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Preface

This Standard was prepared by the Train Detection Development Group, overseen by the RISSB Train Control Systems Standing Committee.

Objective

The objective of this Standard is to provide the Australian rail industry with a set of mandatory and recommended requirements for the detection of all trains/rolling stock/rail vehicles to ensure that the signalling system receives reliable, accurate, sufficient and up-to-date information regarding the position and movement of all detectable trains/rolling stock/rail vehicles necessary for the safe control of the railway.

The Standard addresses the requirements of the train detection system for the use of signallers and other operators. It spans accuracy and detail of train detection information and sufficiency of update frequency such that the signaller or other operator can safely control the movement of trains, including (so far is reasonably practical) during periods of failure.

The use of this Standard will allow a uniform approach to be applied to: the design, installation, set up, testing and commissioning, modification, use, fault finding and disposal of train detection systems.

The Standard is intended to –

 provide a uniform basis for compliance with AS 4292 Railway Safety Management;

 be adaptable to different railway environments; and

 identify the risks (hazards) being controlled.

This Standard specifies the accepted criteria to be employed when designing, procuring, installing, maintaining, fault finding and monitoring train detection systems to ensure technical and safety integrity.

Compliance

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

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

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

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

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

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

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

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

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

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

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Section 1 Scope and general

1.1 Scope

This Standard specifies the safety, functional, and maintenance requirements for any member or participant of the Australian rail industry that is involved in any phase of the life cycle (as per the structure of the Standard) for train detection systems both rail-based and on train.

This Standard applies to all railways over 600 mm track gauge and can be used in miniature railways and amusement railways, sugar cane, tourist and heritage.

This Standard provides the minimum requirements for the application design of train detection systems. It does not preclude the application of higher performance standards (e.g., based on local experience and good engineering practice which can be contained in the management of train detection systems standards, codes, guidelines and procedures of rail transport operators).

A train detection system is equipment and systems forming part of, or providing input to, the interlocking system to detect:

(a) the presence or absence of detectable rolling stock within the limits of a track section; or

(b) that a train has reached, is passing, or has passed a specific position.

1.2 Normative references

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

- AS 1085.12, *Railway Track Materials - Insulated Joint Assemblies*
- AS 1141, *Methods for sampling and testing aggregates*
- AS 2758.7, *Aggregates and rock for engineering purposes Railway ballast*
- AS 4292.1, *Railway Safety Management – Part 1: General Requirements*
- AS 7501, *Rolling Stock compliance certification*
- AS 7505, *Signalling Detection and Interface*
- AS 7514, *Wheels*
- AS 7633, *Railway Infrastructure: Clearances*
- AS 7638, *Railway Infrastructure: Earthworks*
- AS 7651, Axle Counters
- AS 7639, *Track structure and support*
- AS 7640.1, *Railway Infrastructure – Rail Management*
- IEC 62053 (EN13509), *Electricity Metering Equipment (AC) – Particular Requirements*
- IEC 62280 (EN50159), *Railway applications – Communication, signalling and processing systems – Safety-related communication in transmission systems*
- IEC 62425 (EN50129), *Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling*

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

1.3 Defined terms and abbreviations

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

1.3.1

broken rail
fracture of the rail including a broken joint or weld, or detachment of a piece from the rail which necessitates an immediate stoppage of traffic or the immediate imposition of a speed restriction lower than that currently in force

1.3.2
driver machine interface (DMI)
system by which drivers can interact via controls and indications within a machine. The interface includes hardware (physical) and software (logical) components. Interfaces exist for various systems, and provide a means of input (i.e. allowing the users to provide data to the control system) and output (i.e. allowing the system to indicate the effects of the driver's manipulation or action)

1.3.3
train borne
systems located on the train

1.3.4
train protection and warning system (TPWS)
combines the elements of AWS with some train protection elements; this system will stop a train that passes a signal at danger within the overlap area beyond the signal

1.3.5
rail-based
within the rail easement, within the track right-of-way and relevant to rollingstock structure and clearance gauge

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

Section 2 General

2.1 General requirements for train detection systems

This section specifies the general requirements for train detection systems.

2.1.1 Environment

All train detection equipment shall be designed and installed to operate reliably in the environmental conditions in which it is to be located with minimum requirements for adjustment or recalibration to compensate for varying environmental or track conditions including:

(a) with ambient free-air shade as a guide in temperatures between -10°C and 60°C, and equipment housing temperatures up to 70°C;

(b) within the relative humidity ranges from 20% to 100% condensing;

(c) cyclonic wind conditions with associated heavy rainfall and water run-off;

(d) frequent lightning strikes;

(e) extended periods with little or no rainfall; or

(f) airborne dust.

Where track flooding might be encountered, train detection and any subsequent system integration and or protection/control measures should be defined by the rail infrastructure manager (RIM), to ensure the system meets the specific RIM operational requirements which are generally based on the site-specific risks.

2.1.2 Security

Train detection equipment shall be vandal and tamper resistant.

The performance of train detection equipment shall not be adversely affected by the use of enclosures and housings.

2.1.3 EMI

All train detection equipment, irrespective of the classification into which it fits, shall be provided with effective protection against electromagnetic interference (EMI) where this is necessary to ensure correct and reliable operation and avoid permanent damage.

External sources of EMI can include 50 Hz AC mains, conducted and radiated electrical noise generated by rolling stock as with electronically switched traction systems operating under 1,500 V DC and 25 kV AC traction, and under body induced noise from 3-phase induction traction motors in both electric and diesel-electric rolling stock as described in AS 7505.

Internal sources of EMI include noise generated by BRB 930 series relays, and high voltage impulse track circuits.

External sources of EMI can also include areas around the rail corridor, for example, industrial zones.

2.1.4 Electrical Safety

Personnel engaged in installation, maintenance and decommissioning shall not be exposed to electrical hazards due to incomplete or faulty bonding or fault currents (step and touch voltages).

2.1.5 Modular Design

Where possible, train detection equipment should be modular in design, to facilitate rapid replacement of failed modules and restoration to normal operation:

(a) Equipment modules of train detection equipment should have suitable coding to prevent insertion of any incorrect unit or type where such insertion would present a safety or functional risk.

(b) Wiring terminations on rack-mounted modules should be provided with means to eliminate the possibility of incorrect connections being made when a module is replaced.

(c) Modules should be so designed that no misconnection can render the train detection system less sensitive than before the change.

(d) All modules of the same type should be interchangeable without adversely affecting location specific programming of the system, i.e. should be simple and require a minimum amount of reconfiguration.

2.1.6 System Design

All electrical circuits and terminations used in train detection systems shall be of RIM approved corrosion resistant materials or protected from corrosion.

Train detection systems shall provide for simple measurement and setting of correct operating levels, and any subsequent adjustments.

Equipment and systems supplied and used for train detection systems shall be supported by the applicable procedure/maintenance manuals and rail transport operator organizational policies.

Technologies used for detection of rolling stock shall be fail safe and be type approved by the RIM, based on proven technology and preferably in-service with other railway operators in high density traffic areas.

System performance shall not be adversely affected by other adjacent systems nor be adversely affected by normal track infrastructure, track supporting structures or non-metallic objects.

Systems shall not be adversely affected by any vehicle/rail car on an adjacent track.

The resolution of a system providing speed measurement shall be designed to meet the intended function.

System design shall be such that any component failure shall not result in an unsafe condition and shall change the operation of the system so that the failure is evident, and output is forced into a more restrictive state.

The supplier of the train detection system shall provide details of the time for occupancy and vacancy of the system for the movement of the train. (this includes the system's processing delay times)

Detection systems shall be capable of detection when the vehicle/rail car enters the area protected by the system and shall maintain detection until the vehicle/rail car has passed beyond the limits of the protected area.

Unless it can be shown that the risk of a train becoming divided is acceptably low, the train detection system shall be capable of identifying and safeguarding against the effects of train division.

2.2 Reasons for the provision of train detection systems

Train detection systems perform a safety critical function providing the signalling system with timely information on the position of trains and the occupancy status of track sections. This is essential to perform its primary function of preventing collisions and derailments.

The principal reasons for providing train detection systems, as a sub-system within the train control system, are:

(a) to maintain safe train separation;

(b) to manage risk at level crossings; and

(c) to assist with traffic management.

2.3 Provision of train detection systems

Train detection systems shall be provided where:

(a) the safe operation of the train control system is dependent on accurate and up-to-date information on the position and movements of trains;

(b) information on the position and movements of trains is required for the control of level crossings, staff warning systems or other systems associated with safety of train operations; or

(c) it is necessary for the signaller to know the position of trains for the safe operation of the railway.

2.4 Detectable rolling stock

The train detection system used shall take into account the operation of detectable and non-detectable rolling stock. Rolling stock is assessed using the process described in AS 7501.

Detectable (by track circuits) rolling stock is defined in AS 7505.

2.5 Integrity and reliability of train detection systems

The reliability with which train detection systems detect and indicate the presence, absence or passage of trains shall be consistent with the overall safety performance targets for the train control system of which they form part, taking account of:

(a) the purposes for which the train detection information is required to be used and the possible consequences of an error in that information;

(b) any additional features within the train control system which provide safeguards in the event of incorrect operation of the train detection equipment; and

(c) any train-borne equipment provided to achieve (or assist in the achievement of) reliable actuation of the train detection systems (e.g., track circuit actuators).

Train detection systems shall be designed, applied and maintained in a manner which minimizes the risk to trains, the public and railway staff, from failure of:

(d) the train detection system;

(e) the means of communication of train detection information to the interlocking system or other systems; or

(f) associated power supplies.

When any significant change in the volume, speed or type of rail traffic is proposed, or there is a change in any other factor that could affect the safe operation of train detection systems, the RIM shall review the train detection arrangements to ensure that the integrity of the application is maintained.

Train detection systems and equipment shall meet the reliability requirements set by the Rail transport operator.

All train detection systems shall be designed and implemented such that no single component or single point of failure can result in unsafe operation.

All new train detection equipment shall be designed and meet safety integrity level equivalent to SIL 4, as defined in IEC 62425, *Railway applications – Communication, signalling and processing systems – Safety related electronic systems for signalling*.

Train detection systems shall be fail-safe in design; application and operation such that If any component or connection in an operating train detection system fails in any mode, open circuit, short circuit or an intermediate condition, the track section itself and/or one or more of the two contiguous track sections shall immediately indicate a detected state.

Train detection systems which rely on memory devices, e.g., axle counters, shall incorporate a safe means of bringing them back into use following any maintenance or other disruption or failure.

2.6 Suitability of train detection systems

The means of train detection, and the method of communication of train detection information to the interlocking system or other systems, shall be suitable for the purposes for which the train detection information is required to be used. Selection of a suitable system shall encompass, at a minimum, the following factors:

(a) The requirements of the train control system and/or the signaller for train detection information.

(b) The length of track sections over which detection is required.

(c) The level of accuracy and detail of train position information required for the safe operation of the railway.

(d) Permanent way layouts and associated critical dimensions.

(e) Requirements for the control of level crossings and train activated warning systems.

(f) The need for any directional and/or speed information.

The train detection system shall be compatible with the traction and detectable rolling stock.

(g) Compatibility with rolling stock parameters is required to ensure correct operation of the train detection equipment, including vehicle wheelbase, bogie length, wheel profile, wheel/rail contact and vehicle overhang.

(h) Electromagnetic compatibility.

The train detection system shall be suitable for the conditions in which it is to be installed and operated. Consideration shall be given to the following, insofar as they are relevant to safety:

(i) Environmental conditions.

