	862	873	884
40	887	899	912	925	937	950	963	975	988	1001
45	990	1004	1018	1032	1046	1060	1075	1089	1103	1117
50	1093	1108	1124	1140	1155	1171	1187	1202	1218	1233
55	1196	1213	1230	1247	1264	1281	1298	1315	1333	1350
60	1299	1318	1336	1355	1373	1392	1410	1429	1447	1466
65	1402	1422	1442	1462	1482	1502	1522	1542	1562	1582
70	1505	1527	1548	1570	1591	1613	1634	1656	1677	1699
75	1608	1631	1654	1677	1700	1723	1746	1769	1792	1815
80	1711	1736	1760	1785	1809	1833	1858	1882	1907	1931
85	1814	1840	1866	1892	1918	1944	1970	1996	2022	2047
90	1917	1945	1972	1999	2027	2054	2082	2109	2136	2164
95	2020	2049	2078	2107	2136	2165	2194	2222	2251	2280
100	2123	2154	2184	2214	2245	2275	2305	2336	2366	2396
105	2226	2258	2290	2322	2354	2385	2417	2449	2481	2513
110	2330	2363	2396	2429	2463	2496	2529	2562	2596	2629
115	2433	2467	2502	2537	2572	2606	2641	2676	2711	2745
120	2536	2572	2608	2644	2681	2717	2753	2789	2825	2862
125	2639	2676	2714	2752	2789	2827	2865	2903	2940	2978
130	2742	2781	2820	2859	2898	2938	2977	3016	3055	3094
135	2845	2885	2926	2967	3007	3048	3089	3129	3170	3211
140	2948	2990	3032	3074	3116	3158	3201	3243	3285	3327
145	3051	3095	3138	3182	3225	3269	3312	3356	3400	3443
150	3154	3199	3244	3289	3334	3379	3424	3469	3514	3559
155	3257	3304	3350	3397	3443	3490	3536	3583	3629	3676
160	3360	3408	3456	3504	3552	3600	3648	3696	3744	3792

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	80	81	82	83	84	85	86	87	88	89
5	189	191	194	196	198	201	203	205	208	210
8	260	263	266	269	273	276	279	282	286	289
10	307	311	314	318	322	326	330	334	337	341
15	424	430	435	440	446	451	456	462	467	472
20	542	549	556	563	569	576	583	590	596	603
25	660	668	677	685	693	701	710	718	726	734
30	778	788	797	807	817	826	836	846	856	865
35	896	907	918	929	940	952	963	974	985	996
40	1013	1026	1039	1051	1064	1077	1089	1102	1115	1127
45	1131	1145	1159	1174	1188	1202	1216	1230	1244	1258
50	1249	1265	1280	1296	1311	1327	1343	1358	1374	1389
55	1367	1384	1401	1418	1435	1452	1469	1486	1503	1520
60	1484	1503	1522	1540	1559	1577	1596	1614	1633	1651
65	1602	1622	1642	1662	1682	1702	1722	1742	1762	1782
70	1720	1742	1763	1785	1806	1828	1849	1871	1892	1914
75	1838	1861	1884	1907	1930	1953	1976	1999	2022	2045
80	1956	1980	2004	2029	2053	2078	2102	2127	2151	2176
85	2073	2099	2125	2151	2177	2203	2229	2255	2281	2307
90	2191	2219	2246	2273	2301	2328	2355	2383	2410	2438
95	2309	2338	2367	2396	2424	2453	2482	2511	2540	2569
100	2427	2457	2487	2518	2548	2578	2609	2639	2669	2700
105	2544	2576	2608	2640	2672	2703	2735	2767	2799	2831
110	2662	2696	2729	2762	2795	2829	2862	2895	2928	2962
115	2780	2815	2850	2884	2919	2954	2989	3023	3058	3093
120	2898	2934	2970	3006	3043	3079	3115	3151	3188	3224
125	3016	3053	3091	3129	3166	3204	3242	3279	3317	3355
130	3133	3173	3212	3251	3290	3329	3368	3408	3447	3486
135	3251	3292	3332	3373	3414	3454	3495	3536	3576	3617
140	3369	3411	3453	3495	3537	3579	3622	3664	3706	3748
145	3487	3530	3574	3617	3661	3705	3748	3792	3835	3879
150	3604	3650	3695	3740	3785	3830	3875	3920	3965	4010
155	3722	3769	3815	3862	3908	3955	4001	4048	4094	4141
160	3840	3888	3936	3984	4032	4080	4128	4176	4224	4272

