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Preface

This standard was prepared by the Signalling Detection Interface Development Group, overseen by the RISSB Infrastructure Standing Committee.

Objective

The objective of this Standard is to ensure the continuing harmonisation of signalling systems across Australian networks. This standard seeks to ensure that all new and modified rolling stock are compatible with signalling detection systems including those identified for the individual networks upon which it is intended to operate.

Compliance

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

(a) Requirements.

(b) Recommendations.

(c) Permissions.

(d) Constraints.

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

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

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

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

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

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

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

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

Commentary

Commentary *C Preface*

This Standard includes a commentary on some of the clauses. The commentary directly follows the relevant clause, is designated by ‘C’ preceding the clause number and is printed in italics in a box. The commentary is for information and guidance and does not form part of the Standard.

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Figures

Section 1 Scope and general

1.1 Scope

This Standard applies to new and modified Locomotive, Freight, Passenger and Infrastructure Maintenance rolling stock.

The document covers the compatibility with signalling detection systems for new and modified Locomotive, Freight, Passenger, and Infrastructure Maintenance rolling stock. Vehicles that are not intended to be detected by the signalling system are exempt from the requirements of this standard.

Sections 4, 5, 6 and 7 apply to new, modified rolling stock and existing, unmodified rolling stock introduced to a new line.

Sections 4 and 5 apply to existing rolling stock retrospectively.

Implementing suitable change management procedures will be necessary for any new or modified rolling stock.

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:

(a) AS 7472 Railway operations- Management of change

(b) AS 7501 Rolling stock compliance certification

(c) AS 7502 Railway Rolling Stock - Road Rail Vehicles

(d) AS 7514.1 Railway rolling stock - Wheels - Part 1: Locomotive rolling stock

(e) AS 7514.2 Railway rolling stock - Wheels - Part 2: Freight rolling stock

(f) AS 7514.3 Railway rolling stock - Wheels - Part 3: Passenger rolling stock

(g) AS 7514.4 Railway rolling stock - Wheels - Part 4: Infrastructure Maintenance rolling stock

(h) AS 7530.1 Railway rolling stock - Electrical systems - Part 1: Locomotive rolling stock

(i) AS 7530.2 Railway rolling stock - Electrical systems - Part 2: Freight rolling stock

(j) AS 7530.3 Railway rolling stock - Electrical systems - Part 3: Passenger rolling stock

(k) AS 7530.4 Railway rolling stock - Electrical systems - Part 4: Infrastructure Maintenance rolling stock

(l) EN 50121-3-1 Railway applications - Electromagnetic compatibility - Part 3-1: rolling stock – Train and complete vehicle

(m) EN 50121-3-2 Railway applications - Electromagnetic compatibility - Part 3-2: rolling stock - Apparatus

(n) EN 50121-4 Railway applications - Electromagnetic compatibility - Part 4 : emission and immunity of the signalling and telecommunications apparatus

(o) EN 50121-5 Railway applications - Electromagnetic compatibility - Part 5: Emission and immunity of fixed power supply installations and apparatus

(p) Sydney Trains Rolling Stock Signalling Interface Requirements Standard (ESG 006)

(q) CLC/TS 50238 Railway applications – compatibility between rolling stock and train detection systems

(r) DS CLC/TR 50507 Railway Applications - Interference Limits Of Existing Track Circuits Used On European Railways

1.3 Defined terms and abbreviations

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

1.3.1

AC immune
DC track relays and feed units used in areas of AC electrification that have been immunised, so they are not responsive to AC currents.

1.3.2
AF track circuit
Audio Frequency track circuits consist of a transmitter which transmits a modulated audio frequency signal along the track to a receiver, which operates at the same frequency at the other end of the track circuit. The receiver will only respond to a signal with the correct modulation. Adjacent track circuits utilise a different modulated frequency and jointless AF track circuits utilise a tuned zone to provide electrical separation between adjacent track circuits. Some AF track circuits are fitted in jointed mode where electrical separation between adjacent sections is achieved by insulated rail joints.

1.3.3
axle counter
Equipment used to detect the presence of rail vehicles by counting the number of axles entering or leaving a location. They may be used to operate signalling or other infrastructure equipment.

1.3.4
DC track circuit
Powered from a transformer/rectifier or a battery and is connected through a feed resistor to the rails.

1.3.5

detectable
Rolling stock able to reliably shunt track circuits.

1.3.6

drop away shunt
The maximum resistance in ohms which will cause the track circuit relay contacts to open when the resistance is placed across the rails at the most adverse shunt location. Also commonly known as 'Drop Shunt'.

1.3.7
EMC
Electromagnetic compatibility

1.3.8
EMI
Electromagnetic interference

1.3.9
freight rolling stock
Hauled rolling stock used to transport goods and materials.

1.3.10
GEC RT Reed

This track circuit uses tuned reed filters to transmit and receive individual audio frequencies. They can be used in either jointed mode (insulated rail joints used to provide electrical separation between adjacent track circuit sections), or in jointless mode.

1.3.11
HVI
High Voltage impulse track circuit operates by applying short high voltage pulses to the rails. The operating waveform is asymmetric and the receiver at the far end of the section will only respond to pulses with the correct asymmetric waveform and at the correct rate. The HV impulse track circuit is used in jointed mode only utilizing insulated rail joints to provide electrical separation to adjacent track circuits. It can be operated in both "balanced" i.e. insulated rail joints in both rails (more common) and "unbalanced" i.e. insulated rail joints in one rail only mode.

