Division / Business Unit: Engineering and Systems
Function: Rolling Stock / Signalling
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Rolling Stock Signalling Interface

ESS-32-01

Applicability

ARTC Network Wide SMS

Publication Requirement

Internal / External

Primary Source

ESD-32-01, SDS 26, WOS 01.160, WOS 01.F

Document Status

Version #	Date Reviewed	Prepared by	Reviewed by	Endorsed	Approved
1.0	15 June23	Standards	Stakeholders	Manager Signalling Standards	Head of Engineering Standards 19/06/2023

Amendment Record

Amendment Version #	Date Reviewed	Clause	Description of Amendment
1.0	15 June 23	All	Document has been renumbered from ESD-32-01. Clarified roles and responsibilities, testing requirements, Rollingstock Signalling Interface Compliance Certificate, Track Circuit Assistor (TCA), and other minor updates.

Table of Contents

1 Introduction

1.1 Purpose

The purpose of this standard is to define the signalling compatibility requirements to operate a vehicle or train consist on the ARTC network.

1.2 Scope

This document covers the rolling stock interface requirements with the existing signalling infrastructure on the Australian Rail Track Corporation network. The requirements reflect the compatibility between rolling stock and the signalling system including train detection system, signal sighting for driver, train braking compatibility with signal spacing, rollingstock traction system and electromagnetic compatibility. The standard also covers the process for confirming compliance of rolling stock by the Train Operator.

1.3 Responsibilities

The Head of Engineering Standards is the Document Owner. For any query, initial contact to be made at standards@artc.com.au

The Rolling Stock Operator is responsible for providing details of compliance of new locomotives and rolling stock to the signalling interface requirements detailed in this standard. The Rolling Stock Operator is also responsible for ensuring the continued compliance of the rolling stock throughout its operational life, particularly after any modifications to the rolling stock.

1.4 Reference Documents

1.4.1 Australian and International Standards

The following Australian and International standards support this document or a referenced in this document.

- AS 4251.1 Electromagnetic compatibility - Generic emission standard Part 1: Residential, commercial and light industry.
- EN 50121 Railway Applications - Electromagnetic Compatibility - Part 1: General
- EN 50121 Railway Applications – Electromagnetic Compatibility – Part 3-1 Rolling stock – train and complete vehicle.
- EN 50121 Railway Applications – Electromagnetic Compatibility – Part 3-2 Rolling stock – apparatus.
- EN 50121 Railway Applications - Electromagnetic Compatibility - Part 4: Emission and Immunity of the Signalling and Telecommunications Apparatus
- EN 50592 Railway applications. Testing of rolling stock for electromagnetic compatibility with axle counters
- ERA/ERTMS/033281 - Interfaces Between Control-Command and Signalling Trackside and Other Subsystems
- CELENEC CLC/TS 50238-2 - Railway applications - Compatibility between rolling stock and train detection systems - Part 2: Compatibility with track circuits

- CENELEC - CLC/TS 50238-3 - Railway applications - Compatibility between rolling stock and train detection systems - Part 3: Compatibility with axle counters
- AS4292 Railway Safety Management
- AS 7715 – Train Detection
- AS 7501 Railway Rolling Stock Compliance Certification (definition of ICP, certification sign off etc)
- AS7502 - Road Rail Vehicles
- AS 7505 Railway Rolling Stock - Signalling detection interface
- AS 7514 Railway Rolling Stock - Wheels (wheel material and conductivity)
- AS 7515 Railway Rolling Stock - Axles (axle material and conductivity)
- AS7517 Railway Rolling Stock - Wheelsets: - geometric tolerances (back to back interfacing with turnouts)
- AS 7533 Railway Rolling Stock - Driving cabs (signal sighting)
- CCITT - Consultative Committee for International Telephony and Telegraphy
- AS 7722 EMC Management
- RISSB - Code of Practice - Wheel Defects
- RISSB – Rollingstock Safety Assessment Guideline

1.4.2 ARTC Standards and Specifications

The following ARTC documents support this standard or are referenced in this document.

- ESC-07-02 Trackside Equipment Installation
- ESC-04-01 Signal Sighting and Position
- ESD-05-03 Train Braking Application Design
- ESM-07-02 – Track Circuit and Train Detection Devices
- ESD-05-14 – Frauscher Axle Counter Systems
- ESD-05-15 – Design of Frauscher Axle Counters
- D20001-4 – Design and Planning manual Frauscher Advanced Counter
- D5686 version 6 – FAdC R2 – Vehicle Type 020 – RSR180
- ESD-03-02 – Level Crossing Predictor Design, Certification and Test
- ESD-32-02 - ATMS Equipped Train Braking Standard
- ESS3201-F01 – Rolling Stock Signal Compliance Certificate
- EPP-32-01 Track Maintenance Vehicle Registration and Operation
- ERP-31-01 Registration of Rolling Stock / WOS01.A1/A3/A3/A4 Vehicle Information Packs
- WOS 01.100* General Interface Requirements – Introduction (as replaced by ERP-32 series of interface documentation)

- WOS 01.200* Common Interface Requirements (as replaced by ERP-32 series of interface documentation)
- WOS 01.300* Locomotive Specific Interface Requirements (as replaced by ERP-32 series of interface documentation)
- ARTC Track & Civil Code of Practice Section 7 - Clearances
- ARTC Route Access Standard (RAS)

*The WOS documents although generally applicable for New South Wales are applicable to all of the ARTC network for the purposes of evaluation to meet the requirements of this standard.

1.5 Definitions

The following terms and acronyms are used within this document:

Term or acronym	Description
Block Worked	Vehicle required to be Block Worked - Vehicle not certified to activate train detection system reliably and are not compliant. Such vehicles are required to operate under alternate safe working methods i.e., Block Working, Track Occupancy Authority or Track Warrants as applicable by the operational rules
Consist	Listed order of the vehicles arranged to make up a complete train. A combination of motive power and vehicles having defined parameters in terms of locomotive number, type and performance characteristics.
Certifier	An engineer with signalling knowledge and experience of assessment and testing of the locomotive or rollingstock for compliance to the signalling interface requirements of the ARTC and AS standards.
DMU	Diesel Multiple Units
EMC	Electro-magnetic Compatibility
EMI	Electro-magnetic Interference
ICP	Independent Competent Person as defined by rolling stock as defined in AS7501 and for track maintenance vehicles as defined in EPP-32-01
OEM	Original Equipment Manufacturer
Rail bound	Track maintenance vehicles that only operate on track, for example tampers, regulators, etc.
Rail Motor	Self-propelled passenger rail vehicle
RAS	Route Access Standards
Road Rail Vehicle	A road vehicle fitted with retractable rail guidance wheels. Also known as a hi-rail vehicle.
Rolling stock	This is a collective term referring to any rail vehicle
Rolling Stock Operator	This is the Accredited Rail Operator who owns and/or operates the locomotives and rolling stock.
Shunt	When a rollingstock passes over the railway tracks, the wheels of the rollingstock shorts the electrical circuit. This ‘short-circuiting’ is known

	as ‘shunting’ or ‘dropping the track circuit’.
TCA	Track Circuit Assistor
Unit	Any independent item of rolling stock

2 Role and Responsibility

The approval and certification of rolling stock to operate on the ARTC Network will involve various engineering and operational disciplines within the rail industry which may include:

- Rolling Stock Operators
- Rolling Stock Owners
- Rolling Stock Manufacturers (including equipment suppliers)
- Rolling Stock Operators Delegated Representatives; and
- ARTC

2.1 Rolling Stock Operator Responsibility

The Rolling Stock Operator is responsible for ensuring that all rolling stock that it operates are compatible with the signalling interface requirements detailed in this standard throughout the vehicle's lifecycle, particularly after any modifications to the rolling stock.

The Rolling Stock Operator in conjunction with the rolling stock owner or manufacturer (including the traction equipment supplier), shall provide appropriately configured rolling stock that is ready for testing. The compliance of the rolling stock to these nominated ARTC signalling requirements shall be Certified by the Rolling Stock Operator or a Delegated Representative of the Rolling Stock Operator and recorded on certificate ESS3201-F01.

The Rolling Stock Operator shall ensure that a qualified crew is provided to operate the rolling stock during testing. Vehicle testing may be required to be undertaken at various locations on the ARTC Network.

During the planning phase, the Rolling Stock Operator or Delegated Representative shall arrange for any waivers or notices for operation, possessions required for on-track testing and Worksite Protection Officers (as required) competent in ARTC Network Rules and Procedures.

The Rolling Stock Operator is responsible for the undertaking of tests, assessments and the production of reports that confirm that the locomotives and rolling stock meet all of the nominated ARTC requirements. The tests shall be undertaken by suitably qualified persons who have the required competencies to perform the tests and work on the equipment. Desktop assessments, computer simulations and other means of determining compliance to the ARTC requirements may be used as applicable to the requirement. The tests and reports shall be used as the basis for a Certification by the Rolling Stock Operator that the referenced locomotives and rolling stock meet the nominated ARTC and AS requirements. The Rolling Stock Operator shall complete the Certification prior to the rolling stock operating on ARTC infrastructure, unless approved to operate under an Operational Notice waiver with specified operating conditions. A summary and validation of these tests shall be listed on the ESS3201-F01 Rolling Stock Signal Compliance Certificate by the Certifier.

The Rolling Stock Operator shall also maintain compliance with the requirements while the locomotives or rolling stock are operating on ARTC infrastructure.

At the conclusion of testing, test sites shall be re-certified prior to the resumption of train services.

2.2 Rolling Stock Operator Delegated Representative

The Rolling Stock Operator may appoint a Delegated Representative to be responsible for managing and undertaking the testing of the locomotives or rolling stock to confirm the conformance to AS 7501 and other applicable ARTC and Australian standards. The delegated representative's credentials shall meet those of the ICP as defined in AS7501 for rolling stock or as defined in EPP-32-01 for track maintenance vehicles.

Where the locomotive is not owned or under the control of an accredited rail operator, the owner or manufacturer of the locomotive may appoint a Delegated Representative to be responsible for managing and undertaking the testing of the locomotives or rolling stock to confirm the compliance to ARTC and Australian Standards.

2.3 ARTC Responsibility

For the purpose of certification, ARTC may make available access to ARTC infrastructure for the testing of rolling stock, under agreed and controlled conditions.

ARTC will notify the Rolling Stock Operator of any changes to this standard or to related signal interface requirements.

2.4 Certifier

The Certifier is an engineer with signalling knowledge and experience of assessment and testing of the locomotive or rollingstock for compliance to the signalling interface requirements of the ARTC and AS standards.

Certifier undertaking the testing and certification of the rolling stock is responsible to the Rolling Stock Operator for any work and certification undertaken. All actions of the Certifier are the responsibility of the Rolling Stock Operator.

The Certifier shall be competent to undertake the engineering assessment and report on the compliance of the rolling stock to this standard and AS standards. Any staff working as part of the certification shall be competent and experienced in the tasks that they perform and in accordance with the ARTC Signals Competency requirements.

The Certifier shall have a comprehensive understanding of the operational characteristics of the rolling stock being tested and the signalling and control systems installed on the ARTC Network, with demonstrated experience in:

- understanding the risks associated with operating new or modified rolling stock on the ARTC Network;
- identifying test equipment appropriate for the proposed tests;
- the process for setting up and conducting tests in the rail corridor; and
- capability to evaluate results and equate these to compliance with ARTC and AS standards.