Line Speed (km/h) ↓	AWD or ROD (Seconds)									
	90	91	92	93	94	95	96	97	98	99
5	212	215	217	220	222	224	227	229	231	234
8	292	295	298	302	305	308	311	315	318	321
10	345	349	353	356	360	364	368	372	376	379
15	477	483	488	493	499	504	509	515	520	525
20	610	617	624	630	637	644	651	657	664	671
25	742	751	759	767	775	784	792	800	808	817
30	875	885	894	904	914	924	933	943	953	962
35	1007	1019	1030	1041	1052	1063	1075	1086	1097	1108
40	1140	1153	1165	1178	1191	1203	1216	1229	1241	1254
45	1272	1287	1301	1315	1329	1343	1357	1371	1386	1400
50	1405	1421	1436	1452	1467	1483	1499	1514	1530	1545
55	1537	1555	1572	1589	1606	1623	1640	1657	1674	1691
60	1670	1689	1707	1726	1744	1763	1781	1800	1818	1837
65	1802	1823	1843	1863	1883	1903	1923	1943	1963	1983
70	1935	1956	1978	1999	2021	2042	2064	2085	2107	2128
75	2067	2090	2113	2136	2159	2182	2205	2228	2251	2274
80	2200	2224	2249	2273	2298	2322	2347	2371	2396	2420
85	2332	2358	2384	2410	2436	2462	2488	2514	2540	2566
90	2465	2492	2520	2547	2575	2602	2629	2657	2684	2711
95	2597	2626	2655	2684	2713	2742	2771	2799	2828	2857
100	2730	2760	2791	2821	2851	2882	2912	2942	2973	3003
105	2862	2894	2926	2958	2990	3021	3053	3085	3117	3149
110	2995	3028	3062	3095	3128	3161	3195	3228	3261	3294
115	3127	3162	3197	3232	3266	3301	3336	3371	3405	3440
120	3260	3296	3332	3369	3405	3441	3477	3514	3550	3586
125	3392	3430	3468	3506	3543	3581	3619	3656	3694	3732
130	3525	3564	3603	3642	3682	3721	3760	3799	3838	3877
135	3657	3698	3739	3779	3820	3861	3901	3942	3983	4023
140	3790	3832	3874	3916	3958	4001	4043	4085	4127	4169
145	3922	3966	4010	4053	4097	4140	4184	4228	4271	4315
150	4055	4100	4145	4190	4235	4280	4325	4370	4415	4460
155	4187	4234	4281	4327	4374	4420	4467	4513	4560	4606
160	4320	4368	4416	4464	4512	4560	4608	4656	4704	4752

Appendix 2 – Track Circuit Release Times

The following table gives values to be used for the timed release of crossing controls when the controls have been activated by a train approaching a signal at stop and free of approach locking.

Track Circuit Length (m)	Release Time (s)
<= 200	45
201 – 300	50
301 – 400	55
401 – 500	60
501 – 600	65
601 – 700	70
701 – 800	75
801 – 900	80
901 – 1000	85
1001 – 1100	90
1101 – 1200	95
1201 – 1300	98
1301 – 1400	100
1401 – 1500	105
1501 – 1600	110
1601 – 1700	115
1701 – 1800	120
1801 – 1900	125
1901 – 2000	130

Appendix 3 – Signal Release Times

The following tables give values for approach control times to be used for the release of any signal aspect reading over an active level crossing, where an approaching train is occupying track circuits between an approach warning point and the signal. Timing shall commence as soon as the signal is ready to clear.

This table gives approach control times for signals located within approach warning distances, required to maintain the minimum crossing warning times.

Distance of Signal from Crossing (m)	Approach Warning Time (s)				
	<= 25	26-35	36-45	46-55	56-65
0 – 25	25	35	45	55	65
26 – 100	20	30	40	50	60
101 – 200	15	25	35	45	55
201 – 300	10	20	30	40	50
301 – 500	5	15	25	35	45
501 – 700	0	10	20	30	40
701 – 900	0	5	15	25	35
901 – 1150	0	0	10	20	30
1151 – 1400	0	0	5	15	25
1401 – 1800	0	0	0	10	20
1801 – 2300	0	0	0	0	10
> 2300	0	0	0	0	0

This table gives approach control times for signals located within outer warning distances but outside the approach warning distance, required to maintain the road open time.