(j) Compatibility with electrification systems (where present).

(k) Compatibility with other infrastructure systems.

(l) Compatibility with infrastructure maintenance and renewal processes.

(m) Ballast condition.

(n) Rail section.

(o) Other metallic objects.

(p) Guard rail.

(q) Interference from other sources.

In determining the type of system to be used, any secondary safety benefits and/or disbenefits shall also be considered.

2.7 Outputs from train detection systems

Outputs from the train detection system shall be presented as defined states (e.g., track section occupied or clear; vehicle present or no vehicle present at a specific location).

Transitions between these defined states shall not give rise to unsafe conditions. The train detection system and/or the associated train control systems shall be designed so as to ensure that no permanent or transient unsafe effects or misleading indications can result from any change of state in response to the presence or movement of a train.

2.8 Additional requirements for train detection systems

2.8.1 Output states

Where a train detection system is provided for the purpose of proving that a section of track is clear of rolling stock, the state of each track section shall be presented as clear or occupied. An occupied output state shall be given by the train detection system whenever all or part of the track section is detected as being occupied by rolling stock.

2.8.2 Continuity of train detection

Where the safe operation of the train control system is dependent upon continuity of train detection, there shall be no loss of detection at boundaries between track sections. Where a track section is divided into portions (e.g., track circuits through switches and crossings), there shall be no loss of detection of entire vehicle for any time passing between different portions of the track section.

2.8.3 Minimum length of track sections

The train detection system shall be designed such that no track section can be detected as clear while straddled by any detectable rolling stock. Where the train detection system does not inherently provide this feature, this requirement shall generally be achieved by ensuring that track sections exceed a specified minimum length.

2.8.4 Clearances

Train detection systems for proving the track clear shall be applied so as to ensure that acceptable clearances as specified in AS 7633 are maintained at all points and crossings and converging tracks, taking account of any line curvature and the maximum vehicle overhang of permitted rolling stock. Where a track section contains points and/or crossings, train detection provision shall at minimum extend to all applicable clearance points. It is permissible for train detection controls within the interlocking system to be conditional upon the position of points provided there is no risk of a vehicle standing foul and remaining undetected.

2.9 Interface management

Where there exists a planned railway activity interface which involves other parties, other functional areas or other railway operators, an interface agreement shall be in place.

Any agreed interface arrangements shall clearly delineate the responsibilities of each party or functional area involved.

Interface arrangements should include the following:

(a) Determination of the functional areas inside each organization which will be involved and the interfaces across which coordination needs to be established.

(b) Determination as to which party agrees to accept responsibility for each item of subject matter identified.

(c) Procedures for the exchange of safety information and for regular review of the arrangements

(d) Procedures for assessing and monitoring the compatibility of engineering and operational parameters.

Section 3 Requirements and types of rail-based train detection systems

3.1 Purpose

The purpose of this section within the Standard is to detail the rail-based systems and requirements of such systems associated with train detection.

Rail-based train detection systems operate over a defined range, continuously detecting the absence of trains.

Requirements for provision of track-mounted equipment (e.g., balises) to support odometry-based detection systems on trains are included in section 4.

3.2 General

Ballast resistance has a significant influence on the track circuit. In minimum ballast resistance conditions, adjustment of the track circuit requires more energy to be consumed to overcome the 'in-track' losses. As ballast conditions improve, a risk to train detection then arises as the detection sensitivity of the track circuit decreases. All track circuits shall operate satisfactorily over the range of ballast conditions as set by the RIM.

Train detection systems may also be used to confirm the presence of a train, such systems where provided shall comply with the same RIM requirements/specifications as those detecting its absence.

All track circuits shall operate and satisfactorily shunt at the minimum ballast resistance value for each type as set by the RIM.

Track circuits, except where impracticable due to special conditions or where single-rail track circuits are used, shall be insulated or isolated from all adjoining track circuits and from all non- track-circuited track.

All rail-based train detection equipment shall be adequately protected from lightning and other voltage surges, often transmitted or induced through power connection wiring and or track cabling.

Rail operators, where possible, should positively locate and protect signalling and communications cables and equipment used in train detection systems, in particular track cables making each location compatible with the operation of track tampers/compactors, ballast regulators and rail grinders.

Train detection systems shall be designed, installed and maintained in accordance with the RIM procedures and specifications so that the fastest time to detect a vehicle/train is always greater than the slowest time for system reactions for both the shortest and fastest trains accessing a network.

Each RIM shall identify whether rail-based train detection systems are required to provide broken rail detection (as far as possible) and if so, the RIM will apply train detection infrastructure to meet those requirements (e.g., track circuits versus axle counters).

Certain types of rail defects such as those that do not cause a clean rail break, cannot be identified by detection systems such as track circuits.

3.3 Electrified areas and immunity to traction currents

Within any one-track circuit, traction return should be arranged to follow a path of continuous rail in the main line or most travelled route, without any transpositions unless absolutely unavoidable.

Track circuits used in conjunction with electric traction shall provide an unbroken, low-resistance path for traction current to flow from train to substation, while maintaining the sectioning of tracks to provide a means of determining the location of a train.

Track circuit equipment and bonding shall be compatible with the traction return requirements for the type of electrification used.

All train detection equipment or systems attached or connected to the rails within electrified areas, shall be designed to be immune, and withstand the currents and voltages associated with the electric traction current.

In particular, where light rail systems are within close proximity or intersect, additional investigations and consideration shall be given to the effects of stray currents and harmonics from such interaction on train detection systems. The use of dual immune track circuits, feed end track relays or the installation of higher voltage track relays can mitigate these effects.

At all points/crossings, insulated rail joints, bonding shall be provided to ensure that track circuits operate effectively, and a traction return path is maintained. Train detection shall be maintained over all parts of the track circuit, and broken rail protection is maintained to the maximum extent permitted by traction bonding configuration.

Long single-rail track circuits should not be used in electrified areas.

Changes that lead to increasing or decreasing the traction return circuit impedance require the review and approval of the appropriate traction engineering authority and signalling department.

Where the length of track circuit is excessive, the levels of DC being superimposed may result in failure of the relay protecting fuse.

To obtain broken rail detection within DC electrified territory, it is desirable that cross bonds between neutral connections of impedance bonds on parallel tracks or between a neutral connection and a negative propulsion return cable not be located closer than at alternate impedance bond locations.

3.4 Non-electrified areas

Traction return bonding shall extend beyond the boundary of the electrified section sufficiently (taking account of train dimensions) to protect equipment and personnel from traction return currents due to electric trains over running the electrified area.

Appropriate measures shall be taken between electrified and non-electrified sections to apply immunity for both track circuits and for the return of any traction currents.

Where a non-electrified line is in proximity with a non-electrified line the bonding arrangements between the two shall be controlled in accordance with EN 50122.

3.5 Common detection systems

3.5.1 General

The electrical condition of any track section is the difference of potential between rails with no battery connected. Electrical track conditions for any given track section shall be maintained at levels as determined by the RIM.

Rail inductance and capacitance between the rails will influence maximum length of common type train detection systems.

Train detection for track circuits is the result of one or many axles making effective electrical contact with the surfaces of rails, providing a low-impedance path and thereby depriving a correctly adjusted receiver/relay of energy.

Train detection systems which depend on electrical contact between wheelsets and rails shall have a minimum shunt sensitivity to be determined by the RIM, over the entire length of the track section apart from interface zones between adjacent track sections (electric separation joints) or permissible dead zones.

An integral time delay shall be incorporated in the train detection system or the interlocking to prevent output of a track clear indication resulting from a brief loss of detection during the passage of a train through the track section.

Train detection systems shall use the minimum number of discrete operating frequencies or configurations required to provide effective isolation between successive track sections on one road, and between adjacent roads.

Train detection equipment shall not generate electrical or electromagnetic interference that affects the operation of existing signalling equipment which can include audio frequency track circuits operating at nominal frequencies of 1,700 Hz, 2,000 Hz, 2,300 Hz and 2,600 Hz, and ATP equipment conforming to ETCS standards.

All track circuits and other systems that use the rails as a conductor shall be selected and designed so that:

(a) multiple systems are only provided over the same section of track if their electrical characteristics are such that each system does not affect the performance of any other system in respect of reliability, sensitivity of detection, response time, and the performance of the safety function;

(b) where multiple units of the same type of train detection system are installed adjacent or in close proximity to each other (e.g., jointless audio frequency track circuits), they shall be electrically isolated from each other such that each unit correctly detects the occupancy status of the track section monitored. Failure of any components providing the electrical isolation shall cause one or both units to adopt their most restrictive state; and

(c) systems to be considered shall include cab signal systems, broken rail detection systems and other uses of the rails as an electrical conductor in addition to train detection.

At each extremity of a track circuit, in particular turnout/points tracks, the feed/transmitter and relay/receiver connections shall be as close as possible from the insulated joint to minimize any dead sections in the event of a broken rail. There shall be no welds between the rail connection and the insulated joint.

The characteristics and limitations are such that the following requirements shall be met:

The trains, rolling stock and other on-track vehicles intending and prior to their use shall be determined and approved by the RIM of being capable of being detected by the train detection system/s.

The clearance points at convergent tracks shall be as per the RIM specifications and proved for the dimensions and axle spacing of the trains, rolling stock and other on-track vehicles intended to be detected.

The train detection system shall ensure that vehicles can be detected at all extremities of the section of track being monitored.

The track section to be monitored, shall be of sufficient length to account for any inherent delays in detecting the presence and subsequent absence of the fastest train or on-track vehicle intended to be detected.

3.5.2 Coded track circuits

Where track circuits are not provided for train detection or signalling purposes, broken rail detection may be provided by the use of a pulsed or intermittent coded systems, which is acceptable for broken rail detection, provided the operation cycle is small compared with the time interval between train/vehicle movements.

Each RIM shall set and determine the information use and the maximum track circuit length for all coded tracks.

3.5.3 Track circuits (AC and DC)

Safe track circuit lengths are constrained by the range of ballast resistance encountered.

AC track circuits are sensitive to interference by stray mains frequency currents, resulting in potentially unsafe situations. RIMs should develop and maintain special maintenance precautions to ensure safe operation of installations using AC track circuits.

Track circuits when located within a traction area shall include arrangements to limit the maximum level of traction current which may be applied to the track relay.

Traction rails in single-rail track circuits shall be as direct and continuous as possible, including between sequential track circuits.

Where a relayed cut-section is used in territory where non-coded direct current track circuits are in use, the energy circuit to the adjoining track shall be opened and the track circuit shunted when the track relay at such cut-section is in de-energized position.

Where there are two or more tracks in parallel, current sharing in traction areas is provided between adjacent tracks, generally by means of impedance bonds or air cored inductors mounted in both tracks. In traction areas, cross-bonds are provided at regular intervals with no more than one cross bond per track circuit.

In areas of DC electrification, connections may be provided from the traction return system to buried services, to protect them against electrolysis damage from stray traction current. These connections may be passive, or active devices injecting up to 30 A DC into the rail.

3.5.4 High voltage impulse track circuits

High voltage impulse track circuits apply a brief but high voltage (typically hundreds of volts) pulses to the rail to overcome rail contamination.

The RIM shall define and approve the type of train detection system used over points and crossings, and where infrequently used tracks are located.

Where doubt exists as to the effectiveness of track shunting, then alternative solutions should be employed such as HVI or axle counters.

3.5.5 Audio frequency track circuits

Audio frequency train detection systems shall be capable of detecting track occupancy and broken rails, and provide shunt-fouling protection, where required.