1.3.12

infrastructure maintenance rolling stock
Track Machines and Road-Rail Vehicles. Also known as On Track Vehicles.

1.3.13

IPITC
Intelligent Processor Island Track Circuit (a form of AF track circuit). The Intelligent Island processor is a microprocessor-based multi-frequency, short range track occupancy detector. It is designed to detect poor shunting conditions in the IPI track circuit and initiates a loss of shunt timer that prevents the relay drive from energizing during poor shunting.

1.3.14
locomotive rolling stock
Self-propelled, non-passenger-carrying railway vehicles used for hauling other (typically freight or passenger) rolling stock.

1.3.15
modified rolling stock
Rolling stock where a change has been implemented that affects its compliance with the requirements in this Standard.

1.3.16
non-detectable
Rolling stock that does not shunt track circuits.

1.3.17
operator
The person or body responsible by reason of ownership, control or management, for the provision, maintenance or operation of trains, or a combination of these, or a person or body acting on its behalf.

1.3.18
overlay
A detection device designed to detect the approach of a train in addition to the normal track circuit train detection is referred to as an 'overlay' device.

1.3.19
passenger rolling stock
Rolling stock carrying people and facilities for these people. Excludes locomotive and infrastructure maintenance rolling stock.

1.3.20
pulse coded track circuits

These track circuits operate by applying a signal to the rails that is switched on and off to produce the relevant codes, which are detected by a similar unit at the far end of the track circuit. The two units at either end work together continuously providing bi-directional communication.

1.3.21
RIM
Rail infrastructure manager

1.3.22
shunt
A by-path introduced into an electric circuit.

1.3.23
signalling detection system
A system that detects the absence of a train or any other on track vehicle intended to be detected on a section of track. Systems include track circuits, axle counters, treadles and global positioning systems.

1.3.24
track circuit
An electric circuit that uses the rails of a railway as conductors such that a train electrically connects them via its axles. The absence or presence of this rail-to -rail connection indicates the absence or presence of a train or item of rolling stock.

1.3.25
track machine
A flange wheeled vehicle used for infrastructure maintenance, construction and inspections. Separate to freight rolling stock (e.g. wagons used for carrying rail, sleepers, spoil, ballast etc.) and road-rail vehicles.

1.3.26
UIC
The International Union of Railways

1.3.27
vane relay track circuits
These track circuits are operated by 50Hz AC or 25Hz AC which is applied to the rail at the transmitter end of the track circuit. At the far end of the track circuit a 50Hz or 25Hz double element vane relay detects the presence of the 50Hz or 25Hz signal. These track circuits can be fitted in double and single rail mode where insulated rail joints are fitted in one or both running rails to provide electrical separation from adjacent track circuit sections.

1.3.28
Westrak track circuits
These are predominantly used for remote level crossings. They operate by applying an AC signal to the rails derived from mains or from a DC source (battery), which is inverted to provide the AC signal. A DC track relay is connected in parallel with the track feed and the far end of the track circuit is fitted with a diode across the rails. With the track unoccupied the diode short circuits the feed on alternate half-cycles, leaving an asymmetric (DC) current to energise the relay. When the track is occupied the track feed and diode are short circuited leaving the relay with only a small AC current and therefore de-energised.

1.3.29
wheelset electrical resistance
It is the resistance between the rail contact surfaces of wheels on the same axle. The electrical resistance is measured from the rail contact surface of one wheel to the rail contact surface of the other wheel via the axle of that wheelset.

1.3.30
wheel rail contact
The electrical contact point between the rail and a wheel.

1.3.31
work closure
A section of railway track closed off to normal traffic and undergoing maintenance, construction or inspection.

1.3.32
Organizations
For the signalling detection interface this includes rail operators, infrastructure managers, rolling stock and signalling designers, vendors, and rolling stock owners.

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

Section 2 Change management

2.1 General

The organization shall establish procedures for ensuring safety risks associated with change are identified and controlled. Forms of change have the potential to affect safety and therefore need to be managed which include the following:

(a) Infrastructure and rolling stock.
(b) Procedures, processes and systems.
(c) Job roles and responsibilities.
(d) Interfaces.

2.2 Requirements

Any proposed change which could affect safe operations shall require the following:

(a) A risk assessment.
(b) The identification of suitable controls.
(c) Consultation with affected stakeholders, including relevant rail safety workers.
(d) Documentation of the change.
(e) A check that the proposed change conforms with relevant legislation.

2.3 Safety validation

Before a proposed change, the organization shall prepare a safety validation for any change which affects safety related activities including the following:

(a) Driving and operations of trains.
(b) Control of the movement of trains.
(c) Track and civil infrastructure.
(d) Rolling stock activities.
(e) Signalling, operational systems and telecommunication infrastructure.
(f) Electric traction infrastructure.

(g) Interface with other engineering and operating systems, equipment and infrastructure including roadways.

(h) Personal workplace safety.

(i) Safe working systems and procedures.

The safety validation shall cover each life-cycle stage affected by the change (i.e. concept, design, construction, implementation, commissioning, operation, monitoring, maintenance, modification, decommissioning and demolition).

2.4 Sign off

Safety validations shall only be undertaken by people who have the skills, knowledge and experience and the mandated competency in the areas affected by a proposed change. As part of the change management process, it is necessary to determine who is responsible for safety validation sign-off. More than one person may be required to sign-off a safety validation.

All safety validations shall be approved before proposed changes are introduced. Where the proposed changes have a significant impact on safety, such safety validations shall be reviewed independently of the area affected by the change although this may be done within another part of the organization.