Distance of Signal from Approach Warning Point (m)	Road Opening Time (s)				
	<= 20	21-25	26-30	31-35	36-40
0 – 25	20	25	30	35	40
26 – 100	15	20	25	30	35
101 – 200	10	15	20	25	30
201 – 300	5	10	15	20	25
301 – 500	0	5	10	15	20
501 – 700	0	0	5	10	15
701 – 1000	0	0	0	5	10
1001 – 1200	0	0	0	0	5
> 1200	0	0	0	0	0

Appendix 4 – Positive Start Distances for Predictor Crossings

The following table gives values for positive start settings which, together with a predictor warning time setting 10 seconds greater than the required MWT, will ensure that an accelerating train cannot reach a crossing in less than the MWT.

	MWT (Seconds)									
	21	22	23	24	25	26	27	28	29	30
Positive Start Position (m)	335	365	395	425	460	495	525	560	595	630

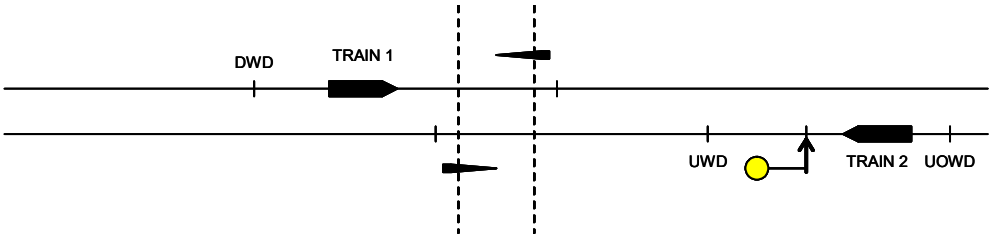
	MWT (Seconds)									
	31	32	33	34	35	36	37	38	39	40
Positive Start Position (m)	670	705	740	780	820	855	895	935	975	1015

	MWT (Seconds)									
	41	42	43	44	45	46	47	48	49	50
Positive Start Position (m)	1055	1095	1135	1175	1215	1260	1300	1340	1385	1425

	MWT (Seconds)									
	51	52	53	54	55	56	57	58	59	60
Positive Start Position (m)	1470	1510	1555	1600	1645	1685	1730	1775	1820	1865

Appendix 5 – Outer Warning Controls

The following considers the case where train 1 arrives at the DWD and activates the level crossing warning, closely followed by train 2. Wherever it is possible for a second train (train 2) to activate the crossing before the Road Open Time (ROT) expires outer warning controls are provided to prevent the clearance of the crossing warning until train 2 has passed over the crossing or has come to a stand at an intervening signal at stop. This appendix outlines the operation of outer warning controls.



The controls would equally apply should train 2 arrive first followed by train 1.

When train 1 reaches the Down Warning Distance (DWD) the level crossing warning will be activated until the train clears the crossing, in the absence of a second train.

If, while train 1 is within the level crossing warning distance, train 2 passes the Up Outer Warning Distance (UOWD) with the signal at proceed, the level crossing warning shall remain activated after train 1 clears the crossing, and shall not clear until train 2 clears the crossing.

a) If, while train 1 is within the level crossing warning distance, train 2 approaches the signal and has passed the UOWD, then the following shall apply:

b) If the signal is at stop and is free of approach locking, train 2 will have no effect on the level crossing warning system provided that it does not pass the signal, and when train 1 clears the crossing the warning will clear, or;

c) If train 2 passes the signal at stop the up outer warning condition will be activated to prevent the level crossing warning clearing after train 1 clears the crossing, or;

d) If the signal is at stop and attempts to clear to a proceed aspect the signal may clear immediately and the up outer warning condition will be activated to prevent the level crossing warning clearing after train 1 clears the crossing, or;

e) If the signal is at proceed and is replaced to stop before train 2 passes it then the up outer warning condition will remain activated until either the signal approach locking clears or a timed release occurs, provided that train 2 does not pass the signal, or;

f) If train 2 passes the signal whilst timing the up outer warning condition will remain activated.

If train 1 has cleared the level crossing, and train 2 has passed the UOWD and is either approaching the signal at stop or is stationary at the signal at stop, then the signal shall be prevented from clearing until a set clearance time has elapsed. The clearance time is dependent on the distance of the signal to the UWD and the required ROT: Refer to Appendix 3 for standard times.