Audio frequency train detection systems shall use frequencies or coded pulses that do not interfere with predictor-based warning systems.

(a) Audio frequency train detection system circuits shall operate at the RIM's specified frequencies, coding or modulation and track circuit length to a minimum of 2 ohms per 300 m distributed ballast resistance and, when applied as a part of railway level crossing approach track circuit, 2 ohms lumped ballast resistance at the crossing unless directed otherwise.

(b) Additional security such as coding or modulation shall be provided for all vital applications.

Manufacturers of audio frequency track circuits should provide equipment and applications to couple track circuit signals around insulated joints, from track to line wire, from line wire to track, from transmitter to line and from track to receiver.

Audio frequency track circuit transmitters shall provide a single frequency audio track circuit signal at stable amplitude, employing a secure means of coding or modulation ensuring that:

(c) the receiver gain of audio frequency track circuits shall not vary more than ±2 dB over the entire operating range of the equipment;

(d) system hysteresis shall be provided and maintained in receiver or by the relay characteristics or other electronics device operated by the receiver;

(e) transmitter level and/or receiver threshold shall be adjustable by field personnel to adapt to the RIM track conditions and parameters;

(f) signals applied to any audio frequency track circuit shall be modulated sinusoidal AC with no greater than 5% harmonic content; and

(g) bandwidth of modulated transmitter signal for audio frequency tracks shall be no greater than ±2% of fundamental frequency.

Audio frequency train detection transmitters and receivers shall automatically reset.

Audio frequency train detection transmitters and receivers should attempt a restart after a condition causing system shutdown has been eliminated.

Audio frequency track detection systems shall not generate any receiver drive voltage or output until self-initialization software and hardware testing have been completed to determine that the system is operating properly and as designed.

Audio frequency track circuits shall incorporate a time delay on the output to the interlocking. The intent of this time delay is to avoid the premature or false energisation of the track relay under momentary loss of shunt or block skip conditions and prematurely releasing safety route locking conditions.

Audio frequency systems shall incorporate a receiver output relay drive recovery time constant sufficient to avoid loss of shunt within or between track circuits.

Audio frequency track circuits shall operate independently of DC, AC or any other co-existing track circuits where system fundamental frequency is not present.

Audio frequency systems shall not energize any output relay with any level of DC or unmodulated AC applied to the receiver input.

Audio frequency track circuit systems shall operate on track where mains frequency and associated harmonics are present.

Audio and overlay track circuits may be susceptible to interference from harmonics induced from commercial power systems. Interference should be minimized through proper isolation, elimination of staggered rail joints and other means.

Where interference could exist, system operating frequencies shall be selected to avoid interfering frequencies.

Transmitters and receivers shall be provided with protection which enables them to operate for an indefinite period with the output of either one short-circuited or open-circuited, without permanent damage to the unit.

With RIM approval, audio frequency track circuits may be installed as conventional track circuits, separated by electrical separation joints or by insulated rail joints with impedance bonds to provide traction return continuity.

Where jointless tracks abut both ends of a section of jointed track circuits (e.g., at an interlocking) the frequency alternation scheme should be maintained for the audio frequency track circuits that abut each end of the jointed section.

Where a short jointless track lies between two long tracks (which will have the same frequency), the long tracks should be arranged with both transmitter ends abutting the short track or, if this is impractical, with both receiver ends abutting.

3.5.6 Overlay track circuits

When audio overlay track circuits are used, the frequency shall be selected to minimize interference with other adjacent circuits.

Track circuits including overlay tracks should be selected to be compatible with the traction system, and other RIM detection equipment on the network such as track circuits.

On jointed track circuits which use audio frequency or coding systems to differentiate between adjacent track circuits the manufacturer's recommended frequency alternation schemes shall be strictly adhered to, unless otherwise advised by the RIM.

Where overlay track circuits are provided for approach control purposes, the main track circuit shall indicate occupied when the overlay track circuit is occupied to draw attention to faults and thus minimize the risk of the overlay track circuit not operating as intended and permitting premature signal clearance.

Where overlapping of physically adjacent audio frequency track circuits occurs, overall application design and installation shall assure compatibility, without mutual interference, between all devices.

Audio frequency overlay track frequencies shall be selected to operate with expected minimum ballast resistance and track circuit length.

For overlay track circuits, the distance of pre-shunting shall be considered as part of the design and implantation (the primary consideration is not to replace signal before leading vehicle has passed it).

Ballast resistance, including distributed resistance and lumped resistance, should be maintained at levels which will allow proper operation of overlay and audio frequency track circuits.

3.6 Predictor systems

Predictors detect the speed of a train approaching a level crossing so that a constant warning time can be provided, irrespective of the train's speed (except for very low speeds).

If a change in train/vehicle velocity occurs on the approach to a level crossing using predictors, the actual warning time provided will differ from the warning time configured within the system.

Appropriate controls for managing any change in warning time for predictors, including network rules, should be implemented by the RIM prior to use on the system.

Predictor systems and equipment should be selected to be compatible with the traction system, and other equipment on the network.

Predictor systems shall be capable of detecting low ballast resistance conditions that would interfere with motion detection sensitivity or ability to detect track circuit discontinuity and shall interrupt the associated relay drive output if such low ballast condition exists.

Ballast resistance, including distributed resistance and lumped resistance, such as at level crossings should be maintained in accordance with the RIM procedures and standards or at levels which allow proper operation of the predictor system.

If normal rail traffic within areas where predictors are used will not provide adequate shunting, measures should be taken to improve shunting or track circuits which provide shunting under adverse conditions should be considered.

In the event the predictor detection system fails to properly self-check, the health output shall be set false.

Predictor systems shall be capable of operating safely with any type of movement, e.g., through moves, stopping and starting within approach or island limits (for any length of time), and switching moves (including reverse moves).

Predictors systems shall maintain awareness of train/vehicle presence at any point within its approach or island limits, including conditions of system reset or power loss.

A train/vehicle occupying the island limits shall remain continually detected regardless of whether it is stopped, and for any length of time.

Manufacturers of predictor systems shall define and ensure the user is aware if a system can differentiate between trains and on-track maintenance equipment (e.g., tampers, road-rail vehicles).

For systems that cannot differentiate between types of vehicles, such as road-rail vehicles versus trains, the system shall not be falsely activated or otherwise adversely affected when such a vehicle enters or leaves the approach or island limits without completing a normal through move (e.g., is removed from the track within the approach or island limits).

Operation of the island detection system for train prediction systems shall not depend upon previous knowledge of an approaching train.

Train predictor systems shall operate independently of DC track circuits and other track circuits where circuit impedance is constant and interference is not present at system frequency.

Approach track circuits for train predictor systems shall be defined with termination shunts and insulated joint bypass units (IRJ bypass units used only at locations where they do not affect track circuit operation and cab signal is not used), where required, in accordance with the RIM's instructions and shall not interfere with operation of other signalling or detection systems.

Where overlapping or adjacent audio frequency track circuits are used, overall application design and installation shall assure compatibility, without mutual interference, between all devices.

Frequency and approach track circuit length of predictor systems shall be selected to operate with minimum ballast resistance.

Where predictor systems are applied in bi-directional approach applications, approach track circuits shall be of equal length or balanced by the addition of passive components in series with the termination shunt.

DC and electro-mechanical coded DC track circuits shall be isolated from predictor systems via the use of reactors and/or filters as detailed by the manufacturer and in accordance with RIM's requirements.

Calibration and shunt tests shall be made on each approach and each island track circuit per manufacturer's and RIM's requirements.

Train/vehicle moves through predictor-controlled areas should be observed as instructed by the RIM to ensure; demonstrate and document that the system is capable of operating in accordance with its design and purpose.

Special tests for entry in and or out of alternative roads/sidings if required, shall be carried out according to manufacturer's recommended applications and RIM's instructions and procedures.

3.7 Proximity loops and switches

Non-vital car detection system shall neither interfere with nor be adversely affected by track circuits, cab signalling, locomotives, radios, data communications and EMI environments of electrified territory.

Systems shall detect the presence of a train/vehicle regardless of car construction, contents or physical configuration

Proximity detectors should have a minimum of three selectable operating frequencies.

The performance of non-vital car detection systems relies on the rails within the area being bonded to the same RIM standards as for conventional track circuits.

Non-vital detection loops should be securely fastened to prevent movement relative to track, metallic track components, and the loop wire itself so as to stabilize loop inductance.

In using non-vital car detection system using inductive loop proximity detectors to ensure correct operation and performance:

(a) loop wire shall be protected against dragging equipment in accordance with RIM standards; with Loops installed so as to minimize any tripping hazards;

(b) the clearance of installed proximity loops should be greater than 100 mm, between the loop wire and gauge plates; the loop wire at a point of crossing; and other non-movable metallic track components;

(c) a minimum clearance of 300 mm should be maintained between the proximity loop wire and any point/turn out rodding and other movable metallic track components;

(d) where possible a minimum separation of 1,200 mm should be maintained between the perimeter of a loop and the near rail of an adjacent track;

(e) the minimum separation between adjacent loops on the same track should not be less than 800 mm unless otherwise approved by the RIM;

(f) where track circuits are not present, hard wire shunts should be installed as per the RIM design standards;

(g) for use in point & turnout locking; provision should be made for loops to extend beyond the intended protection zone to assure detection of cars. This distance will depend on the size of the loop, sensitivity of the detection system, and type of equipment being detected;

(h) for single loop detection systems lineal distance from beginning to end of the loop should not be less than 10 m or greater than 30 m;

(i) for multiple loop systems any side of loop shall not be shorter than 3 m and shall comply with the RIM's specifications;

(j) loops longer than 10 m should be transposed near the centre to prevent detection of equipment on adjacent tracks;

(k) proximity detectors should be capable of resuming normal operation if intermittent or failed loops self-heal; and

(l) proximity detectors should be designed to not automatically re-tune after a power interruption.

Where several proximity detectors are used and their loops are in close vicinity to one another or high frequency track circuits are used, power might need to be removed from adjacent units and the high frequency track circuits while each individual unit is tuned.

In order to test non-vital proximity loops and detectors performance, a frequency-reading device, or frequency meter connected to the proximity detector output may be used as rolling stock is slowly moved through the loop.

Periodic testing as per the RIM procedures, should verify that different vehicles and cars cause a sufficient frequency shift past the detection trigger point before an output is indicated. Such testing shall include tests to verify proper detection, especially under skeleton cars and long frameless tank cars.

3.8 Treadles and non-vital wheel detectors

Treadles are a train detection system that can be used to augment, or as an alternative to, track circuits. Treadles may be used to provide additional information on train location such as speed discrimination.

Treadles, their type, position and application shall be approved by the RIM.

Mechanical treadle type detectors should have sufficient vertical movement to permit the actuator arm being depressed at least 25 mm greater than any wheel flange would depress it.

Wheel detectors used in non-vital applications shall be mounted and operate properly while retaining sufficient clearance between wheel flange and top of device to minimize the possibility of damage from worn wheels or sharp flanges.

Wheel detectors used in a non-vital application shall:

(a) provide one output pulse or indication for each wheel passage at all speeds within its rated operating range;

(b) not interfere with, or be adversely affected by track circuits, cab signalling and any electrical interferences associated with the environments of a railway; and

(c) be designed to prevent false operation from any parts of a railway vehicle and or locomotive frame or its body; other than the wheel.

Wheel detectors used in non-vital applications should remain undamaged when exposed to shock and vibration of normal railway operations and not be adversely affected by metal fillings.