Section 3 Signalling detection systems characteristics

3.1 General

Table B1 in Appendix B contains the characteristics of train detection systems common to the various networks throughout Australia.

Section B2 in Appendix B contains the characteristics of train detection systems used on networks throughout Australia that are unique to a specific network.

Appendix C in this document provides references to more information about network signalling detections systems in use on Australian rail networks.

Section 4 Track circuit detection requirements

4.1 Track circuit shunting

UIC Code 737-2 contains general information on track circuit shunting.

4.2 Locomotive, freight & passenger rolling stock

Locomotive, freight and passenger rolling stock shall have a DC electrical resistance between rail contact surfaces of wheels on the same axle of not greater than 1 mΩ, measured with a voltage source with an open circuit voltage no greater than 1 V.

All rolling stock should have a minimum axle load that accommodates the characterises that affect reliable shunting of the track circuits such as the type of track circuits used and any wheel to rail interface issues. The minimum axle weights are network and rolling stock specific.

A rail infrastructure manager (RIM) shall nominate a minimum axle load to ensure reliable shunting of track circuits.

As a generic guide, it is known that rail vehicles with less than 2 axle tonnes do not provide a reliable track circuit shunt, refer to RIM specific axle tonne requirements for further guidance.

All non-electric locomotive and non-electric passenger rolling stock shall provide the leading and trailing wheelset (the extremity axles) of each vehicle with a means to remove surface contaminants from

wheel tread surfaces. This excludes heritage steam locomotives fitted with operating sand removal systems.

Conventional tread braking systems, or tread scrubbers/dressers fitted with disc-braked wheels, are suitable means of cleaning tread surfaces.

Some locomotive, freight and passenger rolling stock do not reliably shunt track circuits on tracks where other trains are operating successfully. Where alternative operational controls to overcome the problem are not considered appropriate, additional measures shall be employed on the vehicle to provide effective track circuit shunting.

Additional measures employed on rolling stock to improve track circuit shunting can include:

- Track circuit actuators.
- Increased axle load.
- Additional rail electrical contact points, e.g. track brushes.
- Tread cleaning on wheels of disc-braked vehicles.
- Alternative wheel profile.
- Bonding of all axles to the underframe.
- Use of abrasive (metallic or non-metallic) inserts into non-metallic brake blocks.

Operational and wayside conditions leading to unreliable track circuit shunting include:

- Rusty rails due to damp environment or infrequent trains
- Rail head contamination from leaves, sand, oil, product from wagons etc.
- Narrow rail head contact bands due to homogeneous traffic and well aligned rails.
- Poor quality track ballast resulting in lower shunt sensitivity due to leakage currents.
- Shorter trains having fewer wheelsets to shunt the rails.
- Unloaded trains having lower wheel to rail contact load.
- Faster trains causing exiting track circuit to pick up before entered track circuit shunts.

Locomotive, freight and passenger rolling stock shall not deposit insulating materials on the rail contact surface to an extent which prevents trains from being detected by the signalling system.

4.3 Infrastructure maintenance rolling stock

4.3.1 General

Infrastructure maintenance rolling stock that travel outside work closures shall be identified as either detectable or non-detectable in regards to track circuit shunting.

Track circuit shunting requirements for detectable rolling stock are contained in clause 4.3.2 of this standard.

Track circuit shunting requirements for non-detectable rolling stock are contained in clauses 4.3.3 and 4.3.4 of this standard.

Non-detectable rolling stock are subject to special safeworking rules when travelling outside work closures.

When in travel mode, infrastructure maintenance rolling stock shall not leave insulating materials deposited on the rail contact surface to an extent which prevents rolling stock from being detected by the signalling system.

When in working mode and material is unavoidably deposited on the rail during operation, then procedures can be required to ensure material is removed before the track is released to general traffic.

4.3.2 Detectable infrastructure maintenance rolling stock

Detectable infrastructure maintenance rolling stock shall have a DC electrical resistance between rail contact surfaces of wheels on the same axle of not greater than 1 mΩ, measured with a voltage source with an open circuit voltage of no greater than 1 V.

Detectable infrastructure 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 tread surfaces.

Conventional tread braking systems, or tread scrubbers/dressers fitted with disc-braked wheels, are suitable means of cleaning tread surfaces.

Detectable infrastructure maintenance rolling stock shall meet the axle load requirements of the network on which they operate.

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 the vehicle to provide effective track circuit shunting.

Additional measures employed on rolling stock to improve track circuit shunting can include:

- Track circuit actuators[1].
- Increased axle load.
- Additional rail electrical contact points, e.g., track brushes.
- Tread cleaning on wheels of disc-braked vehicles.
- Alternative wheel profile.
- Bonding of all axles to the underframe[2].
- Use of abrasive (metallic or non-metallic) inserts into non-metallic brake blocks.

Operational and wayside conditions leading to unreliable track circuit shunting include:

- Rusty rails due to damp environment or infrequent trains
- Rail head contamination from leaves, sand, oil, product from wagons etc.
- Narrow rail head contact bands due to homogeneous traffic and well aligned rails.
- Poor quality track ballast resulting in lower shunt sensitivity due to leakage currents.
- Shorter trains having fewer wheelsets to shunt the rails.
- Unloaded trains having lower wheel to rail contact load.
- Faster trains causing exiting track circuit to pick up before entered track circuit shunts.

[1] Electrical devices to help break down the wheel to rail contact resistance - refer to RSSB Standard GM/RT2477.
[2] Refer to AS 7514 for acceptable wheel profiles.