Certifier is required to provide a detailed signed off signalling compatibility report against each of the requirement of this standard and AS 7505. The report shall clearly detail any non-compliances and provide clear recommendation for acceptance of rollingstock operation on ARTC network with additional restrictions/operational/administrative controls. In addition, certifier is required to complete and sign ESS3201-F01 – Rolling Stock Signal Compliance Certificate.

Certifier may require to perform additional test not included in this document based on his experience in consultation with the rollingstock operator or manufacturer in case of any novel or historical type of rollingstock.

3 Risk Factors

3.1 Risks for Locomotives and Trains in General Service

When new or modified rolling stock are operated on the ARTC Network, there is a risk to the integrity of the signalling system. Risk factors include the following:

- ineffective detection of train presence
- electromagnetic interference between trains and signalling infrastructure
- electrical interference between trains and signalling infrastructure
- train braking performance and acceleration
- damage to signalling equipment such as facing points and axle counters, due to mismatched wheel geometry.
- Information transfer between signalling systems and train or driver
- the ability of the driver to initiate appropriate responsive action

Context and actions to be taken to control the risk factors, are detailed within the respective sections of this standard.

3.2 Risks for Rolling Stock in Restricted Service

Where it is proposed that rolling stock is only used in restricted service or has a restricted usage on the network (route restricted or other) due to not being able to reliably operate train detection systems, then an Operational Notice shall be applied for the restrictions against the technical requirements of this standard. The rolling stock will have operating restrictions applied where applicable in accordance with ERP-32-01 - Registration of Rolling Stock.

3.3 Risks for Rolling Stock in Transition Service

Where it is proposed that rolling stock is to be moved or transferred across the ARTC network and is not to operate train detection systems, then a movement Operational Notice shall be sought from ARTC and the rolling stock will have operating restrictions applied where applicable.

3.4 Risks for Self-Propelled Rail-Bound Track Maintenance Vehicles

Self-propelled rail bound track maintenance vehicles that do not reliably operate the train detection systems shall only be operated under special operating conditions as prescribed in the ARTC Network Rules/Procedures and may have operating restrictions applied where applicable. These vehicles can be operated under Block Working, Track Occupancy Authority or Track Warrants.

3.5 Risks for Light Self-Propelled Passenger Vehicles (DMUs and Rail Motors)

The primary risk for light self-propelled vehicles is loss of shunt events on track circuits. Where this risk is present, those vehicles shall be operated under Blocked Working, Track Occupancy Authority or Track Warrants through the respective sections. Installation of track circuit assistor

(TCAs) will assist to mitigate risk of loss of train shunt. Refer to Section 5 & 6 for Testing and Certification requirement.

3.6 Risks for Heritage Locomotives

The primary risk for heritage locomotives is loss of shunt events on track circuits or miscounts on axle counter systems. Where this risk is present, those vehicles shall be operated under blocked working, Track Occupancy Authority or Track Warrants through the respective sections.

Track Circuits:

Before heritage locomotives are operated in new areas of operation, assessments should be co-ordinated with corridor signalling maintenance personnel so that any irregular signalling events can be immediately addressed before alternating safe working arrangements are withdrawn. This risk is mainly due to the possibility of high wheel to wheel electrical resistance that can negatively affect track circuit shunting performance.

Axle Counters:

Where locomotives are fitted with flangeless drive wheels and/or small spoked leading bogie wheels, these can generate miscounts in axle counter systems due to the lack of metallic interaction near the wheel sensor.

3.7 Risks for Modified Locomotives

Where the locomotive may have systems or components altered that potentially change compliance with this standard, the loco shall be tested and fully certified with this standard.

3.8 Risks for Road-Rail Vehicles

Road-Rail Vehicles should be appropriately insulated to prevent operation of rail vehicle track circuit detection systems.

4 Rollingstock Testing and Approval Procedures

4.1 Rolling Stock

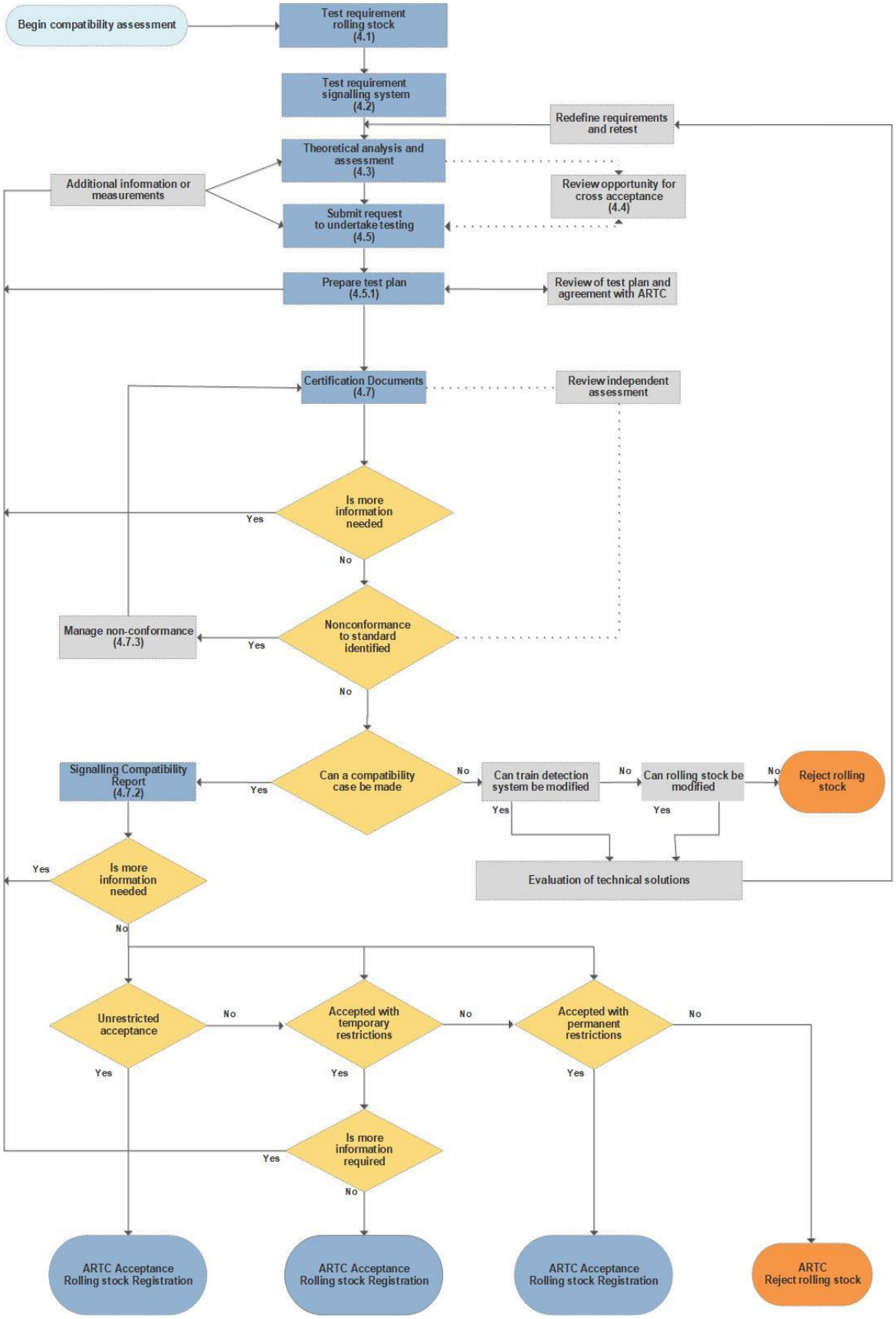
The Rolling Stock Operator or Delegated Representative is accountable for the testing and certification of the rolling stock and for providing the assurance of its compatibility to operate on the ARTC Network.

The Rolling Stock Operator or Delegated Representative shall:

- understand the potential hazards that new or modified rolling stock may present to its safe and reliable operation on the ARTC Network;
- undertake a detailed review of the rolling stock and its operating characteristics;
- have a detailed technical understanding of rolling stock traction systems;
- survey the signalling system to identify the scope of tests required to satisfy the compatibility case;
- prepare a detailed test plan and identifying test locations;
- coordinate the various bodies needed to conduct these tests;
- provide the test equipment;
- execute the tests as necessary;
- evaluate the test results;
- identify and manage any nonconformance identified during the testing process;
- have test results reviewed if and when necessary; and
- provide the compatibility report with clear recommendations to the accepting body.

Testing shall be generally undertaken in accordance with the sequence as shown in Flow Chart Figure 4.1.

Figure 4.1 – Rollingstock Testing and Approval process Flow Chart



4.2 Signalling System

The Rolling Stock Operator Delegated Representative and Certifier shall have a comprehensive understanding of the operational characteristics of the various types of train detection and signalling systems installed on the ARTC Network. Those responsible for undertaking testing shall have experience in:

- identifying test equipment appropriate for the proposed tests;
- setting up and undertaking testing within the rail corridor; and
- capability to evaluate results and equate these to compliance to this standard and others.

4.3 Theoretical Assessment and Analysis

The Rolling Stock Operator Delegated Representative and Certifier may use desk top assessments, computer simulations and other means, for determining compliance.

Testing and analysis shall be undertaken by qualified persons who have the required competencies to undertake this work.

4.4 Cross Acceptance Testing

Where a class of rolling stock has:

a. previously been tested and certified for another train operator; or

b. an item of equipment on the locomotives that has previously been tested and certified for another locomotive; or

c. previously been tested and certified for a train operator, and is transferred or otherwise comes under the control of another train operator,

The Certifier may use the results of those tests if applicable to current ARTC operational environment for consideration.

The Rolling Stock Operator Delegated Representative shall demonstrate that the test results and certification are applicable to the configuration of rolling stock under consideration.

Acceptance of prior approvals shall be evidence-based, utilising the following criteria:

- the vehicle being offered is identical in all respects;
- the vehicle has operated on a similar Australian rail network without incident;
- the class of train detection being accepted is identical in all respects;
- the pass or fail criteria used in the original safety case are assessed as being acceptable and appropriate to current ARTC standards, practices and operational environment;
- the results of tests are in a similar format; for example, units of measure are currents or voltages as nominated in this standard;
- the results indicate what level of interference is being injected into the train detection equipment and is not just measuring the electrical noise being produced by the train;

- the test results detail degraded modes of operation of the vehicle under test, for example, traction inverter modules cut-out; and

Full documentation of the previous testing and certification shall form part of a new set of certification documents. The certification documentation shall be complete, stand alone and not dependent on other documents.

4.5 Rolling Stock Operator's Test Plan

The Rolling Stock Operator Delegated Representative and Certifier shall provide a written request prior to undertaking testing which shall provide full details of the proposed schedule of tests. It shall include:

- test site locations;
- the types of tests which will be undertaken;
- the limits of any possession that may be required;
- the details of any signalling equipment to be booked out of order during testing;
- schematic circuits for the connection of test equipment;
- configuration of the rollingstock;
- the testing instruments to be used and confirmation of calibration;
- the staff who will be involved in the testing and their competency certificates;
- a risk assessment on the operation of the rolling stock for each test site; and
- the overall test programs.