Wheel detector devices designed to provide wheel detection down to zero speed shall provide a continuous output indicating wheel presence whenever a wheel is stopped on top of it.

Wheel detectors for non-vital applications devices designed to provide wheel direction information shall provide a different output signal or code for each direction of wheel passage.

3.9 Axle counting systems

Axle counter systems adopt a totally different approach to the detection of trains. Instead of continuously checking the whole of the track section for the absence of vehicles, axle counter systems monitor entry and exit of axles at the extremities of the track section.

Axle counter systems are a train detection system that may be used to augment, or as an alternative to, track circuits.

Where axle counter systems are used, they shall comply with the requirements of AS 7651.

3.10 Automatic train protection (ATP) and cab signal

When the coded signal changes in response to cab signal requirements, detection of occupied or clear status of the track circuit shall be maintained

Where cab signal equipment and track circuits share the same rails, track circuit equipment and bonding shall be configured so that the transmitted cab signal is continuously detected by trains over the full length of the track section for all applicable movements.

3.11 Bonding

Within a track circuit, traction and signalling bonding shall be utilized and arranged to electrically connect all parts of point/switch layouts in order to detect a train/vehicle or rail car on each and every part of the track circuit.

Bonding of points/switches for signalling and traction shall be arranged electrically to connect all parts of point/switch layouts, to provide maximum broken rail detection of both rails in the main line and maximum assurance of train detection in the turnout.

If the rail sections through a point/switch layout are longer than the shortest train/vehicle which can possibly not be detected if some bonding is missing or damaged, then series bonding is best employed.

For the purpose of improving broken rail detection over point/turnouts additional receivers/relays rather than full parallel bonding shall be used unless otherwise approved by the RIM.

Bonding for double rail track circuits shall be achieved by the use of separate receivers/relays on each leg of the turnout. Where this is not practicable, special parallel bonding arrangements for the turnout leg of the track circuit may be used with the RIM's approval.

Where a track circuit configuration requires two or more receivers/relays, a minimum of two bonding cables shall be used for the series bond connecting each rail of a turnout to its respective rail on the main line.

The traction connection to rail is generally made to a track circuit neutral point, in one of the following ways:

(a) To the neutral point of a conveniently located existing impedance bond.

(b) To the centre-tap of a conveniently located air-cored inductor in a tuned loop, if available.

(c) To the centre-tap of a purpose-designed iron-cored inductor, connected across the track circuit at the required connection point.

Traction return continuity at interfaces to other track circuits, or where insulated rail joints are required to provide a very sharply defined cut-off point, shall be achieved by means of impedance bonds in DC traction areas or air cored inductors in AC traction areas.

Traction return faults could result in momentary high current levels in the order of 5,000 A to 10,000 A, for durations of less than 1 s.

In electrified areas, where single-rail track circuited or non-track circuited track is in use, the traction current return rails shall be bonded directly to the negative bus bar, unless adjacent siding or refuge tracks provide supporting parallel paths.

Each bonding conductor shall be of sufficient conductivity that the track relay or equivalent electronic device will detect an occupancy when occupied or shunted.

In DC electrified areas where jointless track circuits are in use, the connection to a substation shall be made at mid track, if possible, but at a minimum of 50 m from any track circuit tuning unit connection. Impedance bonds in these situations shall be resonated as required.

Where the connection cannot be made 50 m from the junction of two jointless track circuits, they shall be treated as conventional double rail track circuits and shall require IRJs in each rail and Impedance bonds including a connection to the substation negative busbar from the neutral point of the bonds.

High voltage impulse track circuits are generally not suited to the connection of additional impedance bonds mid-track.

Connections to substations shall be made across the junction of two track circuits specifically sited for that purpose.

Double rail track circuits when used in electrified areas should be bonded similarly in each rail to ensure the traction currents are balanced.

Dissimilar bonding in one rail will cause an unbalanced condition of the track circuit leading to saturation of the impedance bond

Rail joints and track circuit connections within road crossings, on bridges, within tunnels or in station platforms are not recommended, but where joints exist where rail bonding is inaccessible, all joints shall be double bonded as a minimum.

Bonding and track connections shall be installed as per the RIM's standards, with cabling protected where possible so as to reduce the possibility of conductors being broken by dragging equipment.

The rating of impedance bonds shall meet or exceed the designed traction current.

Rails connected by parallel bonding shall not exceed 50 m in length and the track circuit parameters shall conform to the manufacturer's recommendations.

The use of complex, multi-branched track circuits shall be avoided.

Any track circuit which branches three or more ways should be subdivided into two or more simple track circuits.

Detection system and track circuits plans/diagrams shall accurately reflect the relative positions of items on track. Bonding layouts which appear feasible on paper could be complex and unmanageable in the field.

The signalling rail of the single-rail track circuit shall be bonded to the same standards as the traction rail with exception of series bonds, which need not be used or rated for traction return current.

Transitions, where insulated joints and bonding are provided to swap the traction rail between the up and down rails of one track circuit, or between contiguous track circuits, shall not be permitted except subject to prior specific individual design approval by the appropriate RIM design authority.

Unless otherwise approved by the RIM, series bonding shall not be used for traction current return purposes. The sole exception to this requirement is the series bond connecting the turnout leg of a set of points with double receivers.

Parallel bonding shall be installed to the RIM's standards. If not stated it shall be fully visible throughout its length, and not be permitted to become hidden or buried by ballast.

Cross bonding is normally responsible for passing one third to one half of the traction current generated on one road to the parallel road. In fault conditions the cross bonding might have to carry the full traction load.

Cross bonding could, under certain bonding fault conditions, allow circulating signalling currents to interfere with the safe operation of the track circuit. It is for this reason that cross bonds shall be separated by a clear track circuit.

On multiple-track lines, cross bonds shall not be installed between track circuits of the same frequency.

In electrified areas, parallel roads shall be cross bonded together as frequently as required by the Traction Authority.

Where impedance bonds are used to change from a single-rail to a double-rail track circuit, the total number of neutral leads specified shall be connected to the common (traction) rail of the single-rail track circuit.

Where tracks are wired for electric traction but not track circuited, their rails should be bonded together and cross bonded into the adjacent traction return system at their extremities and at intermediate points, depending on the length of the track involved.

Within traction areas, where double rail track circuits including audio frequency track circuits are used, bonds from the negative busbar shall be connected to the rails via the neutral points of paired impedance bonds on each track.

Cable connections to the rail for both traction and signalling shall be of the approved RIM type and method, with conductors kept as short as possible.

Bonding and cable connections (traction and signalling) and detection components attached or forming part of any rail (insulated rail joints) could experience one or more of the following mechanical effects:

(d) Vibration due to heavy axle loads, maintenance functions; or inadequate support from ballast and formation.

(e) Flexing of the rail.

(f) Rail creep due to a predominance of traffic in one direction

(g) Anchoring of the rail to the sleepers.

(h) Thermal expansion.

(i) Damage by track maintenance equipment.

(j) The intentional movement of point switches.

3.12 Impedance bonds

In DC electrified areas, where double-rail track circuits (including jointless track circuits) are in use, the connection to the rails shall utilize two impedance bonds of the appropriate rating.

Impedance bonds intended for DC traction systems shall be so designed that the traction current in one half of the winding can exceed that in the other half by 12% of the total (two-rail) continuous capacity of the bond without the impedance decreasing more than 10% at the stated impressed signal voltage, or as instructed.

Where the expected current loadings exceed the rating of the 2000 A per rail impedance bonds, approval from the RIM shall be required and impedance bonds combined with jointless track circuits may be used.

3.13 Air cored inductors

In AC electrified areas, where double rail track circuits (including jointless track circuits) are in use the connection to the rails may utilize air cored inductors. They shall be rated to the maximum load and fault current provided by the traction system. The maximum load and fault current shall be detailed in documents that are approved by the Traction Authority.

3.14 Insulated rail joints

Insulated rail joints shall conform to AS 1085.12 in addition to any additional tests and requirements as specified by the RIM.

Unless specified otherwise by the RIM, all new and where possible replaced insulated rail joints, shall be factory prepared, glued, reinforced, tested and installed in accordance with the RIM's specifications and policies.

In locating insulated rail joints consideration shall be given to minimum wheelbase, maximum clear span and lateral clearance of equipment.

Track insulated rail joints shall be positioned so that no engine/vehicle can be foul of the points without the points track circuit/s being proved and indicated as occupied.

Insulation between rails within a turnout shall be provided in the diverging or least used track, unless otherwise specified. Such insulated joints may be staggered with approval by the RIM, but only to a distance that is less than the minimum bogie wheelbase of any vehicle.

When the traction rail changes from one side to the other, at transitions, or in turnouts, care shall be taken to ensure the joints are so arranged that a continuous traction return path is provided for each axle on the train/vehicle over the transition.

Where insulated rail joints are used for separation for track circuits of the same type, the polarity of adjacent track circuits shall be alternated to ensure that the integrity of the insulated rail joint is monitored unless otherwise approved by the RIM.

Where friction buffer stops are provided on track circuited lines, insulated joints should be provided before the buffer stops to ensure the correct operation of the track circuit.

Section 4 On train detection systems

4.1 Purpose

The purpose of this section is to detail the on-train systems and their interactions associated with train detection.

The purpose of on train detection systems are to constantly acquire or generate train position information and transmit this information securely to the signalling system and to provide information to the on-board train propulsion/braking systems.

4.2 General

On-train detection systems using odometry to measure a train's position on track shall also utilize sufficient absolute position references (e.g., transponders) to minimize errors in position reporting. Position references shall be unique to the line of route, individual track and position along the track.

Position reporting shall ensure that the train's length is taken into account when determining the occupancy status of track sections.

(a) Where all trains are of the same length or within a set maximum length, the length may be set as a system-wide parameter.

(b) Where trains may be of variable length, the vehicle transmitting the train's length shall have a current and correct train length value.

(c) Where there is a credible risk of a train becoming divided, the position report shall confirm that the train is intact.

(d) Position reports shall take account of applicable offsets and errors between the transponder reading equipment and the front and rear of the train.

All locomotives, self-propelled vehicles and vehicles with a driving position operating in the on-train detection system limits shall be equipped to report their position.

Vehicles not equipped to report their position shall only operate over tracks using on-train detection systems when coupled to a locomotive or vehicle capable of reporting position.

Vehicles that cease reporting their position shall have their movement authority restricted so as to maintain safe separation. Train protection systems shall ensure this restriction is enforced.

Vehicles where position reporting equipment is not operational shall be prevented from entering tracks using on-train detection systems.

On-train detection systems shall be supplemented by other systems where there is a risk that unfitted vehicles or vehicles with inoperative reporting systems may be required to stand or operate.

On-train detection systems using GPS/GNSS without odometry shall:

(e) be designed so as to maintain safe separation taking account of system errors, temporary unavailability of the satellite signal and possible failure modes of on-board equipment; and

(f) where necessary, supplement the position reports with additional data and processing to ensure the reported position is not wrongly interpreted as being on an adjacent parallel track.

4.3 System types

4.3.1 Automatic train protection (ATP)

This Standard does not capture ATP and similar technology, although its use can be considered with regards to interfacing and legacy systems in use.

4.3.2 GPS/odometry systems

All systems used for determining the location of trains for the purpose of train operations shall satisfy the following requirements:

(a) All train location system and detection systems shall have an accuracy and latency which are not only agreed by the RIM, but which appropriate to the method for the safe separation of trains and the signalling system.

(b) The level of integrity and availability of the train location system shall be consistent with the overall safety integrity of the signalling system.