4.3.3 Non-detectable infrastructure maintenance rolling stock

Non-detectable infrastructure maintenance rolling stock should have an AC / DC electrical resistance between rail contact surfaces of wheels on the same axle of greater than 20,000 Ω.

Non-detection is typically provided by having insulated wheels and, where appropriate, insulation of mechanisms that touch the rails during work mode.

4.3.4 Non-dependably-detectable rolling stock

If the infrastructure maintenance rolling stock is neither "Detectable" (clause 4.3.2) nor "non-detectable" (clause 4.3.3), then appropriate operational / safeworking controls, as defined by the RIM, shall be applied.

4.4 Vehicle dimensions

4.4.1 Overhang

The extremities of any rolling stock vehicle shall not extend longitudinally past the outermost detectable axles by the amount defined by the network on which it operates.

4.4.2 Axle spacing

The distance between the inner axles of adjacent bogies on any rolling stock vehicle shall not exceed that defined by the network on which they operate.

The separation distance of extremity axles on any rolling stock vehicle, shall not be less than that defined by the network on which they operate. This excludes non-detectable infrastructure maintenance vehicles.

Section 5 Axle counter detection requirements

5.1 General

Compliance with the AS 7514 requirements for wheels cover typical axle counter requirements.

5.2 Axle counter requirements

The type of issues that should be reviewed include;

- Wheel profile within the operating limits
- Maximum operating track speed
- Size of the rail
- Rail profile
- Wheel material
- Rolling stock induce electrical noise
- Number of axles to be counted
- Distance axles and coupled wagons
- Manufacturers installation requirements
- Any other items in AS 7651

Section 6 Interface affecting the signalling system

6.1 General

Rolling stock electrical equipment can generate electrical and electromagnetic energy which can interfere with the signalling detection system in the following ways:

- Radiated EMI causing interference to trackside / track mounted equipment;
- Electromagnetic induction generating interfering currents in the rails directly below a vehicle or bogie;
- Traction supply return current containing harmonic components which are resistively coupled into the signalling track circuits; and
- Interfering energy causing an occupied track circuit to falsely indicate an unoccupied state, an unoccupied track circuit to falsely indicate an occupied state, or a track circuit to remain in a failed state even after the source of interference has passed.

Interference can occur at the nominal operating frequencies of the signalling equipment concerned, and at other frequencies related to the internal operation of the equipment.

The types of vehicles which can generate sufficient rail currents to warrant concern can typically be electric rolling stock and diesel-electric locomotives with three phase inverter drives.

For radiated EMI requirements of new or modified rolling stock, refer to AS 7530 and EN 50121 series of standards.

On-board electrical equipment containing power semiconductor switching devices that produce tractive or auxiliary electrical power on new or modified locomotives or passenger rolling stock shall not generate rail currents with harmonic components at the signalling system frequencies above levels as specified by the RIM.

Rolling stock suppliers and/or operators shall provide evidence of testing carried out to measure the emitted electromagnetic characteristics of any new or modified rolling stock.

6.2 Rail current harmonics

New and modified locomotives and passenger rolling stock shall under all operating conditions meet the rail current frequency limits shown in Figure 1. Harmonic values at specific frequencies may be varied by agreement with the RIM of the network.

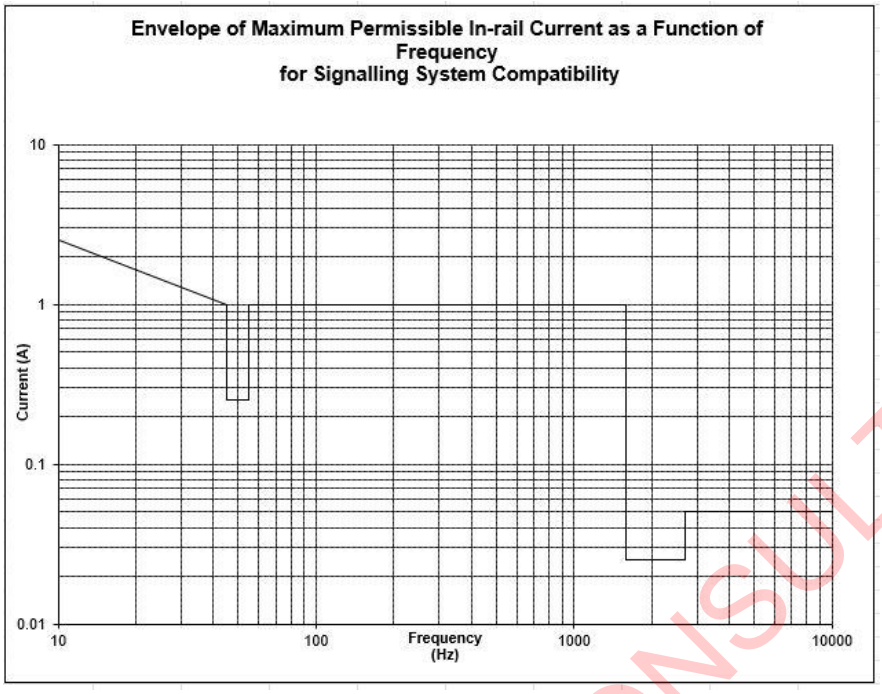

Figure 1 - Rail current harmonic limits

The above 50Hz applies to the DC traction networks.

If higher current levels are accepted, then for any current which exceeds the limits in Figure 1, the RIM should specify a maximum duration which does not exceed the inbuilt energization delay for the type of track circuit involved, to prevent false energization of an occupied track circuit.