Appendix 6 – Reference Drawings

Arc Infrastructure have a number of drawings in the S2 typical circuit book series available on request for use as templates for typical crossing designs. These cover a range of crossing, train detection and power types as follows: -

- S2-121: Axle counter flashlight with mains power;
- S2-123: Axle counter flashlight with solar power;
- S2-125: Westrak flashlight with mains power;
- S2-127: Westrak flashlight with solar power;
- S2-129: GCP4000 predictor flashlight with mains power;
- S2-131: GCP4000 predictor flashlight with solar power;
- S2-133: Axle counter boomgate with mains power;
- S2-135: Axle counter boomgate with solar power;
- S2-137: Westrak boomgate with mains power;
- S2-139: Westrak boomgate with solar power;
- S2-141: GCP4000 predictor boomgate with mains power;
- S2-143: GCP4000 predictor boomgate with solar power;

The following Arc Infrastructure equipment book drawings are relevant to active level crossing design and construction: -

Equipment Book M1 – Foundations

Drawing No.	Sheet	Drawing Title	Function	Type
W-CE-909	-	100, 127 & 150 Diameter Masts	Base	Assembly
W-FE-1738	-	100, 127 & 150 Diameter Masts	Base – Concrete Reinforcing	Detail
W-FE-1739	-	100, 127 & 150 Diameter Masts	Bolt Support	Detail
W-FE-1740	-	100, 127 & 150 Diameter Masts	Spider – Concrete Reinforcing	Detail
W-HE-779	-	100, 127 & 150 Diameter Masts	Base	Assembly & Detail
W-HE-780	-	100, 127 & 150 Diameter Masts	Spider	Assembly & Detail
W-HE-781	-	100, 127 & 150 Diameter Masts	Top	Assembly & Detail
W-HE-782	-	100, 127 & 150 Diameter Masts	Top – Concrete Reinforcing	Detail
W-HE-976	-	100, 127 & 150 Diameter Masts	Bolt	Detail

Equipment Book M2 – Protected Level Crossings

Drawing No.	Sheet	Drawing Title	Function	Type
W-HE-1022	2	Boomgate	Mast	Detail
W-FE-1910	3	Pipe Clamp	-	Detail
W-HE-971	4	Wind Guard Bracket	-	Detail
W-HE-795	5	R6-9 Sign	Stop on Red Signal – Reflectorised	Detail
W-HE-970	6	Sign	Stand-Off Bracket	Detail
W-HE-791	7	Boomgate	Pan Arm Support Bracket	Detail
W-HE-870	8	Boomgate	Flexible Conduit	Assembly
W-HE-871	9	Boomgate	Lights – Flexible Conduit	Assembly
W-FY-121	11	Boomgate – Single Carriageway	0 to 89° – Acute Angle Road	Layout
W-FY-122	12	Boomgate – Single Carriageway	90° – Right Angle Road	Layout
W-FY-123	13	Boomgate – Single Carriageway	91° to 180° – Obtuse Angle Road	Layout
W-HM-200	15	Track Signage	Standard Aluminium Post	General Assembly
W-HE-936	16	Signage	Speed Restriction & Xing Board - Reflective	Assembly & Detail
W-HE-937	17	Signage	Instruction Boards - Reflective	Detail
W-H-443	18	Signage	Fault Reporting Label	Detail
W-HE-973	19	Signage	Predictor Marker – 50%, 100% & Positive Start	Assembly & Detail
W-HE-622	20	Boomgate	Location Case & Conduit	Typical Arrangement
W-CE-955	28	Boomgate	Clinometer	Assembly & Detail
W-F-591	29	Boomgate Counter Balance	Extension Arm	Detail
W-H-442	30	Boomgate	Booms Drive Down Warning Label	Detail
W-C-215	31	Boomgate	Retaining Latch	Assembly
W-H-393	32	Boomgate Retaining Latch	Mounting Brackets	Detail
W-H-438	33	Boomgate Retaining Latch	Warning Label	Detail
W-H-394	34	Boomgate Retaining Latch	Support Bracket & Latching Pawl	Detail
W-H-395	35	Boomgate Retaining Latch	Locking Bar & Latch Bolt with Nut	Detail
W-HE-1021	42	Flashlight	Mast	Detail
W-HE-939	43	W7-2-2 Sign	Multiple Track - Reflectorised	Detail
W-HE-940	44	R6-25B Sign	Railway Crossing - Reflectorised	Detail
W-HE-947	45	R6-25B Sign	Railway Crossing - Reflectorised	Fixing Detail
W-CE-1053	46	Boomgate	Aluminium with W7-2-2 & R6-25B Signs	Assembly
W-CE-1054	47	Flashlight	With W7-2-2 & R6-25B Signs	Assembly
W-HE-948	48	Boomgate	Signage Mounting Bracket	Detail
W-HE-886	50	Flashlight	Location Case & Conduit	Typical Arrangement
W-FY-101	51	Flashlight – Single Carriageway	0 to 74° Acute Angle Road	Layout