Odometer based train detection systems shall ensure that odometry and distance systems errors are removed or zeroed every time a transponder is encountered. For avoiding impact of a single point failure, such systems should be designed to function even if one transponder reading is missed, which means distance error does not reach its maximum permitted value before the next transponder is read.

The interface mechanisms, the level of integration, and accuracy for the use of GPS tracking technology used to supplement or enhance train detections system such as in positive train control (PTC) shall be agreed by the RIM prior use.

Mitigations against a loss of signal used in global navigation satellite system (GNSS) / GPS train positioning/detection systems shall be provided.

Train integrity or mitigations against the loss of a car from a consist/train should be provided for vehicles/cars not fitted with active train detection equipment. Such mitigations include other RIM approved methods of train detection, such as rail-based detection systems i.e. track circuits/axle counters.

Section 5 Design requirements

5.1 Purpose

The purpose of this section is to describe the specific design requirements that are applicable to train detection systems to ensure:

(a) train detection systems meet and exceed the RIM and system safety requirements for such systems;

(b) train detection systems accurately; consistently and unambiguously report the position of trains/vehicles;

(c) train detections system performance remains within operational parameters by all outside, electrical, mechanical and environmental influences to which they are used within;

(d) train detection systems provide for the display of information for the use of signallers and other operators, and that the train detection information is of sufficient accuracy and detail, and updated sufficiently frequently, that the signaller or other operator can safely control the movement of trains, including, so far is reasonably practical, during periods of failure; and

(e) train detection systems where required to prove both the presence and the absence of a train or rail vehicles may, where practical, allow an undefined state whenever the train or vehicle detection system or associated transmission system or power supply has failed. If it is not practical to record an undefined state, the failure modes need to minimize the risks to trains or rail vehicles. If it is not practical to record an undefined state, the system shall trigger such failure mode which minimizes the risks to trains or rail vehicles.

5.2 Performance requirements

Train detection system design shall ensure that no track section can be indicated as clear while occupied by minimum vehicle length bogie wheelset and shall show occupied even if only one wheelset at the front or rear of the train occupies a track section.

In order to meet the design characteristics, safety, reliability targets (without exceeding limitations) of train detection systems such as track circuits or axle counters, the following RIM application requirements shall be satisfied:

(a) Trains, rolling stock and other on-track vehicles intended to be detected shall maintain the characteristics (without deviation) required to make each vehicle/car/train capable of being detected continually, and reliably by detection system employed.

(b) The clearance points at convergent tracks shall be defined and verified in accordance with the RIM specifications for all dimensions and axle spacing of the trains, rolling stock and other on-track vehicles as intended to be detected.

(c) Track circuits shall be longer than the maximum axle spacing on any unit of rolling stock or on-track vehicle that is expected to be detected.

(d) The interconnection of the rail segments and the location of the connection of the track circuit devices shall ensure that vehicles can be detected at all track circuit extremities.

(e) The track circuit shall be long enough to account for any inherent delays in detecting the presence and subsequent absence of the fastest train or on- track vehicle intended to be detected.

High voltage impulse type track circuits may be a suitable alternative that ensures reliable operation under turnouts and crossovers where there may be infrequent operation of trains over one of the legs of the turnout. Axle counters are a suitable alternative.

Designers of train detection systems shall ensure, where appropriate, the RIM's re-set and maintenance procedures for such systems (I.e. axle counters or track circuits) have been incorporated into any design.

Dead or undetectable train detection zones/lengths shall be as defined and as determined by the RIM.

The design of train detection equipment/systems should:

(f) limit the impact of operational failures;

(g) limit the use of common power supplies;

(h) avoid the unintentional powering down of the equipment for resetting purposes; and

(i) where appropriate, contain power supply and internal circuit protection.

Designers shall ensure that any component failure within a train detection system that could result in unsafe operation because of successive component failures shall result in an occupied output state.

Train detection equipment and detection systems attached to rails or located within the rail easement shall be designed and protected so as to avoid damage by normal train operations, and track maintenance plant and equipment.

The amount of equipment in the danger zone shall be minimized.

Train detection equipment shall be installed such that it is easily accessed and can be maintained safely.

Track mounted detection equipment/components and systems contained within the rail easement shall be designed and installed to ensure equipment in each classification can withstand without damage and continue to operate correctly under extended periods of vibration conditions.

For reliability and in order to meet the RIM's safety requirements and standards, the designer shall assess the interaction between the transmitted signal level, the signal level required to energize the receiver, the series impedance of the rails, the parallel impedance of the sleepers and ballast (which usually varies according to weather conditions) and the impedance of wheelsets.

The designer should consider the RIM's operating environment and consider whether more severe protection is required and specify this requirement to any equipment supplier.

Condensation on and within equipment can occur under some combinations of temperature and humidity. Train detection equipment shall be protected from condensation and continue to operate correctly under these conditions.

Train detection equipment shall be designed such that self-generated heat which results in temperatures within the unit higher than the specified maximum ambient does not result in incorrect operation or permanent damage.

When designing track circuits, care shall be taken that the length of the circuit does not lead to a voltage drop along the signalling rail which could result in circuit/equipment reliability issues or failure. The traffic flow, gradient and the location of the nearest substation are significant factors in determining both the magnitude of the problem and its solution.

In designing a yard area containing train detection systems and where the layout renders it impossible to maintain polarity reversal at every insulated joint for track circuits, the design shall be adjusted to make the like polarities appear at a feed-to-feed interface:

(j) The polarities of adjacent track circuits shall be staggered for feed/feed and relay/relay configuration unless otherwise approved.

(k) Audio frequency type track circuits shall maintain the correct alternation of frequencies or separations on each line; and any adjacent lines.

Track insulation such as insulated rail joints should be designed and provided in accordance with the RIM procedures and standards to use the minimum number of joints.

5.3 Suitability and selection of train detection systems

The means of train detection, and the method of communication of train detection information between the receiver and transmitter, relay and feed, evaluator and counting head, to the interlocking equipment or other systems, shall fit the requirements of the RIM, be suitable and secure for the purposes for which the train detection information is required to be used.

A consistent approach to the identification of detection areas to track sections shall be adopted to complement the style of signalling for which they are provided.

In selecting a suitable detection system, the following factors shall be considered and their associated risks controlled:

(a) The requirements of the signalling system and/or the signaller using any such train detection information.

(b) The level of accuracy, timeliness and level of detail of train position information required for the safe operation of the railway.

(c) Track/permanent way layouts and its associated critical dimensions such as clearance/fouling points.

(d) Requirements for the interfacing; initiation and information needed for the safe operation/control of level crossing systems and Train and Vehicle activated warning system.

(e) The need for any directional and/or speed information.

(f) Contaminated rail surfaces due to environmental conditions or insufficient use.

(g) Areas exposed to, or subject to sudden changes in normal weather conditions, such as high heat, high rainfall, flooding, dust or snow, etc.

(h) Narrow rail head contact bands that could develop over time due to homogeneous traffic and well aligned rails.

(i) Poor quality track ballast resulting in lower shunt sensitivity due to leakage currents or contamination could impact reliability and or safety of the system.

(j) The provision of appropriate procedural controls to manage situations where the passage of vehicles that could not be adequately detected is necessary.

(k) Faster trains causing pre-shunting or early pick up by detection systems and should cater to future train performances of both braking and acceleration.

(l) Detection requirements for maintenance plant, road-rail, and track vehicle use.

(m) Areas subject to sudden high wind loading lowering wheel to rail connection.

(n) The effects of atmospheric discharge and electrical interference on system performance and reliability.

(o) The stopping location of trains.

(p) The maximum speed of the train/vehicle intended to be detected at that location and if applicable the vehicle's braking system and allowance for performance characteristics of future rolling stock.

(q) The design and construction of the wheels of the train/vehicle or on-track vehicle intended to be detected, being the material, the diameter and width.

(r) The physical dimensions of the trains/vehicles to be detected, including the length of overhang i.e. the portion of the vehicle that extends beyond the extremity axles that are expected to be detected and the extent of the width of the vehicle in relation to the track centre line.

(s) Lightning protection, surge protection and earthing.

The train detection system should be configured and selected to detect the presence of broken rails, including through points, to the maximum extent possible while meeting critical configuration and performance requirements.

Axle counters, treadles and similar systems shall be selected to be compatible with:

(t) wheel construction and wheel diameter;

(u) flange wheel depth, wheel profile and wear condition;

(v) axle spacing;

(w) speed of trains passing counting or detection heads;

(x) rail head mounting position, rail profile, rail wear and rail maintenance (rail grinding and replacement); and

(y) any other objects on the train which could cause a miscount, for example, track brakes.

Where heavy DC traction currents are present, with RIM approval, a shielding or a balancing impedance should also be installed in connection with the track relay to protect against direct current in the relay windings.

5.4 Power supply

Train detection power supplies shall be designed and constructed to maximize immunity to environmental conditions and input power conditions which may contain significant levels of harmonics and other noise, and be subject to voltage surges, dips, skips and brownout situations.

All wiring and polarity of power supply terminals shall be clearly and indelibly marked/identified. Train detection power supplies shall be designed and be tolerant to:

(a) brownout, or long-term reduction of input supply voltage, for periods exceeding 1 s or surge or short-term increase in supply voltage, of duration exceeding 200 ms (10 cycles);

(b) dips or short-term reduction in supply voltage of duration not exceeding 1 s. Skip or short-term reduction of supply voltage to zero, for duration not exceeding 1 s; and

(c) radiation, spikes and surges including those caused by faulty traction systems or consists, generally resulting in very short-term increase in voltage, with fast rise time, duration less than 1 ms, and voltage exceeding normal lineal factor of 5 or more.

Power supplies for train detection systems shall have sufficient regulation for the application. Each RIM shall:

(d) consider if redundancy on power supplies is required; and

(e) the level of redundancy required.

The back-up power supplies systems for train detection systems, shall be designed and installed so as to maintain the normal operations, functions and outputs of the detection system (without any noticeable fluctuation change over) for a period of time in excess of the standard response time for maintenance staff to attend the site.

In the event of an extended power supply interruption that results in the train detection system shutting down, the system should restart and initialize without manual intervention, and on completion of its start-up and initialization cycle should be able to immediately indicate the true state of occupancy of the track section. If it can't indicate true state (e.g., axle counters), it should indicate either an indeterminate state or its most restrictive state.

If the system re-initialization requires a manual reset procedure, such procedure shall not permit the generation of a false track clear indication.

A manual reset procedure should be able to be completed promptly, to enable early restoration of normal rail operations.

Where power phase dependency relationship is a requirement for reliable and safe operation of a Train Detection system, such phase relationship shall be maintained between supplies at both the feed/transmitter and relay/receiver ends.

When adjacent power systems or cathodic protection systems are to be installed or are in operation within the vicinity of railway, testing using IEC 62053 as a reference should be carried out to determine its effects on all train detection systems.

5.5 Communications

All executive and vital system software for train detection systems, including all self-checks, shall be installed and maintained within the system in accordance with the RIM's procedures and standards in a manner that will prevent unintentional changes by the user.

Where the vital train detection system uses data communications links, then the data communications link shall meet the requirements of IEC 62280 (EN 50159) Safety related communication in transmission systems.

The safety integrity level (SIL) of the safety-related transmission systems shall be consistent with the safety integrity level of the train detection system. For example, a SIL 4 axle counter system will require a SIL 4 data communications link (to IEC 62280) between the equipment at the ends of the track section.

The design of the vital data communications link shall be approved in the same manner as for the vital train detection system.