In assessing test results for compliance with these requirements, the RIM should differentiate between exceedances with coherent (sinusoidal) content which could cause interference, and those with random content (white noise) which is not likely to cause interference.

See Appendix B, Section B2 for network specific rail current harmonics requirements.

6.3 Magnetic field

For new or modified rail vehicles operating over networks with track circuits, axle counters and other systems, RIMs should determine the magnetic flux density as this can interfere with the correct operation of this equipment.

6.4 Longitudinal voltage

All new or modified rolling stock operating over any network utilizing DC track circuits shall not be able to cause a longitudinal voltage along a rail between any two wheels exceeding 200 mV rms between 0 and 2.4 Hz.

All new or modified rolling stock operating over any network utilizing AF track circuits shall not be able to cause a longitudinal voltage along a rail between any two wheels exceeding 173 mV rms at any of the specific operating frequencies of AF track circuits.

All new or modified rolling stock operating over any network utilizing 50Hz vane relay track circuits shall not be able to cause a longitudinal voltage along a rail between any two wheels exceeding 150 mV rms at 50Hz.

6.5 DC current limits

New or modified locomotive and passenger rolling stock operating on rail networks with 25 kV AC traction systems shall not generate DC rail currents exceeding the following limits and conditions:

- DC current shall be the total RMS current in the bandwidth 0 Hz to 2.4 Hz
- DC current may exceed 3.8 A RMS (nominal) for period not exceeding 0.25 seconds, subject to the condition that DC current did not exceed 2.9 A rms in the period immediately preceding the exceedance.

6.6 Close up effect

Close up effects result from large inductive sources such as traction motors inducing a small voltage onto an axle. Close up effect currents flow as a result of this small voltage causing a current to flow in the low impedance secondary circuit formed by the wheels, axles and rails. These induced currents can cause interference to track-mounted inductive sensors or similar devices.

New or modified rolling stock operating over any network utilising inductively coupled track mounted sensing devices shall not generate close-up currents at any of the specific operating frequencies of the inductive devices, sufficient to cause a failure of the device.

See Appendix B, section B2 for the close-up effect requirements of rolling stock on the Sydney Trains network.

Section 7 Testing

7.1 Shunting tests

All new or modified rolling stock (including detectable infrastructure maintenance rolling stock) should be type tested to confirm it can reliably shunt all forms of track circuit that it will encounter during its intended operation as follows:

(a) The residual voltage on the track circuit should be less than 50% of the drop away voltage while the first wheelset is starting to traverse the track circuit,

(b) The residual voltage on the track circuit should remain below 10% of the drop away voltage while the vehicle is fully traversing the track circuit,

(c) The residual voltage on the track circuit should remain below 50%, while leaving the track circuit, until the last wheelset has cleared the track circuit.

The RIM shall determine need, scope and scale of the test on a risk-based approach for each specific model of rolling stock.

7.2 Interface tests

New rolling stock (not previously type tested) and modified rolling stock (where the modification has the potential to create/result-in interference to track signalling equipment) shall be assessed and type tested to evaluate the compatibility with track circuit signalling systems.

Type testing shall be in accordance with the relevant Rail Infrastructure Manager requirements.

Refer to CLC/TS 50238-2 for an example of the testing methodology for rolling stock compatibility with track circuits.

Refer to CLC/TS 50238-3 for an example of the testing methodology for rolling stock axle counter compatibility.

NOTE: Standard EN 50595 describes the measurement of evaluation methods of rolling stock EMC emissions to demonstrate compatibility with axle counters.

7.3 EMC test

New or modified locomotive and passenger rolling stock should be type tested to measure the line current versus frequency characteristics under the various operating scenarios expected in service operation.

Scenarios can include operation with converters cut out, operating on various overhead line lengths, and operation with other types of rolling stock.

For other EMC requirements, refer to AS 7722.

Appendix A Hazard register – Informative

Hazard number	Hazard	Heading number(s)
5.2.1.13	Rolling stock electrical systems generating the same frequency as an infrastructure system frequency, affecting the signalling system, and thereby causing	
5.2.1.49	Wheel flange being too high and damaging infrastructure e.g. fishplates & bolts, axle counters, crossing flangeways	
5.25.1.29	Signalling detection of insulated rolling stock leading to the inability to maintain timetables	
5.7.1.27	SPAD - Signalling system failure - resulting in an inadequate train separation system causing collision	
5.8.1.2	Signalling system failure resulting in an inadequate train separation system	
5.8.1.12	Train overhang from extremity axles being too long at turnouts, causing side swipe by another train (train foul)	
5.9.1.9	High tyre to tyre electrical resistance causing loss of signal detection so that trains are not detected (Signal failure)	
5.9.1.16	Axle loads are too low causing high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)	
5.9.1.20	Signalling detection being affected by EMI from rolling stock electrical equipment so that trains are not detected (Signal failure)	
5.9.1.22	Wheels being too small to trigger axle counters resulting in trains not being detected (Signal failure)	
5.9.1.23	Bogie or underframe equipment being too low and mis-triggering axle counters resulting in trains not being detected (Signal failure)	
5.9.1.28	Bogie axle spacings being too short for axle counter detection at speed so that axle spacing is not compatible with detection system resulting in trains not being detected (Signal failure)	
5.9.1.29	Vehicle extremity axle spacing is less than maximum “dead” section length so that axle spacing is not compatible with detection system resulting in trains not being detected (Signal failure)	
5.9.1.30	Vehicle extremity axle spacing exceeds the minimum track circuit length so that axle spacing is	