Certifier will confirm from the Asset management/relevant business units the locations, site configuration and variants of train detection systems practically in use and selection of tests sites.

Before permitting rolling stock on the network for the signalling testing, the Rolling Stock Operator is required to submit interim registration and evidence of rolling stock suitability for operating on the track and associated conditions of operations or requirement of operational procedures if applicable.

On receipt of the request, ARTC may permit access to the signalling equipment and will stipulate any restrictions that may need to be imposed.

All personnel accessing signal equipment shall hold appropriate competencies in accordance with ARTC Engineering Competency requirements.

4.5.1 Preparation of a Test Plan

The Rolling Stock Operator or Delegated Representative shall prepare a test plan in consultation with the Certifier for all testing activities to be undertaken. which when effectively implemented will provide the required level of evidence that the rolling stock being tested has met the requirements of this standard and AS7505.

The following should be considered when preparing the plan:

- the rolling stock that is being tested, including the configuration of the consist;
- tests needed to be undertaken to prove compliance e.g.

- shunt test;
- signal interference test;
- acceleration and braking characteristics test for any other aspects of the vehicle that have the potential for interference to the signalling system;
- 50 Hz impedance tests (if applicable);
- 50 Hz detector tests (if appliable);
- testing of other noise-generating sources;

- which track circuits does the vehicle need to be tested over;
- degraded modes of operation for the vehicle - e.g., traction motor isolation,
- transient throttle setting testing and other testing/controls required for gauge discriminator
- what is the worst-case for the track circuit – e.g., an unbalanced track circuit;
- location of applicable train detection systems on the ARTC Network;
- identification of a suitable test site;
- the pass or fail criteria;
- design of circuit schematics;
- what test equipment is needed;
- test equipment calibration requirements;
- will ARTC access be required, and when;
- composition of a test team;
- is the vehicle in use in other comparable railways; and
  - is there sufficient evidence for cross-acceptance
  - what are the differences or deltas that need to be tested;
- which elements of the vehicle can be assessed by desktop audit;

4.6 Rolling Stock Test Matrix

Refer to Appendix E for a list of required tests for vehicle types.

The Rolling Stock Operator or Delegated Representative shall ensure that for the rolling stock being tested, all modes of operation pertaining to rolling stock detection and interference with the signalling system shall be included in the compatibility assessment Certification Documents

4.7 Certification Documents

The Rolling Stock Operator shall produce the certification in a documented format. This shall be supported by reports of tests and other assessments that demonstrate compliance with the requirements.

a. Where a class of locomotives/rolling stocks has previously been tested and certified for another Rolling Stock Operator, then a Certifier may use the results of those tests. The Certifier shall assess or otherwise demonstrate that the test results and certification are

applicable to the configuration of locomotive under consideration. Full documentation of the previous testing and certification shall form part of the new set of certification documents. The certification documentation shall be complete, stand alone and not be dependent on other documents.

b. Where an item of equipment on the locomotives has previously been tested and certified for another locomotive, then a Certifier may use the results of those tests. The Certifier shall assess or otherwise demonstrate that the test results and certification are applicable to the configuration of locomotive under consideration. Full documentation of the previous testing and certification shall form part of the new set of certification documents. The certification documentation shall be complete, stand alone and not be dependent on other documents.

c. Where a class of locomotives has previously been tested and certified for another Rolling Stock Operator and is transferred or otherwise comes under the control of another Rolling Stock Operator, then a Certifier may use the results of those tests. The Certifier shall assess or otherwise demonstrate that the test results and certification are applicable to the configuration of locomotive under consideration. Full documentation of the previous testing and certification shall form part of the new set of certification documents. The certification documentation shall be complete, stand alone and not be dependent on other documents. The Certifier shall assess or otherwise demonstrate that the test results and certification are applicable to the configuration of rolling stock under consideration.

The Rolling Stock Operator will provide ARTC with a copy of the final signed off report and certificate detailing the compliance to ARTC and AS standards and will seek ARTC's consensus. The report shall clearly detail any non-compliances. The report should identify the credentials and details of the Certifier who undertook the tests and completed the evaluation.

4.7.1 Vehicle Information Pack

The Rolling Stock Operator or Delegated Representative shall submit the technical reports on compliance of the item of rolling stock against this standard as part of the Vehicle Information Pack, using form ESS3201-F01 Rolling Stock Signal Compliance Certificate.

The Rolling Stock Signal Compliance Certificate shall be submitted with the final version of the rolling stock registration (ERP-32-01 Registration of Rolling Stock or EPP-32-01 Track Maintenance Vehicle Registration) and operation registration forms (ERP3201 F01 through F04 or EPP3201-F01) as applicable.

4.7.2 Signalling Compatibility Report

The signalling compatibility report shall provide justification for the level of recommendation selected.

The Rolling Stock Operator, or in conjunction with the Delegated Representative where applicable, shall review the report. The review should include an internal process which aims to seek a consensus on the findings of the report.

Once consensus has been agreed, a copy of the report shall be provided to ARTC.

ARTC shall be the accepting body which accepts the final Rolling Stock Signal Compliance Certificate

ARTC will grant either:

- full acceptance,

- temporary acceptance, or
- acceptance with operating conditions.

4.7.3 Managing Non-Compliance

During the evaluation process, it may be necessary to address a non-compliance to this standard.

The noncompliance shall be investigated to establish whether it can be accepted with operational conditions.

Once the non-compliance has been fully investigated, the findings and any restrictions or operational procedures to be applied for safe operation are to be documented in the report and summarised on the ESS3201-F01 Rolling Stock Signal Compliance Certificate.

5 Train Detection Requirements

Rolling stock shall reliably operate the train detection systems. There shall be no vehicle generated disturbance effects that interfere with the operation of the train detection systems or any of the signal equipment or systems.

Vehicles that do not reliably operate the train detection systems, such as track maintenance vehicles, shall only be operated under special operating conditions, such as Block Working, Track Occupancy Authority or Track Warrants.

Train detection may be by way of track circuits, axle counters, treadles and other train detection systems. There may also be wheel presence detectors for rolling stock gauge detection in multi-gauge sections of track.

Train detection systems are provided where:

- the safe operation of the signalling system is dependent on accurate and up to-date information on the position and movements of rolling stock;
- information on the position and movements of rolling stock is required for the control of level crossings, staff warning systems or other systems associated with safety of rail vehicle operations; or
- it is necessary for the Network Controller or other operator to know the position of rolling stock for the safe operation of the railway.

All rolling stock operating on the ARTC Network shall have been tested to ensure they are detected by the existing train detection systems.

The existing signalling train detection systems used on the ARTC network are:-

- DC track circuits, conventional and AC immune
- ‘Westrak’ type DC track circuits with combined feed/relay sets
- 50 Hz AC track circuits, double and single rail
- Audio frequency jointless track circuits operating at 1700, 2000, 2300 and 2600 Hz
- Audio frequency jointed track circuits operating at frequencies between 380 and 510 Hz
- Audio frequency overlay track circuits operating at frequencies between 800 and 5000 Hz
- High voltage impulse track circuits
- Pulse coded track circuits operating with DC or tone-burst transmission
- Level crossing motion detectors/analysers operating between 1 and 4 kHz.
- Axle counter systems using wheel detectors
- Treadles as an aid to track circuit operation
- Wheel presence detectors for gauge detection.

Above list may not be exhaustive and Certifier should contact to ARTC business units to determine the train detection systems installed in the area under review at the time of assessment of the rolling stock.

Significant operating parameters of these track circuit types are shown in Appendix B for guidance only. The Certifier shall refer OEM's technical manuals for each type of train detection system where required to ensure the safe and reliable detection of rolling stock on the ARTC network. ARTC is a national railway comprising of different state jurisdictions and some installation and maintenance practices may differ based on historical reasons and local regional requirements. The Certifier shall coordinate with regional/corridor signal engineer for local operating and maintenance practices.

5.1 Track Circuits

5.1.1 Track Circuit Introduction

Track circuits are used to detect the presence of rolling stock by monitoring electrical contact between one or more wheelsets and the surfaces of both rails.

The wheels in contact with the rails, provide an electrical path through the axles to create an electrical short circuit between the two rails of the track circuit. The short circuit created by the wheels and axles, decreases the current to the track relay/receiver below its designed de-energising (drop away value) causing it to de-energise which is then detected by the signalling control system.

The effectiveness of the wheels and axles to provide a short circuit across the rails of a track circuit, is dependent on a number of factors, either individually, or in combination. These factors include the following:

- track circuit sensitivity;
- rolling stock resistance compatibility requirements;
- wheel to rail interface;
- electric traction interference; and
- electromagnetic interference.

5.1.2 Track Circuit Sensitivity

The shunt sensitivity of track circuits in use on the ARTC Network depends on the type of track circuit. The lower the resistance required to place a track circuit into the occupied state, the less sensitive the track circuit will be to a train shunt. Please refer to Appendix B, ARTC track circuit standard ESM-07-02, AS7505 and manufacturer's manuals for more technical details for each specific type of track circuits.

5.1.3 Rolling Stock Resistance Compatibility Requirements

Rolling stock operating on the ARTC system shall be detected by track circuits installed on the ARTC network.

Rolling stock operating on the ARTC system shall meet the following wheel to wheel and total rail-to-rail resistance values to facilitate compatibility with ARTC track circuits used for train detection:

- Maximum resistance between rail contact surfaces of wheels on the same axles shall be not greater than 1 milliohm when measured with a voltage source with an open circuit voltage no greater than 1 volt.

- The total rail-to-rail resistance of any one unit shall not exceed 1 milliohm, when measured with a voltage source with an open circuit voltage no greater than 1 volt.

5.1.4 Rollingstock Mass and Rail Wheel Metallurgy

The interaction of wheels and rail at the contact surface is critical.

Rolling stock detection effectiveness improves with increasing vehicle mass. Due to the mass of a typical locomotive and the number of wagons in the train consist, loss of train detection is generally not a high risk with freight trains. Light short consist (e.g. light engine or DMU, heritage vehicles, railmotor sets configurations) with optimised bogie design and disc brakes can however, result in a higher risk for loss of train detection by track circuits.

Unsophisticated rolling stock bogie design creates relative movement between wheels and rails resulting in cleaning and polishing of the contact surfaces. Improvements in bogie design (steering bogies) has extended the life of wheels and rails at the expense of contact surface polishing. Wheels which roll without slippage, will pick up a layer of contaminant from the rail surface which can degrade shunting effectiveness, even on clean rail.

Metallurgical factors also play an important role in wheel/rail surface contamination. The propensity of rail surfaces to oxidation can increase the ease with which wheel treads can pick up contaminants when in rolling contact with the rail surface, contributing to wheel tread contamination.

To minimise the risk of loss of train detection due to increased wheel/rail electrical resistance as a result of wheel/rail contamination, the following shall be considered:

- At least one axle per unit may be provided with the means to keep contact surfaces clear of any contaminant build-up, especially while rolling on straight track.
- The vehicle 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.
- As dry sand is an effective electrical insulator when compressed between the surface of the wheel and rail, the use of sand or similar materials to improve rail/wheel friction shall be applied in a controlled manner to prevent excess sand/material forming an insulating layer between the rail/wheel contact surfaces. Locomotives should be fitted with de-sanding equipment. Locomotives not fitted are restricted in operation (see RAS General Information.).