5.6 Track circuit lengths

The maximum length of track circuits is limited by the net effective shunt resistance across the track including the effects of any impedance bond used for tying in or connection substation section huts. Interfaces to other systems and signals equipment

Section 6 Interfaces to other systems and signals equipment

6.1 Purpose

The purpose of this section is to ensure that an entire rail systems approach is taken and all input and output from train detection systems are captured, and that all rolling stock interfaces are considered.

6.2 Input/output requirements

Train detection systems shall be integrated into the signalling interlocking system such that the detection of the train is registered, and the appropriate actions as designed by the system are acted upon.

The output interface of the train detection systems shall be capable of:

(a) directly driving a relay;

(b) driving directly into a computer based interlocking (CBI) input; and

(c) switching a load device by means of one or more isolated output relay contacts.

Output relay contacts of a train detection system shall be in an open state when indicating an occupied state unless otherwise approved by the RIM.

Outputs of train detection systems shall be electrically isolated from any input, power supply or any other electrical connections in the device.

Train detection systems which directly drive an output relay shall be compatible with the incorporation of a track stick circuit function.

Track relays cannot be back proved. Coils of track repeat relays shall not be placed in parallel as they cannot be back proved. Where more than one track repeat relay is required, the first repeat relay shall be controlled from the parent. For subsequent repeat relays these shall be controlled by contacts of the preceding relay in the chain eg the P2R relay controls the P3R relay.

Where an audio frequency track circuit adjoins another audio frequency track circuit, the two should be interfaced via a tuned loop.

Incompatible track circuits in electrified areas should be terminated at insulated rail joints. Impedance bonds will be required for traction return current.

Within areas where signal control circuits are used in conjunction with a cab signal and/or train control system, the code form and frequency of track circuits shall be compatible with such system.

Train detection used in gauge indications/detection shall be considered vital, in that if they fail, a train of one gauge cannot be signalled to a track of a different gauge.

6.3 Rollingstock and wheel interface

Rolling stock shall comply with AS 7505.

Train detection systems shall be immune to electromagnetic interference from rolling stock that complies with AS 7505.

Train detection systems shall detect wheels that are intended to be detected and comply with AS 7514 and AS 7505.

Train detection systems shall not detect wheels that are intended not to be detected and comply with AS 7505.

Section 7 Track, civil and interface

7.1 Purpose

The purpose of this section is to ensure that an entire rail systems approach is taken and all civil and track interfaces are considered in the life cycle elements of each system.

7.2 Performance requirements

Rail use, track and civil infrastructure and its maintenance requirements shall be compatible with the electrical and mechanical requirements of the RIM's approved train detection systems particularly where any electric traction is in use.

The use of light, short railcars with optimized bogie design and disc brakes can result in higher shunt and detection failure risk situations arising particularly where they operate over a corridor they do not normally operate.

The regular operation of short railcars with optimized bogie design and disc brakes in country areas can cause wheel hollowing and a rail to wheel mismatch at the expense of contact surface polishing and the rail/wheel connection to which various train detection systems are dependent upon. Shunt enhancers are the preferred method of mitigating this risk. They should be provided at the leading end of each train.

Prior to utilization on any rail network, or when a train/vehicle is proposed to be used on a different area of a network to which a train/vehicle has not been recently used within, a risk assessment for a vehicle or rail car against those factors that affecting train shunting should be completed.

The outcome of the risk assessment should indicate that the train/vehicle has sufficient inherent features in its design to facilitate in the shunting or detection process.

The surface of a train/vehicle wheel shall not be allowed to be contaminated, by brake residue or other foreign matter where these can interfere with the shunting performance of a train or the vehicle.

Infrastructure/maintenance rolling stock or maintenance machinery when in travel or working modes, shall not leave insulating materials (such as dirt, dust, weed spray, etc.) deposited on the rail contact surface to an extent which prevents trains from being detected by the signalling system or effects the shunting characteristics of a track circuit.

To guarantee the detection and safety of trains/vehicles on converging tracks at clearance points, the extremities of any vehicle shall not extend past the outermost detectable axles by more than 3 m or as determined by the RIM.

Track design, modification and its maintenance requirements shall be compatible with the electrical and mechanical requirements of the train detection system employed and any electric traction systems used.

7.3 Track

7.3.1 Rails

The choice, type, application and size of rail shall be chosen in accordance with AS 7640 with consideration given to the train detection system.

The total rail-to-rail resistance of any one unit shall not exceed the value set by the RIM, when measured on clean straight track at an open-circuit voltage not exceeding 1.0 volts rail to rail.

In order to support train detection and when in electrified areas traction systems, where track guard rails are installed, they should be:

(a) fully bonded;

(b) above electrical earth potential; and

(c) continuous through a road, on shoulders or bridges and (where present) pedestrian footpaths.

7.3.2 Sleepers

The rail support system for use with train detection systems shall comply with the requirements of AS 7639.

Train detection systems will often require an electrical cable connection to both rails. This often requires that the wires pass under both rails to the outside of the second rail. This has a hazard for the abrasion of the insulation of the wires from the vibration of the rails, due to train movements.

Cable insulation shall be protected from damage. The following are alternative means of protection:

(a) Use of Corrugated Steel Protection (CSP) insulated cables as track leads (refer to AS 7663 Railway Signal Cables).

(b) Protective conduit that is affixed to the sleeper.

(c) Hollow sleepers with cable glands.

(d) Special bracket under the rail securing the cable from abrasion.

(e) Cable buried underground.

The sleepers can be constructed of different materials. The timber and composite (alternate materials) sleepers are intrinsically insulated between the two rails. The concrete and steel sleepers are not intrinsically insulated between the rails. An insulation pad must be provided between the rail and the sleeper to ensure the insulation between the rails.

When insulated joints are installed within the rails, special actions are required to ensure that the insulation is not compromised by the rail fixings. For concrete sleepers, the rail fixings shall have an airgap between the fishplates and bolts and the rail fixings. For some equipment, this is a special size of rail fixing that is uniquely painted to be distinctive.

7.3.3 Rail surface contamination

The RIM should monitor, address, and control rail contamination which could affect train detection system performance. Contamination issues could include:

(a) vegetation (e.g., leaves) on the rail when wet and being compressed by passing train wheels;

(b) animal or insect (e.g., millipedes) matter on rails;

(c) contamination by other materials transported on or associated with the operation of the railway (e.g., excessive sanding, mineral or grain leakage/bulk product residue, or liquid (e.g., oil) freight spillage);

(d) excessive rail lubrication;

(e) close proximity to salt water or rain causing rust due to long intervals between trains (including maintenance or weather-related closures and service disruptions as well as normal scheduled intervals between trains);

(f) Installation of new rail. Rust layers on rail that may have been stored for many months before installation is much thicker than rust that forms after trains have not run for a short period of time;

(g) vehicle suspension and ride characteristics resulting in variations in contact pressure and wear patterns;

(h) vehicles with differing wheel profiles cleaning different areas of the rail head; and/or

(i) excessive rain, flooding and mud.

Trains/vehicles and maintenance equipment and or its associated subsequent activities shall not deposit insulating materials on the rail contact surface to an extent which interferes with the ability of the train to be detected by the signalling system.

Detectable infrastructure, including maintenance rolling stock should provide the leading and trailing wheelset (the extremity axles) of each vehicle with a means to remove surface contaminants from wheel surfaces especially while rolling on straight track.

When detectable infrastructure maintenance rolling stock cannot reliably shunt track circuits, on tracks where other trains are operating successfully and operational controls to overcome the problem are not considered appropriate, then additional measures shall be employed on trains and rail vehicles to provide effective track circuit shunting.

7.3.4 Ballast contamination

Ballast contamination effects the shunting characteristics of track circuits, areas of ballast contamination effecting train detection systems should be reported to the appropriate responsible person and rectified as soon as possible.

The RIM should monitor, address and control ballast contamination areas at risk of affecting train detection system performance.

Ballast remediation work can change the performance of train detection systems. Train detection systems shall require adjustment and inspection in accordance with the RIMs standard procedures for such infrastructure.

Areas considered to be ballast contaminated affecting the performance of train detection systems, shall be recorded in accordance with the requirements of Section 3.6.

7.3.5 Flood mitigation

Where flooding could occur, that may affect the performance of train detection systems, the RIM should consider mitigation measures.

Train detection system outputs within flood prone areas, may be interlocked with flood sensors, to provide additional protection to other RIM infrastructure. Such interlocking shall not affect the performance of any detection system.

7.4 Civil

Tracks shall be designed, constructed, and maintained in accordance with AS 7638 and AS 7640.

Consideration shall be given to the performance and positioning of train detection equipment in relationship to the proximity of bridges, roadways, overpasses, other tracks, metal reinforcement in concrete pads and concrete tunnel walls, and similar scenarios.

The placement of train detection equipment in locations such as, but not limited to tunnels, platform areas, on embankments, cuttings or on bridges shall be avoided, unless safe civil access and egress for maintenance and adjustment purposes has been addressed.

The RIM shall ensure that a suitable means is implemented to record the position of train detection equipment and to ensure that any subsequent track alterations do not infringe the required clearance or otherwise result in an unsafe condition.

7.5 Infrequent use and track work changes

A known factor in the dependability of train detection systems is the effect of variations in rail surface condition. Measures shall be undertaken to mitigate the effects on train detection system effectiveness of variability in the rail wheel interface in particularly following track work changes and or during periods of infrequent use.

Where tracks circuits or detection systems that rely on clean rail to wheel interface are located within known areas of infrequent use, mitigation strategies that could be utilized for such condition are:

(a) provision of an additional electrical signal that does not interfere with track circuit operation but has the effect of overcoming contact resistance. One solution of this type is train mounted, i.e. a high frequency voltage that is generated across a circuit loop that includes the two wheelsets of a bogie;

(b) cleaning of rail by light grinding; and/or

(c) running additional trains to keep the rail surface clean; this might be normal trains or special vehicles fitted to clean the rail surface.

Systems not dependent on the rail to wheel interface or systems that offer additional protection against light contamination such as HVI track circuits should be selected for areas of infrequent use or for areas exposed to minor rail head contamination.

Consideration shall be given to systems such as axle counter or treadles to be used to augment track circuits in areas of infrequent use such as wheat lines, freight and goods lines.

Where track work changes such as rail replacement and track maintenance works will affect the performance of track circuits, train detection systems shall be inspected and re-adjusted in accordance with the RIM's standard procedures.

7.6 Processes for managing hazards such as rail surface contamination

The reliable operation of the track circuit is dependent on good electrical contact at the wheel rail interface. Rail surface contamination can be caused by a number of issues as detailed in Section 7.3.3. These issues can vary for each location. However, a specific location could be subject to regular impact from a specific issue or issues. For example, track near the coast is often affected by salt spray; additional maintenance and inspections could address this issue.

Regular rail traffic will keep the rail head clear of contamination. Infrequent rail operations could lead to increased rail head contamination.

One-off events could also have a specific impact on a location or locations. These events could cause a lack of rail traffic for multiple days. These events include:

(a) multi-day strikes of rail operations;

(b) possessions for major project work;

(c) rail accidents that take several days to recover; and

(d) storm damage to track that takes multiple days to repair;

Rail head contamination will cause unreliable operation of the track circuits to varying degrees. This is most significant for the first train to progress over the track section but could also impact multiple trains.

This will impact the safety integrity of the signalling system. The impact could be different for separate sub-systems of the signalling infrastructure.

Level crossings – Unreliable track circuits are safety critical for correct level crossing operation. Unreliable track circuits could lead to short warning time for the level crossing or intermittent operation. The following mitigations could address the situation:

(a) Train to approach the level crossing slowly and only proceed through the level crossing when it is safe to do so.