	not compatible with detection system resulting in trains not being detected (Signal failure)
5.9.1.31	Bulk product spills causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.32	Excessive sanding causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.33	Rusty rails causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.34	Animal or vegetable matter (e.g., millipedes, leaves) causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.35	Fluid leaks - causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.36	Brake block material /residue is electrically insulating causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.37	Brake block material /residue is electrically insulating causing contaminated rail tread surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.40	Wheelsets track differently to typical trains causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.41	Non-standard wheel profile causing contaminated rail head surfaces leading to high wheel to rail electrical resistance resulting in the loss of signal detection so that trains are not detected (Signal failure)
5.9.1.42	Wheel material being unsuitable for triggering axle counters so that trains are not detected

9.25.1.4	Shorting or electrical interference of train detection equipment in the location case

Appendix B Signalling System Characteristics – Informative

B.1 General

Summary characteristics common to train detection systems used on various networks throughout Australia.

This information is provided to assist the reader in the interpretation of the standard.

It does not cover every network / RIM in Australia (i.e. it is not exhaustive).

Whilst every care has been taken in its preparation, it should not be taken as the definitive source for this information - the onus remains on the designer to familiarise themselves with the requirements of the RIM in force at the time.

Table B1 - General signalling system characteristics

Track circuit Type	Operating Frequency	Operating Track Voltage (V)	Normal Shunt Value (Ω)	Applicable Networks
DC Feed	DC	1	0.5 to 0.8	Brookfield, TasRail, V/Line, KiwiRail, Aurizon, AMPRN, ARTC
DC pulse coded track	DC	2 to 3	0.5	BHP, Roy Hill, FMG, Rio Tinto, Brookfield
AC Feed Set DC	DC	1	0.5	Brookfield, TasRail, V/Line, KiwiRail, ARTC
AC Feed Set DC – AC Immune	DC	5	0.25 to 0.5	Brookfield, KiwiRail, Aurizon, PTA, ARTC
AC	50 Hz	1 to 3	0.06 to 0.5	RailCorp, V/Line, KiwiRail, ARTC, TfNSW
Westrak – AC Diode	50 Hz AC half-wave rectified		0.5	Brookfield, TasRail, V/Line, Queensland Rail, KiwiRail, Aurizon, ARTC
Harmon TD4	180 Hz		0.5	V/Line, Queensland Rail
Harmon SCX Level Crossing Controller – AC Diode	50 Hz AC half-wave rectified		0.5	Brookfield
High Voltage Impulse (HVI)	3 Hz bipolar pulse	40 to 120	0.25 to 0.5	Brookfield, RailCorp, V/Line, Queensland Rail, KiwiRail, ARTC

Track circuit Type	Operating Frequency	Operating Track Voltage (V)	Normal Shunt Value (Ω)	Applicable Networks
NZR Impulse	120 V impulse		0.5	KiwiRail
US&S Microtrax Coded	DC pulse coded (up to 23 codes)	±1 to 3	0.25 to 0.5	Brookfield, V/Line, KiwiRail, PTA, ARTC
Harmon Electrocode 2, 4 & 5	DC pulse coded (up to 8 codes)		0.25 to 0.5	Brookfield, V/Line, ARTC
AF Jointed	380 to 510 Hz	3 to 20	0.5	RailCorp
NZR Audio Frequency			0.5	KiwiRail
AF (Jointless) Track Circuit - TI21-2 / EBI Track 200	1,549 Hz (1,532 to 1,566), 1,699 Hz (1,682 to 1,716), 1,848 Hz (1,831 to 1,865), 1,996 Hz (1,979 to 2,013), 2,146 Hz (2,129 to 2,163), 2,296 Hz (2,279 to 2,313), 2,445 Hz (2,418 to 2,462), and 2,593 Hz (2,576 to 2,610).			Queensland Rail, Aurizon, ARTC
AF Jointless	1,700, 2,000, 2,300, and 2,600 Hz	3 to 5, 0.8 to 7.5	0.1 to 0.5, 0.8 to 1.7	RailCorp, V/Line, Queensland Rail, KiwiRail, Aurizon, PTA, AMPRN, ARTC
Audio Frequency Coded (Jade)	1,600, 1,900, 2,200, 2,500 Hz		0.5	KiwiRail
Westinghouse FS2000	Group 1: 4,080, 5,280, and 6,480 Hz Group 2: 4,320, 5,520, and 6,720 Hz Group 3: 4,560, 6,000, and 7,200 Hz		0.5	V/Line
GEC RT Reed Jointless	Frequencies: 363, 366, 369, 372, 375, 378, 381, 384 kHz		0.25	Brookfield
Safetran PSO II / 4000 Overlay	PSO II: Frequencies: 156, 211, 348, 430, 525, 645, 970 4,000 kHz: Modulated overlay – Frequencies: 156, 211, 285, 348, 430, 525, 645, 790, 970, 1,180, 1,450, 1,770, 2,140, 2,630, 3,240, 4,000 kHz		0.25	Brookfield, V/Line, KiwiRail, PTA, ARTC