5.1.5 Wheel to Rail Interface

The match between rail and wheel profiles is of critical importance to the effectiveness and reliability of train detection by track circuits.

Mismatched wheel profiles can lead to loss of train detection when the wheels contact the rail outside the established contact band, running on a previously uncleaned section of the rail thereby creating an intermittent shunting effect.

A mismatch can occur between wheel and rail profiles when a vehicle operates over track not on a regular route for that vehicle. Regular operation can result in the wheel developing the matching contact band on the rail.

Rolling Stock Operators shall establish systems and manage all requirements for ensuring compatible Australian Standard wheel profiles are used on the ARTC Network as set out in Table 5.1.

Table 5.1 - ARTC Network Compatible Wheel Profiles

WHEEL PROFILE	AREA
ANZR-1*	DEFINED INTERSTATE RAIL NETWORK
	HEAVY HAUL NETWORK
	INTRASTATE NETWORK
WPR 2000*	HEAVY HAUL NETWORK (FOR COAL TRAFFIC ONLY)

* for more details: refer to ARTC Route Access Standard RAS and AS 7514 for wheel profile dimensions

Worn wheel profile limiting dimensions are as specified in:

- Route Access Standard
- RISSB - Code of Practice - Wheel Defects

5.1.6 Track Circuit Proof of Compliance

The Operator/Certifier shall certify that any new or modified rolling stock has been demonstrated to comply with the above requirements, by providing the following theoretical and/or field test results documented in the compatibility report. Test on the ARTC track may be required based on the judgement/assessment of Certifier. Proof of compliance will include below:

- Detailed design analysis of vehicle dimensions, bogie and braking system design, wheel profiles and materials, and wheel / axle assembly methods.
- Test results of wheel-to-wheel and rail-to-rail resistance measurements.
- Results of actual track circuit shunting tests at an agreed test site.
- Provision of rail cleaning equipment if sand or adhesion enhancers are used, for example blowers.

Where there is a concern as to how well the leading and trailing single axle can shunt sufficient rail current, additional measures shall be employed to ensure effective track circuit shunting, for example, track circuit assistors.

Track maintenance vehicles and road/rail vehicles which operate under special operating conditions do not need to shunt track circuits.

5.2 Axle Counters

5.2.1 Axle Counter Introduction

Train detection (using axle counters) is achieved when the wheels of rolling stock pass over a sensor attached to the rail.

Depending on the sensor type, accurate and reliable detection of either the wheel itself or the wheel flange passing over the sensor distorts a magnetic field produced by the sensor, which is then detected by an evaluator.

Wheels of smaller dimensions generally have smaller flanges and as such, when travelling at speed, not only distort the magnetic field less, but also distort it for a shorter time. Axle counter evaluators have a minimum integration time which shall be met in order to achieve a reliable count.

Reliable detection of rolling stock is the result of the following:

- wheels or flanges being within the detection limits as specified by the axle counter manufacturer.
- protuberances on the vehicle being outside of the metallic influencing zone as defined in ERA/ERTMS/033281;
- the speed of the vehicle; and
- distance between axles of rolling stock meets the minimum integration time of the wheel sensor

Wheel sensor is electrically isolated from the rail, however there is potential for the sensor to be influenced by strong magnetic fields from traction systems and other large electromagnetic radiating sources on board the vehicle.

5.2.2 Axle Counter - Wheel / Rail Interface Requirements

Reliable detection for both wheel and flange will require the wheels to be kept within prescribed tolerances as specified by the axle counter manufacturers in the technical manuals.

In addition, Reliable detection for both wheel and flange detector systems will require the wheels to be kept within prescribed tolerances as specified in the Route Access Standard and RISSB - Code of Practice - Wheel Defects.

5.2.3 Axle Counter Compatibility Requirements

The basic principle of an axle counter lies in the ability of a wheel to sufficiently disturb a magnetic field produced by a rail mounted wheel sensor. The wheel needs to be of a low permeable material and of sufficient dimension to be reliably detected.

Rolling stock operating on the ARTC Network shall meet the following requirements to be compatible with the installed axle counters:

- wheel materials shall comply with AS 7514 Railway Rolling Stock - Wheels

5.2.4 Axle Counter Proof of Compliance

The Train Operator shall satisfy ARTC that any new rolling stock has been demonstrated to comply with the requirements by providing the following theoretical and test data:

The Certifier shall satisfy ARTC that new rolling stock complies with OEM’s requirements by providing the theoretical and/or field test results documented in the compatibility report. Test on ARTC track may be required based on the judgement/assessment of Certifier. Proof of compliance will include below:

- Vehicle dimensions, wheel dimensions, bogie and braking system design;
- results of actual axle counting occupancy tests at an approved test site;
- results of actual interference tests and;
- compliance to Axle Counter manufacturer’s requirements for wheel profile and dimensions.

5.3 Treadle Switches

5.3.1 Treadle Switch Introduction

Treadle switches detect the passing of a wheel over a sensor mounted to rail. Some sensors are electromechanical, however modern treadles detect the wheel through a change in the magnetic circuit generated by the sensor.

Using treadle switches assist with the train detection. However, on some forms of rolling stock, the wheels are of such a size that they cannot be reliably detected.

Treadle switches are not failsafe in design, so are only suitable in applications where their failure modes do not result in an unsafe condition.

5.3.2 Treadle Switch Requirements

The sensors are designed to detect the passing of a wheel. Some sensors rely on the wheel flange for effective operation.

The minimum wheel diameter for detection of the treadle switches should be compliant to the treadle switch manufacturer's manuals.

5.3.3 Treadle Switch Proof of Compliance

Proof of compliance shall be determined by developing specific test cases tailored to test the vehicle against the installed items.

Acceptance criteria for each test case will be based on the certifier's judgement, including a safety margin to allow wheel wear and requirements of the manufacturer.

5.4 Data Pick-Up Units (DPU)

5.4.1 Data Pick-Up Unit (DPU) Introduction

DPUs, also known as pin- point detectors or intermediate receivers, are a tuned inductive pick-up device and are used with audio frequency track circuit. The DPU is energised by the electrical current that flows in the rail from the parent audio-frequency track circuit.

As the rollingstock wheels passes over the DPU, the short circuit formed by the wheels and axle to the other rail, shunts the track circuit current away from the DPU, reducing its output below the pick-up threshold for the receiver.

5.4.2 Data Pick-Up Unit (DPU) Requirements

DPUs can be used to either detect the leading end of a train, where they are used to typically time a train's approach speeds, or they can detect the rear of the train, where they are typically used for conditional clearing of signals in the rear.

DPUs have been proven to be susceptible to interference from the rolling stock; particularly rolling stock that uses power electronics controlled traction systems.

5.4.3 Data Pick-Up Unit (DPU) Proof of Compliance

Proof of compliance will be determined by specific test cases where the vehicle under test is to power and brake over the DPU, to ensure that noise levels detected by the DPU are acceptable and will not cause any issues with the vehicle detection.

6 ATMS and ATP

6.1.1 ATMS and ATP Requirements

Trains operating in an area where any form of Automatic Train Protection (ATP) or Advanced Train Management System (ATMS) is in service, shall be equipped with compatible interface and control equipment applicable to the particular type of train for the ATP or ATMS system.

Refer to ESD-32-02 - ATMS Equipped Train Braking Standard

6.1.2 ATMS and ATP Proof of Compliance

Where applicable, the operator shall provide details of the design and operation of the Automatic Train Protection equipment on the proposed rolling stock, for approval by ARTC.

The Rollingstock Operator shall satisfy ARTC that any new rolling stock has been demonstrated to comply with manufacturer's requirements of ATP/ATMS by providing the theoretical and test data.

7 Track Circuit Assistors (TCA)

7.1 Track Circuit Assistor (TCA) Introduction

It is a feature of wheel-rail contact, that once a current flow of any kind is established, other currents can follow the same path without obstruction.

Electric rolling stock has the advantage that any temporary loss of wheel-rail contact will be rapidly rectified by the traction return current re-establishing an effective return path.

Light short consist non-electric rail motors or DMU's which are not inherently capable of reliably being detected by track circuits shall be fitted with track circuit assistors (TCA's).

These devices have been demonstrated to improve train shunt characteristics for these types of vehicles, thus reducing or eliminating loss of shunt events. Loss of train shunt events can allow significant unsafe situations to arise that can lead to train-to-train collisions, even if the loss of shunt event is for a very short or transient period.

When fitted, a TCA provides an improved level of track circuit shunting assistance and meets the applicable electromagnetic compatibility requirements.

A Track Circuit Assistor (TCA) fitted between a pair of wheelsets on a vehicle provides a signal induced in a loop formed by the wheels/axles and rail underneath a bogie. This provides a wetting current for the track circuit signals providing improved shunt capability.

The antenna acts as a transformer primary and induces a voltage in the secondary loop formed by the wheels, axles and rails. Maximum voltage at any point on the loop is limited so as not to adversely affect any type of track circuit.

The TCA assists the operation of a track circuit by raising the effective track circuit rail-to-rail voltage at the wheelsets either side of the TCA; this enables a low voltage track circuit to operate as effectively as a higher voltage type. The relatively high voltage at the wheel-rail interface breaks down rail/wheel contamination, allowing track circuit current to flow, de-energising the track circuit relay.

The TCA shunting assistance continues when the track circuit is occupied, as the full voltage and current from the TCA will be available at the wheel/rail interface even when the rail voltage from the track circuit falls below the drop-away level. The TCA therefore continues to reduce the impedance of the contact at the wheel/rail interface.

7.2 Track Circuit Assistor (TCA) Requirements

All light self-propelled (passenger) rail vehicles with axle loadings of 19 tonnes or less per axle shall be fitted with track circuit assistors (TCAs).

All consists of these types of vehicles operating on the ARTC Network with 12 axles or less, shall be fitted with at least two (2) TCAs – one at each end of the consist. Where consists of these types of vehicles are joined together to form a longer consist, provided that the front and rear TCAs are active and being monitored, the additional TCAs located in the middle of the larger consist are not required to be operational.

The track circuit assistor antenna shall be fitted to the leading bogie of a vehicle. Where a vehicle can be operated from either end, a TCA antenna shall be fitted to each leading bogie.

The fitment of the antenna shall be certified in all mechanical (installation and mounting) and electrical (operating) respects. The TCA system when installed and commissioned shall be certified by testing to ensure that it is functioning correctly.

The Rolling Stock Operator shall demonstrate that a fail-safe health monitoring system has been installed to enable in-service failures of the on-board equipment to be promptly detected.

7.3 Operation and Maintenance of Train Detection

Should one or both TCAs fail or are offline, the consist shall be operated under alternate working arrangements until such times as the TCAs have been repaired and the TCAs certified as operational.

The TCA shall be regularly inspected, calibrated and maintained. The Rolling Stock Operator shall determine the necessary maintenance and inspection intervals.

Before a vehicle fitted with a TCA is allowed onto the ARTC Network, all fitted TCA’s shall be proved to be operating, confirmed by no TCA fault indications displayed on the operator’s control panel and by visual inspection of any fault indicators on the transmitter unit itself.