(b) A safe working person to manually activate the level crossing for the approaching train.

(c) Test train(s) over the level crossing until correct operation of the track circuit and level crossing.

(d) The use of minimum activation timers to guarantee that the level crossing operates for a minimum predetermined period of time prior to recovery.

(e) Track section sequencing.

Signal controls – Unreliable track circuits are safety critical for signal control operation. This could cause signals to clear when a track section is occupied or the early release of route locking with the train still in the section. The following mitigations could address the situation:

(a) Test train(s) over the track circuit and observation of correct operating voltages on the occupied track circuit.

(b) Block working of trains through the section of track with unreliable track circuits until they have been checked as operating correctly.

Point motor operation – Unreliable track circuits are safety critical for correct point motor operation. This could cause the dead locking of points to be ineffective and the point motor to operate under a train. The mitigations for signal controls are also effective for point motor operation.

Section 8 Installation requirements

8.1 Purpose

The objective and purpose of this section is to ensure that train detection systems are constructed and installed in accordance with the RIM approved design, manufacturers specifications and the operating performance requirements of all individual components within the systems.

To ensure that all train detection system components are installed in areas that are accessible, safe, secure and where possible outside of the train kinematic envelope.

8.2 Installation

Installation, testing and commissioning activities for train detection systems shall be planned in accordance with the RIM procedures and policies to be undertaken while existing signalling systems remains in a safe and operational state unless otherwise advised.

The standard of materials and workmanship required shall ensure that any train detection system or equipment will remain in service for a minimum of 25 years, (unless otherwise advised) during which it shall remain fit for purpose in its physical and operational environment, in terms of safety, reliability, maintainability, durability, operability and supportability.

The standard of materials and workmanship required for train detection systems shall be at a level that ensures that the necessity for planned preventative maintenance and monitoring tasks to retain the safety, reliability and usability of the asset over its lifetime is maintained at a minimum level.

Train detection equipment and systems operate and are housed in a wide range of environments, ranging from the benign to air-conditioned structures to which could offer only basic shelter or that is exposure to strong field electromagnetic interference levels. Measures shall be taken by suppliers/manufactures to ensure housings and system components are rated, meet or exceed the minimum limits and specifications set by the RIM for most severe class of environment in which equipment can operate in.

Equipment reliability is enhanced if temperature, humidity, surge voltage and EMI are maintained at levels below the maximums recommended.

All train detection equipment should be installed and mounted in accordance with the RIM design and construction specifications for such apparatus/system based on the manufacturer's instructions. It should be located as far practical from all sources of condensing moisture or heat.

Train detection equipment shall be installed and mounted such that conducted, radiated and induced electromagnetic interference is minimized and tolerable.

When installing train detection equipment in an electrically live location, all electrical hazards shall be identified and controlled by appropriate means.

New or modified system installations shall consider impact or effect to existing track circuits or systems.

Trackside mounted train detection equipment shall be mounted adjacent to the rail to which it is to be connected, unless otherwise approved.

The mounting of trackside equipment for train detection systems should not infringe upon the structure gauge and be compatible with track maintenance activities.

Train detection shall be installed in such a manner so as to minimize the potential for slips trips and falls.

Any portion of a train detection system installed between or adjacent to the tracks shall be protected from dragging equipment.

All traction and track cables shall be installed as per the RIM's specification. When multiple methods of attachment for traction and track cabling are available or for selection of a new method, the selection shall consider whether cabling needs to be easily removed for mechanized track maintenance, ballast cleaning or other purpose.

Excess track circuit wiring and track cabling shall be avoided.

All train detection wiring and cabling shall be clearly identified and marked/tagged in accordance with the RIM specifications and standards:

(a) Wiring terminations for track circuit cabling connection points where possible shall be provided with means to eliminate the possibility of incorrect connections being made when wire/cable is installed/replaced.

(b) Tags or other identification marks shall be of an approved type, easy to read in poor lighting conditions, made of insulating material and durable in nature.

The system shall be installed to provide for simple measurement and setting of correct operating levels, and subsequent adjustments.

Section 9 Set up, test and commissioning requirements

9.1 Purpose

The purpose and objective of this section is to provide smooth system integration proving of all systems and their components function reliably in accordance with their design specifications, their intended purpose during the train detection system/equipment set up, testing and commissioning stages.

9.2 Performance requirements

Inspection, set up, testing, and commissioning activities for all train detection systems and their system interfaces shall be planned and programmed to meet both the systems and railway operator's requirements.

Set up, testing, and commission requires the certification of the apparatus/system to verify that:

(a) the systems are physically in accordance with the approved RIM location, design/specifications and any manufacturers recommendations;

(b) installed and functions in accordance with the design and its specifications; and

(c) it is fail-safe.

9.3 Commissioning

All commissioning and integration of train detection systems shall be carried out in accordance with the relevant RIM standards and procedures.

For applicable detection systems, shunt tests simulating train movements shall be made in accordance with the RIM's procedures and instructions.

A test train or test trains/vehicles should be used in a final test before the system is declared ready for train operations.

Where common or adjacent connection points exist such as traction bonding and or power supplies , all applicable testing shall be completed on the adjacent equipment/system at the same time.

Train detection systems shall be integrated into the signalling interlocking system such that the detection of the train is registered, and the appropriate actions as designed by the system are acted upon.

Railway operators can require that train detection systems either providing an input to or that control level crossings such as predictor systems are required to be proved to be correctly operating, in particular for constant warning times at various trains speeds or for train motion detect restart timing sections prior to general use. Test trains may be utilized for this purpose.

Tests shall be made by simulating train movements in both directions on all affected tracks to verify and validate the train detection system performance over the full extent of the track covered by each train detection device or system.

Special tests for points/switches to assure proper shunting of fouling sections, if required, shall be made according to manufacturer’s and RIM instructions.

The results of inspections and tests for all types of train detection systems, shall be recorded, as per the RIM requirements.

9.4 Set up & configuration

After applying power, initial adjustment and setup procedures shall be completed on each individual detection system or component as required in line with the manufacturer’s recommendations and as stated by the RIM instructions.

Abnormal indications and test results shall be investigated fully and corrected before proceeding with any in-service testing.

In applications where track circuit or frequency detection type or similar systems are used, each circuit shall:

(a) be adjusted for shunting sensitivity according to RIM's instructions and procedures; and

(b) always shunt properly with the shunt applied at any point within the track circuit.

Where track circuits are used in an electrified territory, care shall be taken to adjust any resistors/regulators at the relay and transformer ends so that the amount of traction/propulsion current permitted to flow through any relay winding is less than the allowable amount specified for a given relay.

The set up and configuration of train detection systems where possible shall provide for simple measurement and setting of correct operating levels, and subsequent adjustments.

9.5 Testing

Each new, modified or updated train detection system shall at a minimum provide for simple measurement and setting of correct operating levels, and subsequent adjustments in accordance with the RIM's specifications.

Where detection equipment controlling vital circuits or indications is installed, it shall be determined that the equipment is operating within its design parameters and a functional check of all input and output states is made before placing the equipment in service.

Tests should not be made where earths exist or foreign current affects test results until the foreign currents have been removed.

All signalling and traction cables including any cross bonds and rail joints located within the test section shall be properly bonded, connected and inspected prior to completing any adjustments or tests.

When undertaking testing on train detection systems such as track circuits both current and voltage readings should be recorded simultaneously.

Tests shall prove signalling power supplies to be free from earth.

The transmission system used as an integral part of a train detection system shall remain fixed during its and the detection systems life cycle. If major parameters are to be changed, all safety- related aspects of such system shall be reviewed and retested as required.

Section 10 Maintenance and monitoring requirements

10.1 Purpose

The purpose of this section is to capture the maintaining and monitoring of train detection systems, and to identify and apply preventative measures, to capture potential failure conditions and ensure that as far as practical the detection systems functions reliably and in accordance with all design parameters.

10.2 Maintenance requirements

10.2.1 General

As a minimum, the RIM shall assess the asset safety and reliability risks in accordance with the suppliers/manufacture's guidelines with regards to the operating environment and implement appropriate preventative maintenance activities to ensure the integrity of the train detection system.

The maintenance of train detection systems and equipment should be planned and undertaken in accordance with the RIM's systems and procedures, based on the RAMS requirements of such system and its environment to which it is used.

Preventative maintenance activities of train detection systems should be conducted in a way to minimize the need for train services to be disrupted.

Where train detection equipment is to be supplied and installed where not previously used, then training and verification of competence shall be undertaken/provided together with the supply of technical manuals to support the equipment throughout its entire service life which include the following phases:

(a) Product overview.

(b) Application design.

(c) Installation and integration.

(d) Maintenance and monitoring.

(e) Fault diagnosis.

(f) Testing and commissioning.

(g) Decommissioning and disposal.

Information and data from the periodic tests, checks, inspections and maintenance adjustments carried out in accordance with the RIM's code of practice for train detection systems including other Instructions issued from time to time shall be recorded.

Recording, data collection and data management systems shall be utilized in accordance with RIM requirements.

Maintenance, adjustment and testing which could interfere with operation of train detection systems and any subsequent indication to a controller shall not be started until authority from the appropriate train control officer has been granted and all train movements have been fully protected as detailed by the RIM's procedures for such works.

Train detection component level repair or modification of solid-state equipment in the field is not recommended.

All module or PC board exchanges for train detection systems should be completed with power off unless expressly stated by manufacturer that it can be done with power on.

The repair of train detection modules or printed circuit boards should be undertaken only or arranged by an RIM approved electronic repair facility unless stated otherwise by the supplier.

All jumpers, switches and adjustments shall be checked and determined that the replacement module or PC board is configured the same as the one being replaced prior to use.

For equipment controlling vital signal circuits, such as train detection systems, prior to installation it shall be confirmed that any module or PC board or equipment being installed is the same type, configuration and function as the one being replaced.

When train detection systems are repaired by module or PC board substitution, it shall be determined that solid state equipment is operating properly by a functional check against its design parameters of all input and output states made before placing equipment in service.

Train detection modules or PC boards packaging for shipment should substantially protect the module or PC board from abuse. Utilize the manufacturer's shipping container when available.

Set up, adjustment and fault rectification of train detection equipment should preferably be able to be undertaken by one person.

Temporary repairs or adjustments outside of the standard procedures, when required shall be authorized by the responsible RIM officer, recorded for further rectification works and completed in such manner that safety of train operation shall not be impaired.

When making tests of apparatus, proper and calibrated instruments shall be used, and no unsafe conditions shall be created by the application of such instruments.

Each RIM shall ensure proper procedures are implemented to warn level crossing traffic and protect train movements before changes or tests are made which would affect the normal operation of a train detection system protecting such infrastructure.

10.2.2 Modification

If any changes are made to a train detection equipment/system and/or to the adjustment and setup of the device(s) within a system, testing shall be completed and where possible the effect of train/vehicle moves on the system observed as directed by the RIM's procedures to assure that the system is capable of operating within its design parameters.

Re-adjustment and setup procedures initially provided by manufacturer and as approved/amended by the RIM shall be followed when changes or maintenance works are made or undertaken in a train detection system including its modules, track surface or wiring.

10.3 Track and civil maintenance

Where sand, rust, dirt, mud, grease or other foreign matter may prevent the effective shunting of track circuits, the RIM shall be advised promptly to provide for safety of train operations and actions taken.