Track circuit Type	Operating Frequency	Operating Track Voltage (V)	Normal Shunt Value (Ω)	Applicable Networks
Safetran Series Overlay Track Circuit	5,900, 10,000 kHz		0.5	V/Line
Safetran Short Modulated Track Circuit	4.0, 4.9, 5.9, 7.1. 8.3. 10.0, 11.5, 13.2, 15.2, 17.5, or 20.2 kHz		0.5	V/Line
Harmon AFTAC I, II & IIC Overlay	Frequency modulated overlay – Frequencies: 500, 700, 900, 1,100, 1,300, 1,600, 1,900 kHz		0.25	Brookfield, V/Line
Harmon EPIC III	8.2, 10, 11.5, 13.2, 15, 17.5, 20 kHz		0.5	V/Line
US&S AFO II Overlay	Amplitude modulated overlay – frequencies: 870, 9,80, 1,180, 1,285, 1,330, 1,660, 1,900 Hz		0.25	Brookfield
Level Crossing Predictor - Safetran GCP3000 and GCP4000	Predictor frequencies available in the range 45 Hz to 999 Hz, typically 156, 211, 285, 348, 384, 430, 525, 645 and 790 Hz are in use.		0.25	Brookfield, TasRail, V/Line, KiwiRail, PTA, ARTC
	Island track circuits available in the range 2.14 kHz to 20.2 kHz, typically 8.3, 8.5, 10, 11.5, 13.2, 15, 15.2, 17.2, 17.5 and 20.2 kHz are in use.			Brookfield
Level Crossing Predictor – Harmon HXP-3	Predictor frequencies available in the range 86 Hz to 979 Hz, typically 86, 114, 156, 211, 285, 348, 452 and 522 Hz are in use.		0.25	Brookfield, V/Line, ARTC
	Island circuits in use are either 4 kHz or 8 kHz.			Brookfield
Level Crossing Predictor – GE Transportation Electrologic IXS XP4	Available frequencies as per HXP-3		0.25	Brookfield, ARTC, BHP, FMG
Motion Detector – Harmon PMD-3	Available frequencies are in the range 86 Hz to 979 Hz.		0.25	Brookfield, ARTC

Track circuit Type	Operating Frequency	Operating Track Voltage (V)	Normal Shunt Value (Ω)	Applicable Networks
Frauscher ACS2000, FAdC Axle Counter	N/A		N/A	Brookfield, KiwiRail, Aurizon, AMPRN, ARTC
Siemens Az350U, AzS350M, AzS600	N/A		N/A	V/Line, Queensland Rail, KiwiRail
Thales AzLM	N/A		N/A	V/Line, Aurizon
Thales ZP30C-NT/SK30H Axle Counter	N/A		N/A	Queensland Rail
DC using QT1 4 Ω relay	N/A	0.8 to 1.2	Nominally 0.25	TfNSW
DC AC Immune using QTA1 9 Ω relay	N/A	2 to 5	Nominally 0.5	TfNSW
Audio frequency jointless	1,700, 2,000, 2,300, 2,600 Hz	3 to 5	0.15 to 0.5	TfNSW
Audio frequency jointless	380 Hz to 510 Hz	3 to 20	0.5	TfNSW
Audio frequency jointed HV impulse	Bipolar dc pulse (3 pulse / second)	40 to 120	0.25 to 0.5	TfNSW
Microtrax	N/A	~1	0.25	TfNSW

Harmonic values at specific frequencies may be varied by agreement with the rail infrastructure manager of the network.

B.2 Network specific signalling system characteristics

B.2.1 General

Network specific system characteristics are train detection systems used on networks within Australia that are unique to a specific network.

B.2.2 Rail current harmonics

For the Queensland Rail network, new and modified electric locomotives and passenger rolling stock shall limit individual components of the line current to the maximum values within Tables B2 and B3.

For the PTA of WA network, new and modified electric locomotives and passenger rolling stock shall limit individual components of the line current to the values within Table B3.

Table B2 - Queensland Rail ML type track circuit

Centre frequencies	

f1 (Hz)	f2 (Hz)	RMS **Current Level (mA)**	Time (sec)
1532	1566	100	1.5
1682	1716	100	1.5
1831	1865	100	1.5
1979	2013	100	1.5
2129	2163	100	1.5
2279	2313	100	1.5
2428	2462	100	1.5
2576	2610	100	1.5

Table B3 - Queensland Rail & PTA of WA CSEE type track

Centre frequencies			
f1 (Hz)	**f2 (Hz)**	RMS **Current Level (mA)**	**Time (sec)**
1690	1710	100	1.5
1990	2010	100	1.5
2290	2310	100	1.5
2590	2610	100	1.5

For new or modified electric locomotives and passenger rolling stock operating on the Queensland Rail network, there shall be no modulation in the range 1 Hz to 15 Hz of the line current frequency between the centre frequencies given in Table B2.

For new or modified electric locomotives and passenger rolling stock operating on the Queensland Rail or PTA of WA networks, there shall be no modulation in the range 10 Hz to 30 Hz of the line current frequency between the centre frequencies given in Table B3.

For the Victorian network, new and modified electric locomotives and passenger rolling stock shall limit individual components of the line current to the values within Table B4.