Drawing No.	Sheet	Drawing Title	Function	Type
W-FY-102	52	Flashlight – Single Carriageway	75° to 105° Right Angle Road	Layout
W-FY-103	53	Flashlight – Single Carriageway	91° to 180° Obtuse Angle Road	Layout
W-FY-108	54	Flashlight – Single Carriageway	Any Angle Road	Beam Alignment
W-FY-111	55	Flashlight – Dual Carriageway	Any Angle Road	Beam Alignment
W-FY-120	56	Flashlight	LED Lamps	Beam Alignment
W-CE-605	61	Cast Crossarm	2 and 4 way	Assembly
W-CE-644	62	Cast Crossarm	4 way	Detail
W-CE-645	63	Cast Crossarm	2 way	Detail
W-CE-646	64	Cast Crossarm	Cast Pivot Arm	Detail
W-CE-606	65	Cast Crossarm	Elbow & Socket	Detail
W-FE-1385	66	Cast Crossarm	Elbow Gasket & U Bolt	Detail
W-FE-1386	67	Cast Crossarm	McK & H Type Head – Spigot Plate & Gasket	Detail
W-FE-1428	68	Cast Crossarm	Junction Box Cover	Detail
W-FE-1670	69	Cast Crossarm	Pole Bracket	Detail
W-CE-637	71	Target Board	Hinged	Assembly
W-CE-638	72	Target Board Frame	Hinged	Detail
W-CE-653	74	Lamp Unit Hood	LED Type	Detail
W-HE-938	75	Driver’s Indicator	Mast and U Bolt	Detail
W-CE-1701	76	Driver's Indicator	Layout	Assembly
W-HE-941	77	Driver's Indicator	Signage	Detail
W-HE-1001	80	Road-Rail Vehicle	On/Off Tracking Prohibited Label	Detail
W-HC-2980	82	MRD Traffic Lights	MRD – ARC Interconnections	Schematic
W-HE-896	86	Westrak Track Circuit	2.2 or 3.9 Ohm Resistor	Assembly & Detail
W-HE-920	87	Remote Monitoring	RATS Sensor Bracket	Detail & Schematic
W-CE-1051	88	Switch Box	Free Standing	Assembly
W-HE-990	89	Road-Rail Vehicle	Remote Activation Radio Channel Label	Detail
W-HE-974	90	Signage	NO Standing between This Point and The Crossing	Detail
W-HE-977	91	Signage	Z Track – Reflective	Detail
W-HE-975	92	Signage	Predictor	Detail
W-HE-980	93	Driver's Indicator	Pushbutton Enclosure	Detail – Sheet 1 of 3
W-HE-981	94	Driver's Indicator	Pushbutton Enclosure	Detail – Sheet 2
W-HE-982	95	Driver's Indicator	Pushbutton Enclosure	Detail – Sheet 3
W-HE-768	96	Switch Box	Free Standing – Mounting Stand	Detail

Equipment Book M3 – Track Circuits

Drawing No.	Sheet	Drawing Title		
W-HE-638	-	Track Lead Connection	Wooden Sleepers	Detail
W-HE-766	-	Track Connections	Typical Installation	Detail
W-HE-801	-	Track Lead Connection	Concrete Sleepers	Detail
W-HE-873	-	Track Lead	Rail Attachment	Detail

Equipment Book M7 – Equipment Cases

Drawing No.	Sheet	Drawing Title		
W-CE-807	-	Location Control Case Type 1400	Earth Bonded Installation	Detail
W-CE-808	-	Location Control Case Type 750	Earth Bonded Installation	Detail
W-HE-887	-	Location Case	Base Installation	