Access by passenger DMU’s to the ARTC Network shall be restricted to those units which have been fitted with TCA’s and which have been tested to demonstrate reliable operation, in accordance with the requirements of this standard.

Where passenger DMUs are not fitted with a TCA their ability to maintain a reliable shunt on a track circuit shall be assessed by the certifier. Where reliability of shunt cannot be guaranteed to an SFAIRP level, the vehicle shall not be reliant on the signalling system. Alternate means of safe vehicle movements in accordance with ARTC Network Rules and Procedures shall be applied.

7.4 Track Circuit Assistor (TCA) Proof of Compliance

The Rolling Stock Operator and Certifier, in conjunction with the TCA supplier shall conduct a combination of theoretical design analysis, laboratory testing of prototypes and on-site testing of production versions of the TCA.

These tests shall demonstrate that the TCA will provide reliable and effective track circuit detection on all types of track circuits on the routes over which the rolling stock to which it is fitted will operate.

The Rolling Stock Operator shall demonstrate that a fail-safe health monitoring system has been installed, supported by procedures to be adopted by Train Crew if the system detects a fault whilst the rolling stock is in transit.

The Rolling Stock Operator shall provide evidence that maintenance requirements have been assessed and that maintenance and testing programs have been implemented to ensure continued safe and reliable operation of the TCA during its operational lifecycle.

The Rolling Stock Operator shall certify that the operation of the TCAs fitted to each consist are operational following each scheduled maintenance intervention.

7.5 Inoperability of TCA Systems

The Operator shall certify that the operation of the TCAs fitted to each consist are operational following each scheduled maintenance intervention.

Operators should develop operating procedures for managing inoperable TCA’s in consultation with ARTC, to manage the trains under alternate conditions e,g.application of block working or a Track Occupancy Authority or Track Warrants.

8 Traction System Compatibility Requirements

8.1 Traction System Requirement

Rolling stock shall not provide any means for the generation or injection into the running rails of any electrical voltage or current which may interfere with the safe and reliable operation of track circuits and other train detection systems.

This requirement applies equally to currents or voltages generated by the rolling stock itself, e.g. traction power units or auxiliary power supplies, or to components of the electrical traction supply finding a low-impedance path to the traction return system.

8.1.1 Acceptable In-Rail Currents

The signalling noise compatibility diagram Figure A.1 (Traction Return Compatibility Envelope - Acceptable In-Rail Currents at Signalling Frequencies) (Appendix A to this document) shows acceptable levels of noise currents in the traction return, over the frequency spectrum used by the signalling system. Generally, ARTC does not have electrical traction overhead wiring on its tracks. However, it does run parallel or close proximity to other networks with electrical traction. The tracks are cross bonded and spurious currents and noise may cross between the networks. Standards from adjoining railway can be used for traction return requirements in case of any traction return affecting the ARTC network.

Until the signalling system no longer includes track circuits of the 50Hz Double Rail type, rolling stock electric traction units are required to incorporate detector / alarm units which warn of the presence of excessive amounts of 50Hz currents in the traction return. It is not a requirement that such alarms include the ability to disconnect the traction control unit of which they form a part, but operating procedures shall ensure that they are rendered safe as soon as possible.

ERA/ERTMS/033281 details interference limits for axle counters.

New rolling stock that complies with the graph in Figure A.1 under all operating conditions is unlikely to cause interference to the signalling and control systems, however ARTC does not guarantee that rolling stock which meets this curve will not cause interference.

The Train Operator is responsible for ensuring that the rolling stock is fully compatible with the ARTC signalling system under all train operating modes.

8.1.2 Close-Up Effects

Close-up effect refers to electrical noise that is not related to harmonic content in traction return currents and can be generated by electric or diesel power rolling stock alike. It results from large inductive sources such as traction motors inducing a small voltage into an axle. Electrical currents can flow as a consequence of axles and rails forming a low impedance circuit.

DPU coils are easily influenced by these currents which can cause false detection failures or, if the harmonic content emulates that of a track circuit transmitter, falsely energise a DPU-fed receiver.

AS7505 requirements shall be complied with.

8.1.3 Tests on Rolling Stock with Electric Traction

Tests shall be carried out to confirm the nature of the harmonic spectrum associated with the traction unit and auxiliary power supply and other onboard systems.

For electric rolling stock and locomotives, the ripple current and voltage shall be recorded as a train operates in motoring and braking through typical supplied power sections. AC ripple measurements shall be made as the train is operated close to each type of substation.

The results of the above tests shall be processed by an FFT analyser such that the harmonic spectrum is made available for the following

- for a complete power-brake run,
- for each type of substation,
- and for each notch setting.

8.1.4 Tests on Track Circuits

The rolling stock supplier or operator shall conduct a combination of theoretical design analysis, laboratory testing of prototypes and on-site testing of production versions of the rolling stock.

Tests shall be carried out to determine the compatibility of the rolling stock with each of the track circuits over which it will be operated. These tests shall include but not limited to:

- track circuit shunting performance;
- traction current harmonics causing potential failure of track circuits
- traction current harmonics causing potential false energisation of track circuits
- traction unit impedance to traction supply (electric locomotives and EMUs only);
- auxiliary power systems harmonic generation and impedance
- generation of interference to the signalling system by other train-borne equipment (electric & diesel electric locomotives).

The test programmes shall include ‘bench’ measurements of traction current interference, followed by site testing on a comprehensive range of track circuit types.

8.2 Diesel Electric Locomotives

Rolling stock power units equipped with 3-phase induction motors, including EMUs, DMUs, electric and diesel-electric locomotives, may cause circulating currents in the rails between the front and rear bogies. This may be a result of the configuration of the traction units and chassis return current bonding. The requirements of this section shall be tested for all classes of locomotives.

8.3 Traction System Proof of Compliance

The operator shall carry out a combination of theoretical design analysis, laboratory testing of prototypes, and on-site testing of production versions of the rolling stock. These tests shall demonstrate that any traction current noise components, under all conditions of normal operation and component failure, are below the interference thresholds of the track circuits and detection systems in the proposed operating corridor.

The noise components may be generated intermittently or as a transient. The signal levels shall not exceed the nominated levels for more than 1.0 seconds. Where there are multiple transient or intermittent events in a short period, they shall be assessed and certified as not interfering with the signalling equipment.

9 Electromagnetic Compatibility Requirements

9.1 Introduction

Modern signalling systems are based on microprocessors, data communications and other sensitive electronics, which can be affected by the electromagnetic interference.

Older analogue-based systems may be more susceptible to electromagnetic interference.

Systems which could be susceptible include train detection systems, and communication-based train control and signalling systems.

Potential issues include the following:

- false energisation of track circuit relays or intermittent failures of the track circuit when the train is operating on or adjacent tracks.
- lock out or failure of processor-based track circuits and other signalling equipment; and
- interlocking system shutdowns or resets due to induced or capacitive-coupled EMI.

9.2 Requirements

Rolling stock shall not generate any form of electromagnetic interference which may interfere with the safe and reliable operation of the signalling system.

This requirement specifically includes electromagnetic track brakes, which operate by inducing eddy currents in the running rails.

Generally, rolling stock shall comply with current national and international Electromagnetic Compatibility standards.

- AS 7722 EMC Management
- AS7505 Signalling Interface Detection
- EN 50121 Railway Applications - Electromagnetic Compatibility - Part 1: General
- EN 50121 Railway Applications – Electromagnetic Compatibility – Part 3-1 Rolling stock – train and complete vehicle
- EN 50121 Railway Applications – Electromagnetic Compatibility – Part 3-2 Rolling stock – apparatus
- EN 50121 Railway Applications - Electromagnetic Compatibility - Part 4: Emission and Immunity of the Signalling and Telecommunications Apparatus
- AS 4251.1 Electromagnetic compatibility - Generic emission standard Part 1: Residential, commercial and light industry.

9.3 Proof of Compliance

Operators are required to provide evidence of testing carried out to measure the electromagnetic emission characteristics of any new or modified rolling stock.

10 Signalling Equipment

10.1 Introduction

Rolling Stock shall not generate any energy capable of interfering with the ARTC signalling and communications equipment.

10.2 Power Cables

Signalling power distribution is generally at 120 volts AC nominal with some 50 volts DC mains. There may also be 415V AC mains. This may vary in different states or regions. Cable sizes vary from 4 mm2 to 70 mm2 depending on loading drop and the feeders may be open wire, or cable installed in ducting or troughing, or buried. Cable runs are generally parallel to the lines, at any convenient position between the railway boundaries.

Power distribution cables are generally not screened, and where a metallic termite barrier is provided, this is not connected to earth.

10.3 Signalling Circuits

Signalling circuits may be run in multicore cable installed in ducting or troughing, aerial or buried; in individual conductors installed in ducting or troughing; or in open wire line.

Circuits in multicore cable operate generally at 50-volt DC doubled switched, not AC immunised. Conductors are normally 1/0.064” or 7/0.50 mm singles (not balanced pairs or quads).

Audio frequency track transmitters and receivers are connected to the trackside equipment by up to 1500 metres of single pair 7/0.50 mm aluminium foil screened cable, laid in trackside ducts and troughing.

Circuits in individual conductors operate generally at 120-volt 50 Hz, single switched with common return, over distances up to 1000 metres. Conductor size is 1/0.064’ or 1/1.70 mm.

The relatively few remaining open-wire signalling circuits may operate at various voltages between 10 volts and 120 volts DC or 120-volt 50 Hz.

Cable and line routes run generally parallel to the tracks, at any convenient position within the railway boundaries. Signalling cables are not screened, although a metallic tape termite barrier is incorporated.

10.4 Communication Cables

Frequencies in use range from DC to 300 kHz.

Trunk, junction and local type cables quad construction, with screening factors of between 0.04 and 1 at 800 Hz with most cables having a system screen factor of 1. For use mainly in DC to VF range. Balance of cable and equipment generally 40 dB, however in older cables and plastic non-gassed cables that have been subject to the ingress of moisture, the balance may be worse.

Carrier and coaxial cable.

- Carrier cable is of quad construction for use in the range 6 kHz to 150 kHz. Screening factor is similar to above.
- Coaxial cable is used with systems operating in the range 60 kHz to 150 kHz. In most cases no electromagnetic screening is applied to this cable.

All types of cable can be located anywhere within the ARTC Network and may be located in troughing close to the rails.

Cable route plans of buried cables are available if required. However, these are not necessarily typical. Locations of boundary fence line or between tracks, buried and elevated and at times on both sides of the railway easement.

Cables types vary from lead sheathed tape and wire armoured to solid polythene insulated and sheathed with copper tape. A large percentage of cables have screening factor close to unity due to inadequate earthing or screening material. The critical case is related to cable installations in which a reduction of screening factor cannot be achieved due to inadequate screening materials. This type of cable exists on a number of main line routes.

10.5 Telephone and Radio Systems

The frequency spectrum from VF to 108 kHz is used on all routes. There is also an increase in digital data on most routes.

The present planning on new works adopts CCITT standards. The specifications for this equipment are similar to Telstra Specifications.

10.6 Telemetry and Remote Control

A variety of signalling remote control and indication systems, (SCADA, RTU, Telemetry), are in use on the ARTC Network. These systems can be either analogue or digital with the operating range up to 18 kHz.