When undertaking maintenance or in working mode and material is unavoidably deposited on the rail then procedures could need to be put in place to remove contaminated materials before the track is released or open to rail traffic.

Ballast should be kept clear from rails and all rail fastenings, with metallic connections from rail to ground to be avoided. Ballast recommended for use with common rail-based detection systems should be supplied, installed, tested and maintained to AS 2758.7 and AS 1141.

Where ballast resistance is found to be of less than RIM's electrical resistance requirements necessary for the satisfactory operation of the train detection system the RIM shall be advised and action taken as instructed.

Train detection system cabling and (Traction & Signal) bonding and equipment where possible shall be protected against mechanized machinery undertaking maintenance of the track.

All new or modified train detection cabling and bonding shall be designed and installed so where possible it shall not require removal for general track maintenance activities such as tamping, brooming or rail grinding.

While small amounts of foreign current can be found on most track circuits, these currents can rise to excessive levels when track circuits become unbalanced. Broken bonds, defective insulated joints, shorted surge protective devices, or unusual ballast conditions, can cause such conditions and should be corrected immediately.

10.4 Rail-based train detection system maintenance

Rail-based train detection maintenance requirements and its associated detailed inspection requirements of the physical components of the rail-based detection systems include but are not limited to:

(a) recording of track circuit voltages etc. and settings;

(b) shunt and design performance testing;

(c) polarity, community testing and Inspection of track leads/connection cables;

(d) inspection and testing of track head bonds, cross jumpers, signalling and traction bonding;

(e) inspection and testing of track/ballast condition;

(f) inspection and testing of insulated rail joints;

(g) inspection of other associated hardware (e.g., Compensating capacitors, Westrak diodes, shunts and couplers etc.); or

(h) inspection, testing and recording of power supplies.

Voltage, frequency, settings and adjustments for train detection systems should be checked and recorded at intervals as specified by the RIM in accordance with the manufacturer's recommendations.

Track circuit history cards are a method that provides a record of the performance of the track circuit enabling variations to be highlighted and a way of detecting trends in performance, allowing problems to be detected before they cause a failure. Gradual and consistent variations (e.g., adjusting the track feed voltage upward by a small amount every maintenance visit) indicate the deterioration of some component of the track circuit.

Track circuit shunt test shall be made by placing the appropriate shunt resistance across the rails and observing that the track relay or device that functions as a track relay assumes the de-energized position. These tests shall be performed independently at the following locations a minimum of three times at each location:

(i) Each source(s) of energy for the track circuit.

(j) At the track relay end or ends if more than one vital track relay is provided.

(k) At all extremities and the mid-point of turnouts; crossings; points or switches including at any point where bonding (traction or signalling) is attached within a track circuit.

(l) On either side of any insulated joints used within the track circuit.

If available, prior to any readjustments to motion sensitive train detection systems or as required by the railway operator's instructions, internally maintained logs of train moves, and warning times should be reviewed to confirm proper operation of the system.

The results of all inspections and tests completed on motion sensitive train detections systems prior and post adjustment shall be recorded, as instructed by the RIM.

Shunt testing on applicable systems should be made during dry weather conditions when the maximum system current is flowing or during minimum ballast resistance conditions.

Calculations for determination of optimum operating conditions and the actual voltage and phase angles relationships across any train detection system relay or receiver terminals under wet ballast or other adverse conditions shall be maintained and not exceed the margins set by the RIM.

When track work is done at a location containing an insulated joint or other track insulation or rail ends which are heated or welded, the insulation shall be inspected, and if damaged, replaced.

If replacement of any item of axle counter equipment is required, the axle counter section and any associated block section shall be reset on completion of the work in accordance with the RIM's procedures.

Many train detection systems including axle counters are electrostatic discharge sensitive and all standard precautions shall be taken when handling and replacing printed circuit cards. No electrical adjustments shall be made in the trackside connecting boxes while the earth connection to rail is disconnected.

The axle counter configurations for performance monitoring and maintenance purposes shall contain accurate time stamped logging of events and faults.

10.5 On train detection system maintenance

The frequency and scope of the various on-board train detection checks to be carried out should be determined by taking account of the risks to the safety, and use of the train/vehicle.

On-train safety systems, equipment or components should be identified, and procedures should be in place so that if such systems, equipment or components become defective, any risks which can arise can be controlled. These procedures should take account of the routes over which trains operate and should be agreed by relevant transport undertakings and infrastructure managers.

The presence or functionality of relevant safety systems and equipment on-board the train/vehicle should be checked prior to its departure. Relevant safety systems and equipment can include:

(a) DMI interfaces including train braking systems and tachometers/speed systems interfaces; and/or

(b) train protection and AWS systems and its interfaces.

10.6 Reactivation of seasonal or out-of-service train detection systems

A reduction in probability that contamination or oxidation of the rail head due to the suspension of rail services for an extended period thereby adversely effecting train detection system performance, can be achieved by the RIM implementing mitigation processes prior to the recommencement of normal operational services.

Train detection system and equipment on out of service lines for extended periods has a higher risk profile for vandalism and tampering by unauthorized personal, additional spares are recommended to be held in stock to mitigate this risk.

Decommissioned or seasonal out of service train detection systems being brought back into service shall involve testing and commissioning activities in accordance with the RIM specifications to ensure that the reactivated train detection systems meets the applicable safety requirements of the system.

Adequate time shall be allowed for reactivation, inspection and re adjustment of train detection equipment on out of service lines prior to recommencement of train services.

Following an extended period where train services have been suspended and to ensure reliable operation of the track circuits, especially over points in the reverse lay, sufficient trains shall be timetabled through the crossover/points to ensure clean rail surfaces.

Section 11 Fault finding requirements of train detection systems

11.1 Purpose

The purpose and objective of the fault-finding section is to identify and rectify any abnormalities affecting train detection systems or components, to ensure that systems are performing within performance parameters as defined by the RIM, and to capture the management and reporting of faults.

11.2 General requirements

Maintenance and fault finding for train detection systems and equipment shall require a minimum of specialized equipment or tools.

Failure to fully investigate or determine the cause of track indication or system faults could overlook broken rails, damaged bonds and couplers or false shunts.

Authorized RIM maintenance representatives should be granted full access to all parts of the system installation, so as such, that there are no delays or disruption that occurs during corrective maintenance that may be additional attributable to the failed item.

Remedial work should be planned and undertaken as soon as possible to correct any discrepancies that could give rise to a hazardous failure, particularly for level crossings and that process are controlled by train detection systems or where locking could be released because of a delay in detection of a train/vehicle.

Alarm indications shall be provided for detectable equipment failures that require immediate attention from maintenance staff to prevent or minimize train delays.

All alarms for train detection systems are to be stored in an alarm log. When any fault conditions clear effecting a train detection system, the clearing of the fault shall also be logged.

All alarm events logged for detectable faults are to be date and time stamped and appear in the order that they occurred. Alarm event logs shall be stored as historical information as per the RIM's requirements and procedures.

Track circuit and train detection equipment should have the ability to easily interface into the RIM existing systems whereby operational data for each track circuit can be logged.

For maintenance and failure investigations purposes the logged historical data, where provided, shall be easily retrieved and reviewed either on site or with additional hardware as required, in a remote location.

Interfaces to the logging system(s) for train detection systems shall in no way impact on the integrity or reliability of the system and its operation or ability to detect a train or vehicle.

When a fault is corrected, the detection system shall return to normal operation and correctly detect the state of the track or vehicle approaching. No special safety precautions shall be necessary.

Axle counter and similarly classed systems, upon power up or upon detection of a fault condition, all sections affected shall assume an occupied state.

Within traction track circuit areas:

(a) a traction current path shall be maintained at all times during any fault finding and especially during any subsequent replacement process involving impedance bonds or air cored inductor installed within the circuit in an electrified area unless special RIM measures are enacted; and

(b) track cables and where track cables are directly connected to an impedance bond, shall be polarity checked prior to connection with cables colour coded to enable easy identification.

11.3 Fault reporting and management

Details of train detection failures and irregularities shall be recorded and analyzed to determine any corrective action necessary and to ensure equipment/system safety and reliability levels are maintained.

Malicious damage or interference to train detection systems and equipment shall be promptly reported and recorded by the controlling officer.

Together with typical asset type and location details, fault recording systems and methods shall record any change of settings and or operating levels and subsequent test comments should be added where appropriate.

When rails in sections of a track circuit are in such a condition that trains/vehicles cannot be relied upon to shunt the track relay, the signalling maintainer shall disconnect/isolate the track circuit concerned and book out of order or instigate a blocking control on all signals, points or level crossing systems affected by the track concerned until satisfied that a train/vehicle will properly shunt the track relay.

Signal maintainers who become aware of a broken rail that is a danger to rail traffic should arrange for the immediate protecting signal(s) to be placed at stop and disconnected, for a hand signaller to be provided (CTC areas excepted) and for the attendance of the civil/track representatives.

Where a broken rail and subsequent track circuit failure is causing significant delays, the assigned signal maintainer after receiving assurance from the civil/track engineering employee in charge of the works, and confirmation from the signaller that temporary repairs have been made and the line is fit for traffic, should place a temporary bond at the break and restore any disconnected/isolated equipment back into service.

Section 12 Decommissioning and disposal of train detection systems

12.1 Purpose

The purpose of the decommissioning and disposal of train detection systems section is to ensure control of the systems used for the decommissioning and disposal tasks and they do not affect any existing systems or interfaces to other areas.

12.2 Performance requirements

Standards and procedures shall be established and maintained for decommissioning operational signalling, train detection and safety related telecommunications systems prior to disposal.

To achieve the performance requirements of decommissioning and disposal, a determination of the impact shall be made on any complete system or external facility associated with the system to be decommissioned.

The planning of the decommissioning, including the establishment of procedures for train detection systems, shall include:

(a) the safe closing down of the detection system;

(b) the safe dismantling and removal of the system and any associated external enclosures; and

(c) the continued assurance of compliance with RAMS requirements of any external/other systems affected by the decommissioning.

The analysis of lifecycle performance for input into future systems shall be provided including lifecycle costings.

The results of this phase shall be documented, transmitted and archived in accordance with the RIM's standard systems and procedures, along with any assumptions and justifications made during this phase.

(a) Records of all decommissioning and disposal tasks undertaken within this phase shall be maintained.

(b) An updated hazard log should be produced for all decommissioning and disposal tasks.

(c) An approved safety plan in accordance with the RIM procedures and in line with the site conditions should be established to address the decommissioning and disposal tasks and closed out following completion of the works.

Decommission and disposal functions can require a revised application safety case to be produced.

Verification as to the adequacy of the information, and where appropriate, data and other statistics, used as input within this phase shall be assessed.

Verification of the assessment shall be completed prior to the works commencing on site to ensure the adequacy of any documentation, methods tools and techniques for systems affected by decommissioning and disposal activities.

Verification of the competence of all personnel undertaking decommissioning and disposal should be undertaken.

Prior to the commencement of site work for the decommissioning process, a notice shall be published in accordance with the RIM's operating rules.

De-commissioned train detection systems equipment deemed reusable shall be returned to the Accredited Railway Operators nominated site for storage and retesting unless otherwise directed by the RIM.

Appendix A Hazard register (Informative)

Hazard number	Hazard
9.12	Train detection failure (Design)
9.25	Train detection failure (Construction)
9.34	Train detection failure (Test and Commission)
9.44	Train detection failure (Operations)
9.54	Train detection failure (Maintenance)

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- TS 05258, *Common Signals and Control Systems Equipment Requirements*
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- TS 05313, *Inspection and Testing Principles*
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