Equipment Book M8 – Cable Ducting and Pits

Drawing No.	Sheet	Drawing Title		
W-HE-658	-	900 & 1200 Diameter Cover	Reinforced Concrete Inspection Lid & Horizontal Lifting Anchors	Detail
W-HE-788	-	Concrete Liner & Pit	600, 900 & 1200mm Reinforced	Detail
W-HE-918	-	900 & 1200 Dia Cover	Reinforced Concrete Inspection Lid & Vertical Lifting Anchors	Detail

Equipment Book M13 – Points – Electrical

Drawing No.	Sheet	Drawing Title		
W-HE-728	-	Self-Restoring Points	Indicator Type 2 – Mast & U Bolt	Detail

Equipment Book M14 – Equipment – General

Drawing No.	Sheet	Drawing Title		
W-HM-221	-	Unmetered Power Supply	Wiring Diagram	Assembly and Schematic
W-HM-222	-	Metered Power Supply	Wiring Diagram	Assembly and Schematic

Equipment Book M18 – Signage

Drawing No.	Sheet	Drawing Title		
W-HE-979	-	Axle Counters	Axle Counter Board - Reflective	Detail

Appendix 7 – Type Approved Equipment Reference List

The following list is not necessarily all inclusive and is provided as a guide only. It includes relevant Type Approvals and products currently approved for use on Arc Infrastructure:

Alstom Flashlight signal unit type FL-03 with white sidelights. Type Approval Certificate No PRS09;

Harmon 210mm Flashlight Signal unit type LED MOD 8/12 with white sidelights. Type Approval Certificate No PRS10. Restricted for use only in long-range applications where restricted off-axis visibility is acceptable;

Westinghouse 200mm Bright Medium Spread LED Flashlight Signal unit type RG4-RTFB43B48V1 to fit Western Cullen Hayes housing, with white sidelights complete with approved sidelight attachment devices. Type Approval Certificate No PRS11. Restricted for use on long–range applications;

Invensys Rail Level Crossing LED Flashlight Signals type RG4-RCF43B48V11. Type Approval Certificate No. WNRS33;

Invensys Rail Style U2L 2 Aspect LED Colour Light Signals. Type Approval Certificate No. WNRS43;

Westinghouse ‘Q’ and ‘B’ style miniature signalling relays;

Crompton Greaves ‘Q’ style miniature signalling relays. Type Approval Certificate No PRS07;

Selectrail ‘Q’ style miniature signalling relays. Type Approval Certificate No. WNRS41;

Mors Smitt ‘Q’ style miniature signalling relays. Type Approval Certificate No. TBA;

Safetran Grade Crossing Predictor Model 3000. Type Approval Certificate No WNRS29;

Safetran Grade Crossing Predictor Model 4000. Type Approval Certificate No. WNRS32;

Harmon HXP-3 Crossing Predictor;

GE Transportation Systems ElectroLogIXS XP4 Grade Crossing Predictor. Type Approval Certificate No. WNRS40;

Harmon Style C Crossing Controller type SCX-1;

Invensys Rail (Safetran) SSCCiii Plus Solid State Crossing Controller. Type Approval Certificate No. WNRS44;

Safetran Safe Highway crossing flasher type ‘Safe flash’;

Western-Cullen-Hayes crossing gate mechanism Model 10 - 3590 series;

Western-Cullen-Hayes crossing mechanical bell;

Western-Cullen-Hayes fibreglass and aluminium gate arm;

Invensys Rail S60 Level Crossing Barrier Mechanism. Type Approval Certificate No. WNRS39;

Invensys Rail Level Crossing Electronic Bell. Type Approval Certificate No. WNRS34;

Invensys Rail Level Crossing Barrier Arm. Type Approval Certificate No. WNRS35;

Magnetic Automation auto-locking pedestrian gate mechanism;

Broderson RTU8 Data Logger Part No UCR-2810/RTU20.D1/M;

Broderson RTU32S Data Logger Part No. BRS-28IO/1A005.11.

Broderson RTU Expansion Module Part No. UCL-28IO.D1.