Information is transmitted through both communications type cable and aerial lines located at various distances from and running parallel to the track.

10.7 Signalling Equipment Proof of Compliance

Type tests shall be conducted using the train set to measure vehicle generated disturbance effects in signalling track circuits, cables and lineside signalling & telecommunications systems outlined above.

11 Train Braking

11.1 Introduction

AS4292.4 identifies the risks posed by mixing trains of markedly different acceleration, speed and braking performance in one system, whose design shall of necessity be optimised for one type of traffic. This situation applies particularly in the urban and interurban areas.

There are two types of risk factors:

- Safety risk, in that a train whose combined mass, speed and braking capacity make it incapable of braking to a stop before encountering an obstruction presumably 'protected' by the signalling system, may be permitted to enter the system.
- Commercial risk, in that poorly braked trains may have to operate under speed restrictions which make their train path time longer or may even result in delays to other services sharing the corridor.

Analysis has shown that, the signalling infrastructure, augmented by some local speed restrictions imposed on particular train types, is capable of managing trains whose braking meets, or exceeds the GW 16 braking table (original Super freighter braking). Until further notice, the GW 40 braking table is adopted as the standard to which all new services shall comply.

Where an operator proposes to introduce significantly longer and heavier trains on the network, the GW 40 performance limit will be under pressure. The cost of improving signal warning distances or imposing operating speed limits to meet an increased braking requirement will become part of the commercial considerations in deciding whether to introduce the proposed service.

With long, heavy trains, the addition of more locomotives will have very little effect on the train's braking capacity. By contrast, providing extra horsepower, whether by more powerful or additional locomotives, will improve the speed capability to the point where it will be operating at speeds in excess of its ability to brake safely. This is the reason for requiring that, where a particular consist has been assessed and approved for operation, its braking and speed capabilities should be maintained within close limits.

11.2 Train Braking Requirements

All trains operating on the ARTC network shall have a combination of braking performance and maximum operating speeds which permit them to stop safely in the warning distances provided by the installed signalling infrastructure.

Train braking performance of a complete consist, operating at up to its permitted maximum speed, shall equal or better the braking table specified for a given area.

The following sections define the train braking requirements for rolling stock operating on the ARTC system.

11.3 Stopping Distance Tables

To ensure the safe operation of all trains within the signalling limits, train braking performance shall not be less than the braking performances specified below.

The spacing of signals in the Australian Rail Track Corporation network is determined by the braking characteristics of an average train for the terrain and track speeds relevant to the signal location.

Braking Distance tables define this performance for standard types of trains. The Defined Interstate Rail Network is designed to meet the requirements of the GW40 Braking table. Other trains will need to regulate speed as they approach signals to ensure that they can stop within the allowed distance if the signal aspect is red.

High speed passenger trains have improved braking performance than that of freight trains, and thus are permitted to travel at a higher track speed (at XPT speed boards), even when approaching signals. These meet the requirement of the HSP160 and /or the MSP120 Brake Tables.

These tables are for level tangent track and for ascending or descending grades.

Stopping distances are measured from the point of application, when the driver moves the brake handle into full service braking and until the train comes to a stop. Emergency braking is not to be used. These tables assume that all brakes on all locomotives and wagons are working and there are no other adverse conditions that might affect stopping distance.

Trains with stopping distances exceeding these limits shall be driven at reduced speeds to provide the ability to stop within the nominated braking distances.

At some locations ‘advisory speed signs’ have been displayed for XPT/Explorer/Endeavour trains, express trains and freight trains exceeding nominated sizes. This is to ensure that these trains have sufficient distance to enable them to stop within the required signal spacing.

There are speed restrictions for freight trains operating within specific areas including metropolitan areas. Refer to the ARTC Route Access Standard Section Pages for allowable maximum speeds.

All vehicles shall be maintained such that braking performance does not deteriorate over time.

11.4 Applicable Train Brake Tables for Network

The various train braking tables (refer Appendix D) will be applied to various parts of the ARTC network based on engineering and operations requirements. Application of braking tables on the ARTC Network is documented in the Route Access Standard.

Signalling Standard ESD-05-03, Train Braking Design Application Design provides details of these areas and also contains the brake tables specifically adjusted for signalling design use.

All trains operating on the ARTC network shall comply with the standard braking tables included in these tables.

The GW40 table is the default braking table for the Defined Interstate Rail Network (DIRN).

Please Note: The braking tables to be used for signalling design are found in Standard ESD-05-03, Train Braking Application Design.

Certifier is required to compare the braking performance of the new/modified rollingstock and new train configuration with existing rollingstock/train configuration currently in operation and provide assurance that new/modified rollingstock braking performance is either equal or better to the other rollingstock currently operating on ARTC network and will not result in SPAD on existing installed signalling system due to the braking performance.

12 Signal Visibility

12.1 Introduction

Signalling systems rely on effective sighting of signal indication by Rolling Stock Operators. This visibility requirement is directed at ensuring that the operator has sufficient field of vision to see all necessary signals, and that there are no impediments to seeing all line side signals and indicators correctly.

12.2 Signal Visibility Requirements

The driver's seating position and windows shall be of a design to provide clear visibility and sighting distances, for signal aspects and indicators installed in accordance with ARTC Standards and Network Operational Rules.

This shall apply also for ground-mounted shunt signals, gantry signals, and signals mounted at platform ends, on the right-hand side of the train.

This shall consider the anthropometric range consistent with the population of drivers who may operate the unit.

All driving cabs of locomotives, rail bound track maintenance vehicles and passenger driving cabs shall comply with AS7533 Driving Cabs.

12.3 Locomotive Cab sightlines to signals

The requirements for the sighting of signals are detailed in Appendix C

12.4 Signal Visibility Proof of Compliance

Operators shall provide design analysis to demonstrate that the required visibility has been provided. This shall be a design analysis on the drawings for rolling stock units, showing the nominated limits for the anthropometric data. The design analysis shall show the range of persons as a result of the anthropometric range of drivers.

12.4.1 Information to be Provided

The following information shall be provided for each class of locomotive:

- Height of cab floor above rail
- Height of cab seat above cab floor at mid position
- Height adjustment range above and below mid position
- Driver's eye position above rail height

ARTC's objective is to have the top red indication on a main signal at the driver's eye height. Different trains and locomotives have the driver's seat at different heights above rail.

The above information is to assist ARTC in developing a database to determine and update the weighted mean height of the driver's eye above rail.

- Rolling Stock Dimensions

12.5 Introduction

Particular dimensions on rolling stock are critical to the train detection system for both track circuited and axle counter solutions.

Vehicle dimensions that have the ability to affect the signalling system include the length of vehicle overhang and the distance between inner axle centres.

12.6 Vehicle Overhang

To ensure train safety at converging tracks and at clearance points, Operators shall ensure the distance from the front or end of a train (headstock) to the nearest axle centre does not exceed 3 metres.

Details of permitted vehicle outlines and swept paths are documented in Route Access Standard Appendix A - Rolling Stock Outlines and Loading Requirements.

shall

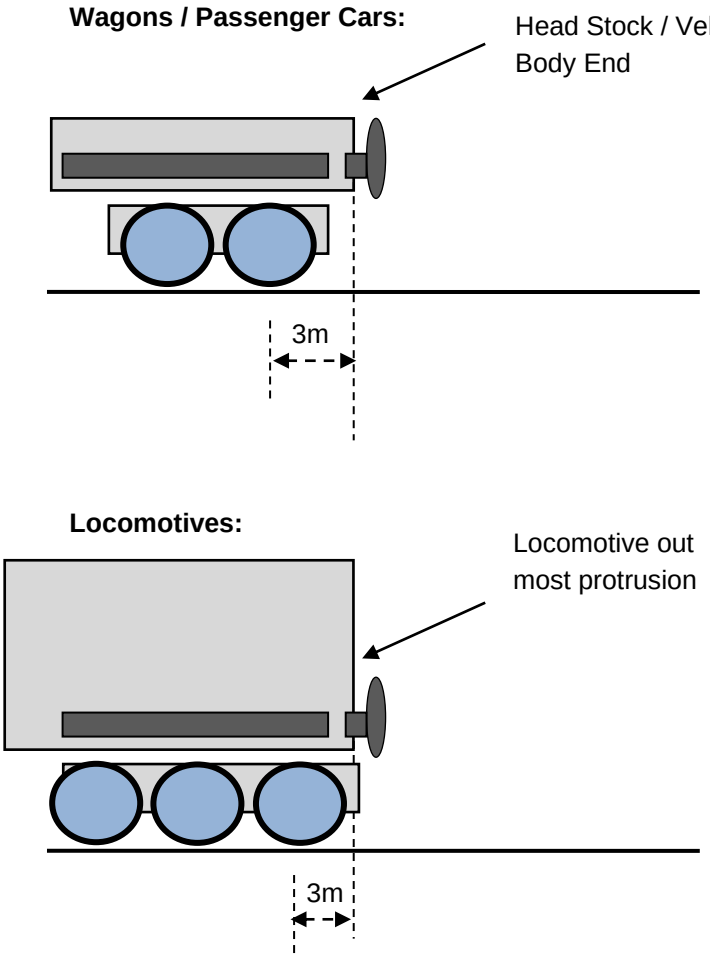


Figure 14 – Minimum axle spacing for overhang

12.7 Inner Axle Centres

To maintain shunting reliability, there shall always be a minimum of two axles shunting a track circuit. The minimum track circuit or axle counter track section length in use on the ARTC

Network is 15m. Consequently, the maximum distance between inner axles of a single vehicle is 14 m, to ensure that there will always be a minimum of two axles shunting the shortest-used track circuit.

Details on the bogie centres for approved rolling stock types can be found in Route Access Standard Appendix A - Rolling Stock Outlines and Loading Requirements.

Where it is proposed to operate a vehicle on the ARTC Network where the inner axle spacing exceeds 14 m, the acceptance for approval shall assess the likelihood and consequence of the potential for a track circuit to energise underneath the vehicle.

12.8 Axle Loads

Vehicles with light axle loads are less effective in providing a consistent shunt.

Axle loads of 10 tonnes or less shall have further consideration in the compatibility assessment with, if necessary, dynamic tests conducted to prove satisfactory shunting performance.

12.9 Train Stops

Train stops are installed on rail networks that interface to ARTC. Fixed train stops may be installed on the ARTC network at the interfaces with these other networks.

The locomotive and rolling stock loading gauge reserve an area for the train stop equipment. This area is not to be infringed by any other equipment on the locomotive.

13 Rolling Stock Modifications and Maintenance Compliance

The Rolling Stock Operator or Delegated Representative shall make representation to ARTC should a modification or change to maintenance practices be undertaken to existing rolling stock that is or was compliant that may have a detrimental effect upon the signalling system.

Where this is the case, the Rolling Stock Operator or Delegated Representative shall detail both the technical changes either implemented or planned to be implemented, as well as the perceived detrimental effects upon the signalling system prior to any changes taking place. In addition, detail shall be provided outlining the rationale behind the change and any mitigation measures taken or to be taken by both the Rolling Stock Operator and/or ARTC to reduce the impact of any such change on the signalling system.