Table B4 - Victorian CSEE, 25 Hz and 50 Hz type track circuit

Frequency (Hz)	**RMS Current Level (mA)**	**Time (sec)**
1700 Hz ± 40 Hz	60	0.3
2000 Hz ± 40 Hz	50	0.3

2300 Hz ± 40 Hz	50	0.3
2600 Hz ± 40 Hz	45	0.3
25	2200	0.1
50	1200	0.1

B.3 Close up effects

For new or modified rolling stock operating on the Sydney Trains network, electrical noise induced in the rails shall not exceed the following limits:

- 1600 Hz to 2700 Hz Rail to rail voltage shall not exceed 30 mV
- 1600 Hz to 1800 Hz Non-sinusoidal / non-modulated harmonics may exceed 50 mA, but shall not exceed 100 mA. Modulated harmonics shall not exceed 25 mA
- 1800 Hz to 1900 Hz No harmonic currents shall exceed 5 mA
- 1900 Hz to 2100 Hz Non-sinusoidal / non-modulated harmonics may exceed 50 mA, but shall not exceed 100 mA. Modulated harmonics shall not exceed 25 mA
- 2200 Hz to 2400 Hz Non-sinusoidal / non-modulated harmonics may exceed 50 mA, but not exceed 100 mA. Modulated harmonics may not exceed 25 mA
- 2500 Hz to 2700 Hz Non-sinusoidal / non-modulated harmonics may exceed 50 mA, but shall not exceed 100 mA. Modulated harmonics shall not exceed 25 mA

Section 14 of Sydney Trains' Rolling Stock Signalling Interface Requirements Standard (Rolling Stock Stock Signalling Interface Requirements TSv05332) contains further information on the permitted close-up effect currents on the Sydney Trains network.

Appendix C Network signalling detection systems – Informative

C.1 General

This is a guide and provides information current at the time of publishing on the Rail Infrastructure Managers responsible for various Australian networks and the equipment in-use on those networks. Users should consult the Rail Infrastructure Manager concerned before placing reliance on network-specific information contained within this standard.

C.2 Australian Rail Track Corporation Network

The ARTC network consists of the interstate standard gauge network, plus New South Wales regional standard gauge network.

http://www.artc.com.au

C.3 Aurizon network

The Aurizon network consists of the Central Queensland Coal Network heavy haul rail infrastructure and also the standard and narrow gauge track in from Tarcoola South Australia to Darwin Northern Territory as well as various narrow gauge track within South Australia.

http://www.aurizon.com.au

C.4 ARC Infrastructure network

The ARC Infrastructure network consists of the West Australian regional narrow and standard gauge network.

https://www.arcinfra.com/

C.5 Kiwirail network

The KiwiRail network includes all the 1067 mm gauge freight track and the majority of passenger track in New Zealand.

http://www.kiwirail.co.nz

C.6 PTA network

The PTA Network consists of the Perth metropolitan narrow gauge and standard gauge network.
http://www.pta.wa.gov.au

C.7 Queensland Rail Network

The Queensland Rail network consists of the Queensland narrow gauge passenger network.

http://www.queenslandrail.com.au

C.8 Sydney Trains Network

Operates and maintains the NSW Metropolitan Heavy Rail network on behalf of Transport for New South Wales.
http://www.transport.nsw.gov.au/sydneytrains

C.9 TasRail Network

TasRail (Tasmanian Railway Pty Ltd) is the Government of Tasmania-owned corporation that operates 1067 mm gauge, mainline railways in Tasmania.

http://www.tasrail.com.au

C.10 Adelaide Metro

Adelaide Metro consists of the Adelaide metropolitan broad gauge network.
http://www.adelaidemetro.com.au

C.11 V/Line Network

V/Line is the Rail Infrastructure Manager of the Victorian broad gauge intrastate regional rail network.

http://www.vline.com.au

C.12 VicTrack Network

VicTrack owns broad gauge (and some standard gauge) branch lines in Victoria. Management of this track is carried out by ARTC, V/Line and Public Transport Victoria.

https://www.victrack.com.au

C.13 Metro Trains Melbourne Network

Metro Trains Melbourne operates the Melbourne metropolitan broad gauge passenger network.
http://www.metrotrains.com.au/

C.14 Country Regional Network

New South Wales regional standard gauge network managed by United Group Rail Lynx

https://www.uglregionallinx.com.au/

C.15 FMG

Standard gauge, heavy haul network in the Pilbara Western Australia.

www.Fortescuemetals.com.au

C.16 BHP

Standard gauge, heavy haul network in the Pilbara Western Australia

https://www.bhp.com/

C.17 Rio Tinto

Standard gauge, heavy haul network in the Pilbara Western Australia

https://www.riotinto.com/

C.18 Roy Hill

Standard gauge, heavy haul network in the Pilbara Western Australia

https://www.royhill.com.au/

Appendix D Bibliography – Informative

The following referenced documents are used in the development of this Standard for information only:

(a) UIC Code 737-2 Measures to be taken to improve track circuit shunting sensitivity

(b) UIC Code 737-3 Application of thyristors in railway technology – Measures for the prevention of functional disturbance in signalling installations

(c) UK RSSB standard GM/RT2477 TCA configuration for rail vehicles

(d) UK RSSB standard GM/RT2400 Engineering Design of On-Track Machines

(e) The Institution of Railway Signal Engineers publication Railway Control Systems

(f) The Institution of Railway Signal Engineers publication Railway Signalling

(g) The Institution of Railway Signal Engineers publication Railway Signalling & Control

(h) CLC/TS 50238-2 Railway applications - Compatibility between rolling stock and train detection systems - Part 2: Compatibility with track circuits

(i) CLC/TS 50238-3 Railway applications - Compatibility between rolling stock and train detection systems - Part 3: Compatibility with axle counters

(j) Rolling Stock Signalling Interface Requirements TS 05332 (Sydney Trains Network)

(k) ESD-32-01 Signalling Rolling Stock Interface (ARTC)

(l) ERA/ERTMS 033281 Interface Between Control-Command and Signalling Trackside and Other Subsystems