Netcomm Industrial Modem Part No IG6000. Type Approval Certificate No PRS14;

Battery Energy Stationary pure lead acid batteries 57-360Ah. Type Approval Certificate No WNRS02;

Exide FaureX stationary pure lead acid batteries 50-660Ah. Type Approval Certificate No WNRS03;

Erico Surge Suppressor Part No UTB36-R2. Type Approval Certificate No WNRS05;

ABB MVR 600 Surge Arrestor. Type Approval Certificate No WNRS08;

Critec UTB9, UTB18, UTB36 transient barrier protection. Type Approval Certificate No WNRS11;

Powernet Battery Chargers ADC5000 series. Type Approval Certificate No WNRS16;

Phoenix Contact FLT25-400 surge protection devices. Type Approval Certificate No WNRS17;

Critec TRB-30-S3, RTB-50-S2 transient barrier protection. Type Approval Certificate No WNRS22;

Critec Transient Discrimination Filter Part TDF-3A-120V. Type Approval Certificate No WNRS24;

Novaris surge filter type SF105DIN and SF120DIN;

Phoenix Contact connecting systems - terminals, fuse holders, etc.

MOTPOL Pty Ltd Boom Arm LED replacement lamp. Type Approval Certificate No WNRS28;

Invensys Rail Level Crossing Barrier Arm LED Lights. Type Approval Certificate No. WNRS35;

Westrak Invertor – Ironcore type T3/59A (6v/10v);

Jeumont Schneider High Voltage Impulse track circuit;

Harmon Audio Frequency Train Activated Circuit AFTAC II.

Safetran PSO 4000 Phase Shift Overlay Track Circuit. Type Approval Certificate No. WNRS45;

Frauscher ACS2000 Axle Counters. Type Approval Certificate No. WNRS42;

Frauscher FAdC Axle Counters. Type Approval Certificate No.

Appendix 8 – Design Checklist

The following check list is provided for guidance only. Designers of level crossings must ensure that they have taken account of all necessary factors set out in this code. To produce a level crossing design the following information must be determined.

1. Name of Crossing. Normally taken from the name of the road crossing the track.
2. Arc Infrastructure Crossing Number. Provided by the Arc Infrastructure signalling drawing office coordinator.
3. Exact Location in track kilometres to nearest metre at centre of road and the section of line.
4. Layout drawing of the level crossing site and road approaches. Must show the angle of road(s) to track(s), location of masts, position of any insulated rail joints with respect to the edge of the road, location of location cases or equipment rooms, name of track circuits and power feed points if applicable.
5. Number of tracks. If it is possible for two or more concurrent train movements to occur then the crossing must be a boom barrier crossing.
6. Number of possible road approach directions. Drivers must be able to see uninterrupted warning signals on all road approaches to a level crossing. Are additional masts or additional warning signal crossarms needed to ensure this? Does vegetation need to be removed or signs or poles moved to provide this?
7. Road treatments. Does the road need to be altered to channel road traffic onto the desired approach to the crossing? Is the surface treatment adequate (stop lines etc.)? Is existing road signage on approach to the crossing adequate? Is vehicle queuing likely to be an issue?
8. Clearance distance of the level crossing. If this exceeds 15m then the warning time has to be extended by one second for every additional 3m.
9. Type of road traffic. If the site has long or slow vehicle movements on a regular basis, consideration may need to be given to adding buffer time to increase the warning time to ensure road vehicles have time to safely clear the crossing. If the site is to be a boom barrier crossing then this increase in warning time may need to be added to the time before the boom arms descend to allow road vehicles to clear.
10. Is there a pedestrian crossing associated with the level crossing? If there is, what level of pedestrian protection is to be provided? Does this involve a maze and additional warning lights, audible signals or even gates? All level crossings with a recognised pedestrian crossing component must have an audible warning signal.
11. If the crossing is in a signalled area, are signals located within the approach to the crossing? If so refer to section 5.7.
12. If the crossing is in a signalled area, are the track circuits used for signalling compatible with that proposed for train detection for the level crossing? Are changes needed to the existing signalling arrangements and/or signal operations because of the level crossing design?
13. Is the level crossing to have advance flashing warning signals? If so refer to section 7.4.
14. Is the level crossing to be interfaced to a road traffic signal system? If so refer to section 7.5.
15. Are there any special train operating factors that need to be taken into account in the level crossing design? These may include the need for shunting over the crossing approaches, regular stopping points, local permanent speed limits or irregular (seasonal) train operations.
16. What power system is to be used to power the crossing? Mains power is preferred with solar power only to be used when access to mains power is uneconomical. Solar arrays, where applicable, and batteries shall be provided and sized in accordance with section 8.5.
17. What facilities will be used for remote monitoring communications? NextG modems are the preferred means.