In the event of rolling stock modifications that may impact upon the signalling system, any changes to configuration and the associated testing results shall be detailed on form ESS3201-F01 – Rolling Stock Signal Compliance Certificate, to ensure compliance to this standard.

Appendix A - Traction Return Compatibility Envelope

Acceptable In-Rail Currents at Signalling Frequencies

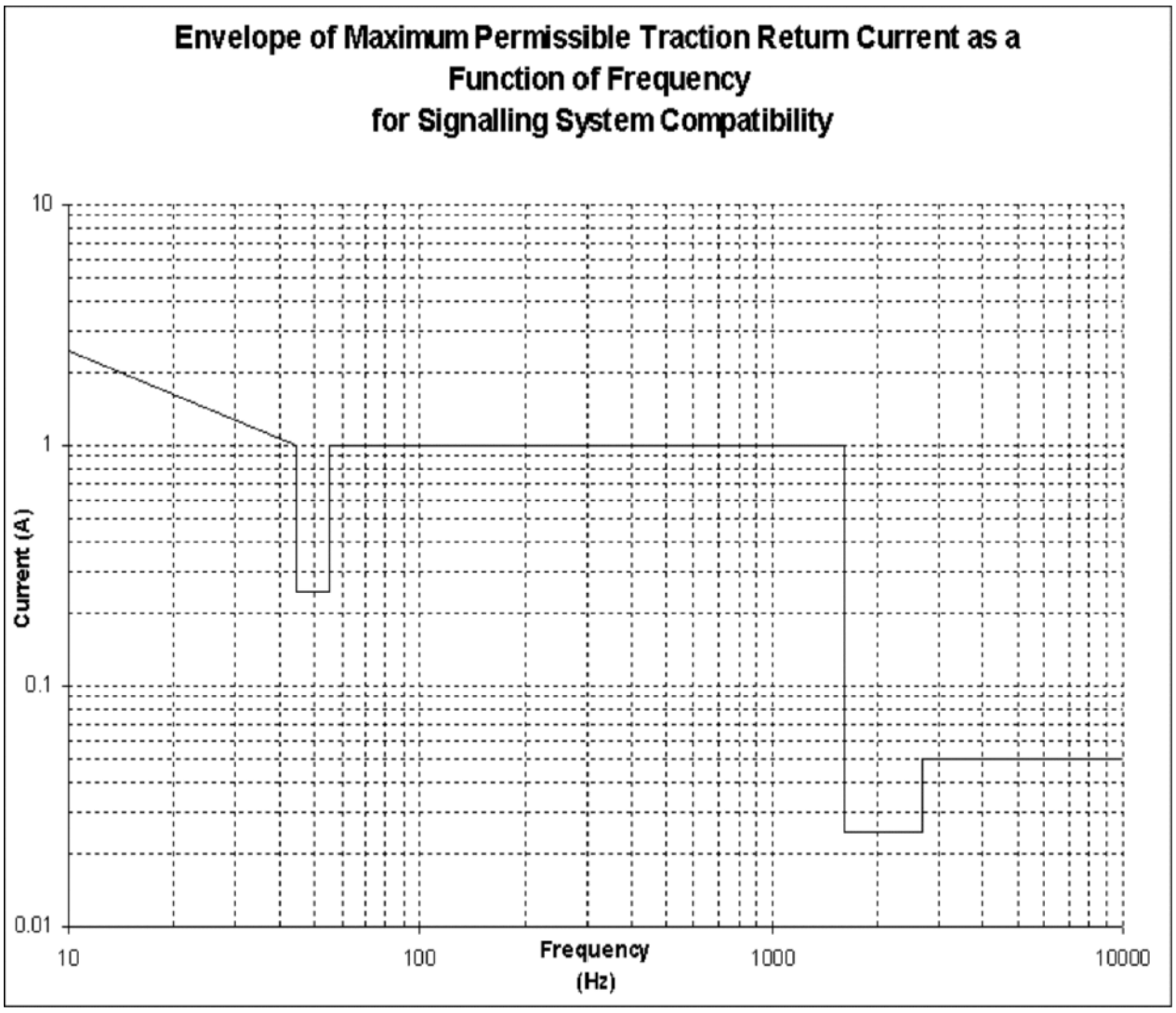


Figure A.1

Appendix B – Track Circuit Parameters

Track Circuit Type	Frequency	Modulation	Operating Voltage	Receiver / Relay			Maximum Length		Nominal shunt value
				Minimum Operation	Maximum Drop-Away	Normal Working	Double Rail	Single Rail	
DC	DC	N/A	1 to 3 V	0.4 V	0.3 V	1 V	2000m	N/A	0.06 to 0.2 ohm
DC - AC Immune	DC	N/A	3 to 5 V	0.9 V	0.6 V	3.5 V	N/A	600m	1.5 ohm
DC – 'Westrak'	50 – 400Hz	N/A	3 to 20 V	0.4 V	0.3 V	1 V			0.06 to 0.2 ohm
AC	50 Hz	Nil	1 to 3 V	0.5 V	0.3 V	1.3 V	1000m	300 m	0.06 to 0.5 ohm
AF (Jointless)	1700 Hz, 2000 Hz, 2300 Hz, 2600 Hz	Fsk ±10 Hz to 15 Hz	3 to 5 V	200 mV	180 mV	400 mV	900m 2000 m Compensated	N/A	0.15 to 0.5 ohm
AF (Jointed)	380 Hz - 510 Hz (10 frequencies)	Fsk ±10 Hz to 15 Hz	3 to 20 V	1.7 V	1.5 V	3 to 12 V	400m	250m	0.5 ohm
AF Overlay	800 – 5000 Hz (Various frequencies)	N/A	0.3 to 1.3 V		0.05 V	0.3 V	800m	N/A	0.06 to 0.15 ohm
HV impulse	Bipolar DC Pulse (3 pulse / sec)	N/A	40 to 120 V	35 V	20 V	40 to 120 V	3000m	500m	0.25 to 0.5 ohm
Coded	2 second coded pulse train, DC or AF burst	N/A	+/-1 V			+/- 0.6 V	9000m	N/A	0.06 to 0.15 ohm
Level Crossing Detector	Steady AF 1 in 4 kHz	N/A	3 to 5 V				1000m	N/A	0.06 to 0.15 ohm

Table: Operating parameters for different types of track circuit

Appendix C - Signal Visibility

Signal Visibility

The driver should be seated so as to have visibility of the signals as detailed in the figures below.

The driver in a seated position shall have direct line of sight to:-

Dwarf or ground signalling equipment located at all distances greater than 13 metres from the driver's eye position and to a width of 2.5 metres from the adjacent rail running face on either side of the track. Refer to Figure C.1.

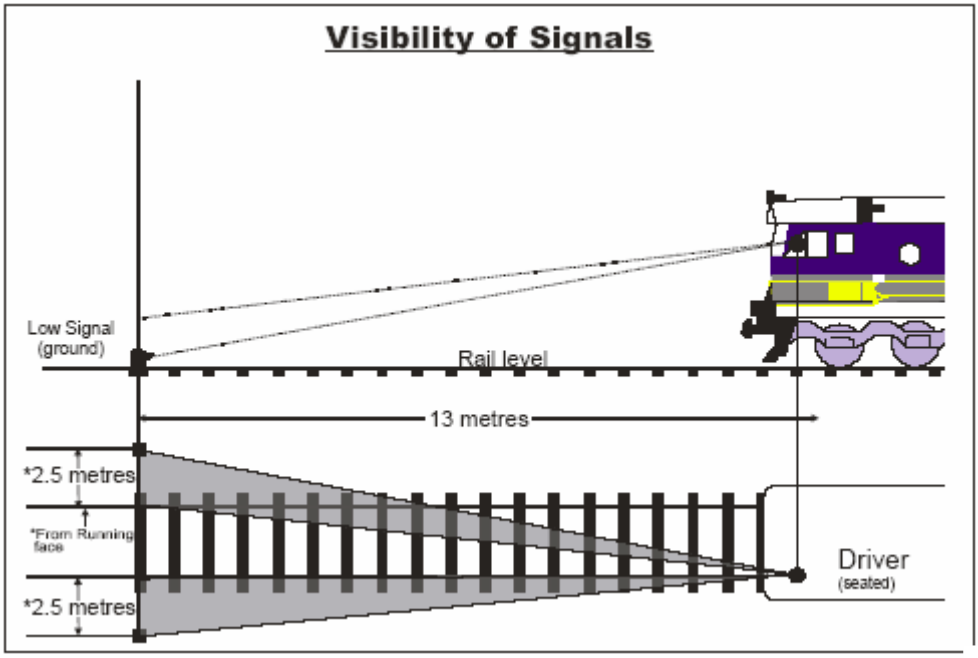


Figure C.1

High or gantry signalling equipment located at all distances greater than 13 metres from the driver's eye position at a normal height of 6.7 metres above rail level and within a width of two to five metres from the adjacent rail running face on either side of the track. Refer to Figure C.2

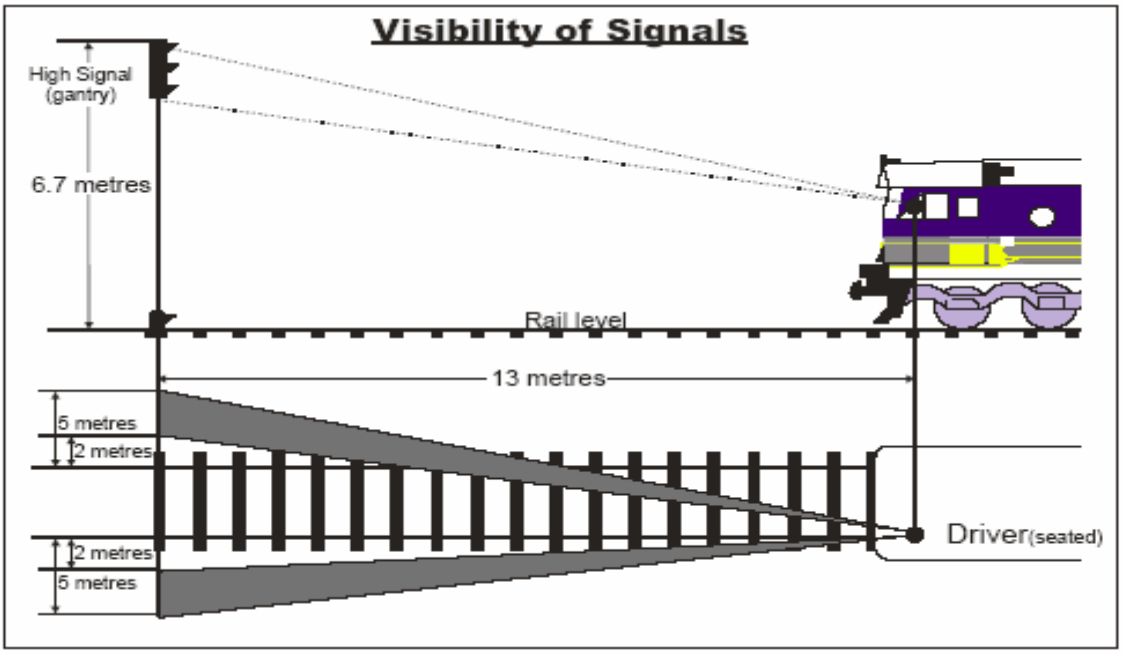


Figure C.2

The driver in a standing position shall have direct line of sight to dwarf and ground signalling equipment located at all distances greater than 4 metres from the driver's eye position and to a width of 2.5 metres from the adjacent rail running face on either side of the track. Refer to Figure C.3.

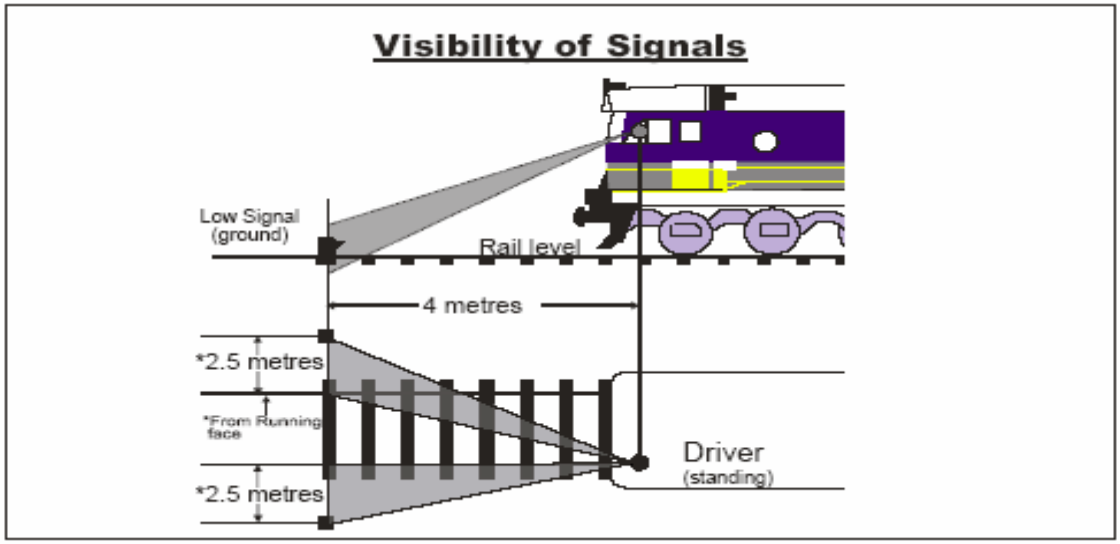


Figure C.3

In the case of vehicles where the driver is not seated at the front of the vehicle, such as in locomotives running long end leading, steam locomotives, or some track maintenance vehicles the driver shall be accompanied by a second person who is qualified in safeworking.

Appendix D – Train Braking Tables

Introduction

All trains operating on the ARTC network shall comply with the standard braking tables included in this appendix. These brake tables are for trains with no brakes cut out.

The GW40 table is the default braking table for the Defined Interstate Rail Network (DIRN).

Please Note: The braking tables to be used for signalling design are found in Standard ESD-05-03, Train Braking Application Design.

GW-40 Superfreighter
for Defined Interstate Rail Network
STOPPING DISTANCE TABLE

(distances in metres)

Full service brake application applied to locomotives and train until point of stop

	Rising				GRADE (1 in X)				Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	240	267	322	379	500	681	852	1158	1450
60	333	370	441	514	665	885	1091	1467	1834
70	441	486	575	666	848	1110	1357	1818	2280
80	560	616	724	833	1048	1358	1653	2218	2798
90	692	759	887	1015	1267	1630	1983	2672	3404
100	837	915	1064	1213	1504	1930	2351	3193	4063
105	914	998	1158	1317	1630	2091	2550	3458	4392
110	994	1084	1255	1426	1761	2260	2758	3725	4728
115	1076	1173	1357	1538	1898	2435	2966	3997	5073

HSP – 160 High Speed Passenger Train
STOPPING DISTANCE TABLE

(distances in metres)

High speed passenger trains that operate up to 160km/h

Full service brake application applied to locomotives and train until point of stop

	Rising			GRADE (1 in X)					Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	100	103	110	117	130	146	159	181	198
60	138	144	155	164	182	204	223	254	279
70	184	192	206	220	244	276	303	345	380
80	238	249	268	285	318	361	397	455	503
90	300	314	338	362	405	460	508	585	650
100	370	387	419	449	503	576	637	738	822
110	448	470	510	547	616	706	784	913	1021
120	535	561	610	656	740	851	949	1110	1246
130	629	661	719	774	876	1011	1130	1329	1495
140	731	769	855	903	1023	1185	1328	1565	1768
150	841	885	965	1042	1183	1375	1543	1823	2067
160	960	1011	1104	1193	1376	1581	1778	2111	2399

MSP – 120 Self Propelled Passenger Train
STOPPING DISTANCE TABLE

(distances in metres)

Self-propelled passenger trains that operate up to 120km/h

Full-service brake application applied to locomotives and train until point of stop

	Rising			GRADE (1 in X)					Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	96	100	110	117	134	155	173	204	231
60	137	144	157	170	193	225	253	301	343
70	186	196	215	232	265	310	350	417	477
80	243	257	281	304	348	408	462	554	635
90	307	324	356	386	443	520	590	709	815
100	379	400	439	477	548	644	732	882	1016
110	457	483	530	577	663	781	887	1070	1233
120	542	573	630	683	786	927	1053	1270	1464

GW-10 Loaded Coal Train

STOPPING DISTANCE TABLE

(distances in metres)

Full-service brake application applied to locomotives and train until point of stop

	Rising				GRADE (1 in X)				Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	238	266	320	377	498	684	873	1270	1745
60	333	369	441	515	668	902	1146	1682	2363
65	385	426	507	590	760	1022	1299	1920	2742
70	441	487	576	669	857	1151	1465	2185	3179
75	500	551	651	753	961	1288	1644	2480	3691
80	562	618	728	841	1070	1435	1838	2808	4301

GW-11 Empty Coal Train
STOPPING DISTANCE TABLE

(distances in metres)

Full service brake application applied to locomotives and train until point of stop

	Rising			GRADE (1 in X)					Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	207	225	261	295	361	447	521	634	722
60	284	308	353	396	477	581	667	800	900
65	327	354	403	451	539	652	745	886	994
70	372	402	456	508	604	726	826	977	1092
75	419	452	511	568	671	802	909	1070	1194
80	468	504	569	630	741	882	995	1167	1300

GW-16 Superfreighter
For secondary lines with passing loops less than 900 metres
STOPPING DISTANCE TABLE

(distances in metres)

Full service brake application applied to locomotives and train until point of stop.

	Rising			GRADE (1 in X)					Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	197	214	245	275	332	409	480	603	714
60	272	293	333	372	444	545	637	800	951
70	356	383	432	480	572	700	818	1032	1233
80	449	482	543	602	716	876	1027	1302	1567
90	552	592	666	738	877	1077	1265	1616	1962
100	666	714	802	889	1058	1303	1538	1982	2430
105	727	779	875	971	1156	1426	1687	2186	2697
110	791	847	952	1056	1260	1558	1847	2404	2969
115	857	918	1033	1146	1369	1696	2014	2624	3247

GW-30 Superfreighter
for lines with Loops less than 1300 metres
STOPPING DISTANCE TABLE

(distances in metres)

Full service brake application applied to locomotives and train until point of stop

	Rising			GRADE (1 in X)					Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	230	254	302	352	452	598	732	971	1195
60	319	351	413	476	588	781	945	1244	1530
70	420	461	538	616	768	983	1184	1556	1920
80	534	583	677	760	951	1208	1452	1912	2376
90	659	718	829	939	1151	1457	1753	2321	2909
100	795	864	994	1121	1370	1733	2089	2789	3524
105	868	942	1082	1218	1487	1882	2272	3043	3833
110	943	1023	1172	1319	1609	2039	2466	3294	4147
115	1021	1107	1267	1424	1737	2203	2661	3548	4471

GW-50 3/4 Loaded Container
for lines with standing room for 1800m long trains
STOPPING DISTANCE TABLE (distances in metres)

Full service brake application applied to locomotives and train until point of stop

	Rising			GRADE (1 in X)					Falling
	33	40	60	100	Level	100	60	40	33
Speed	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance	Distance
50km/h	248	279	340	407	548	772	989	1386	1768
60	347	387	467	552	730	1001	1260	1740	2215
70	459	509	611	714	932	1253	1559	2138	2730
80	585	647	769	895	1152	1527	1888	2588	3327
90	725	799	943	1093	1390	1827	2254	3100	4023
100	876	963	1134	1306	1649	2154	2658	3673	4714
105	956	1052	1234	1419	1787	2329	2876	3954	5067
110	1041	1142	1339	1535	1928	2514	3100	4240	5427
115	1128	1238	1447	1656	2075	2702	3322	4531	5798

14 Appendix E– Rolling Stock Test Matrix

Table E1 – Tests against rolling stock types – vehicle design

Tests	Assessment criteria	Diesel unit no electric traction	Diesel unit DC electric traction	Diesel unit (power electronic controlled traction – AC or chopper)	EMU (If applicable)
Cab sighting	Meets specification	√	√	√	√
Acceleration	Meets specification	√	√	√	√
Braking	Meets minimum braking curve	√	√	√	√
Vehicle overhang	Meets specification	√	√	√	√

Table E2 – Tests against rolling stock types – bogie design

Tests	Assessment criteria	Diesel unit no electric traction	Diesel unit DC electric traction	Diesel unit (power electronic controlled traction – AC or chopper)	EMU (If applicable)
Brake types	Provide detail	√	√	√	√
Trip gear	An approved type	As required	As required	As required	√
Wheel diameter	Provide detail	√	√	√	√
Wheel profile	To an approved wheel profile – ANZR1 / WPR 2000	√	√	√	√
Axle spacing	Provide detail	√	√	√	√
Inner axle spacing	Meets specification	√	√	√	√
Axle resistance	Meets specification	√	√	√	√
Wheel back to back	Meets specification	√	√	√	√
Sand blowers fitted	Fitted as required	√	√	√	N/A
Axle loading	Meets specification	√	√	√	√

Table E3 – Tests against rolling stock types – train detection tests

Tests	Assessment criteria	Diesel unit no electric traction	Diesel unit DC electric traction	Diesel unit (power electronic controlled traction – AC or chopper)	EMU (If applicable)
Shunt test	Refer ARTC standard ESM-07-02 and AS7505	√	√	√	√

Table E4 – Tests against rolling stock types – signal interference

Tests	Assessment criteria	Diesel unit no electric traction	Diesel unit DC electric traction	Diesel unit (power electronic controlled traction – AC or chopper)	EMU (If applicable)
Signal interference testing	Meets specification	None (on the assumption there are no other electrical noise sources)	None (on the assumption there are no other electrical noise sources)	√	√
Regen braking	Interference currents meet specification	N/A	√	√	√
Train start up or shut down	Interference currents meet specification	N/A	N/A	N/A	√
Degraded mode 1 for example 75% traction	Meets interference current limits	N/A	N/A	√	√
Degraded mode 2 for example broken rail	Meets interference current limits	N/A	N/A	√	√
50Hz impedance tests (If applicable)	Meets specification	N/A	N/A	N/A	√
50Hz detector (If applicable)	Functions to specification	N/A	N/A	N/A	√
Special test case	As nominated	As identified	As identified	As identified	As identified