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Signalling Rolling Stock Interface

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ARTC Network Wide SMS

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1.1	07 Oct 09		Disclaimer updated as per Risk & Safety Committee 14/09/2009
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1 General

The existing ARTC signalling infrastructure has been designed and built to design parameters to suit rolling stock whose design and performance lie within a defined range.

This document defines the signalling infrastructure compatibility requirements for rolling stock to be operated on the Australian Rail Track Corporation rail network. The requirements reflect the interfaces between rolling stock and the signalling infrastructure, considering in particular the issues of train detection by track circuits, dynamics and signal spacing and indications. Also considered are those aspects of interfaces to the track and the electrical traction supply system which relate to the operating of the signalling system.

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

The standard covers the technical requirements for compatibility of rolling stock with signalling track circuits, position of signals, general electromagnetic interference and train braking. The standard also covers the process for confirming compliance of rolling stock by the Train Operator.

1.3 Responsibilities

The Manager Standards is the document owner and is the initial point of contact for all queries relating to this Standard.

The Train Operator is responsible for providing details of compliance of new locomotives and rolling stock to the signalling interface requirements detailed in this standard. The Train Operator is also responsible for ensuring the continued compliance of the rolling stock throughout its operational life, particularly after any changes 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 50121:2006 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 50121:2006Railway Applications - Electromagnetic Compatibility - Part 4: Emission and Immunity of the Signalling and Telecommunications Apparatus
- AS4292 Railway Safety Management

1.4.2 ARTC Standards and Specifications

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

- WOS 01.100 General Interface Requirements – Introduction
- WOS 01.200 Common Interface Requirements
- WOS 01.300 Locomotive Specific Interface Requirements
- ESC-07-02 Trackside Equipment Installation
- ESC-04-01 Signal Sighting and Position
- ESD-05-03 Train Braking Application Design

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
Consist	A combination of motive power and vehicles having defined parameters in terms of locomotive number, type and performance characteristics, and rolling stock length, mass, braking index
Unit	Any independent item of rolling stock
Rolling stock	This is a collective term referring to any rail vehicle
Train Operator	This is the Accredited Rail Operator who owns and/or operates the locomotives and rolling stock.
Certifier	This is the representative of the Train Operator who undertakes the assessment and testing of the locomotive or rolling stock and certifies its compliance to the interface requirements.
Road Rail Vehicle	A road vehicle fitted with retractable rail guidance wheels. Also known as a hi-rail vehicle.

2 Standards and Safety Context

The Australian Rail Track Corporation operates in a regulatory environment which includes Australian Standard AS4292 Railway Safety Management. This Standard states a number of requirements for managing the interfaces between rolling stock and the signalling and related infrastructure. Clauses of particular relevance are:

2.1 Australian Standards Requirements

AS4292.1: General and interstate requirements

1.6.2 (b) (ii) Ensuring that both railway traffic, and the track and other infrastructure have compatible operating parameters.

And

AS4292.4: Signalling and Telecommunications systems and equipment

Section 2 "Interface Coordination"

2.2 Interface between Engineering and Operational Functions

2.2 (c) Rolling Stock

- *(v) Size, shape, gauge and profile of wheels*
- *(vi) Limits on wheel condition*
- *(vii) Braking systems, including train performance parameters for both air brake and hand brakes.*
- *(xi) Effective electrical conductivity between wheel-to-rail contact points on the same axle*
- *(xii) Electrical compatibility between traction system components and between traction systems, and signalling and telecommunication systems.*
- *(xv) Sanding equipment and its possible effects on track circuits*
- *(xviii) Train acceleration performance.*

2.2 (d) Signalling and telecommunications systems and equipment.

- *(xvii) Operation of track-to-train automatic protection systems.*
- *(xviii) Required stopping distances, speeds and signal sight distances.*
- *(xix) Restrictions to be applied to particular types of trains where they are signalled over track which operates mixed train types (e.g. freight, loco-hauled passenger and EMU passenger).*
- *(xx) On-board safety systems.*

2.2 Rail Safety legislation Requirements

The national Rail Safety legislation has the following requirements with regard to the safety of rolling stock:

52—Duties of rail transport operators

(1) A rail transport operator must ensure, so far as is reasonably practicable, the safety of the operator's railway operations.

(2) Without limiting subsection (1), a rail transport operator must ensure, so far as is reasonably practicable—

(a) that safe systems for the carrying out of the operator's railway operations are developed and implemented;

(4) Without limiting subsection (1), a rolling stock operator must ensure, so far as is reasonably practicable—

(a) the provision or maintenance of rolling stock that is safe; and

(b) that any design, construction, commissioning, use, modification, maintenance, repair or decommissioning of the operator's rolling stock is done or carried out in a way that ensures safety; and

(c) compliance with the rules and procedures for the scheduling, control and monitoring of rolling stock that have been established by a rail infrastructure manager in relation to the use of the manager's rail infrastructure by the rolling stock operator; and

(d) that equipment, procedures and systems are established and maintained so as to minimise risks to the safety of the operator's railway operations; and

(e) that arrangements are made for ensuring safety in connection with the use, operation and maintenance of the operator's rolling stock; and

(f) that communications systems and procedures are established and maintained so as to ensure the safety of the operator's railway operations.

53—Duties of designers, manufacturers, suppliers etc

(1) A person—

(a) who designs, commissions, manufactures, supplies, installs or erects anything; and

(b) who knows, or ought reasonably to know, that the thing is to be used as or in connection with rail infrastructure or rolling stock, must—

(c) ensure, so far as is reasonably practicable, that the thing is safe if it is used for a purpose for which it was designed, commissioned, manufactured, supplied, installed or erected; and

(d) ensure, so far as is reasonably practicable, that such testing and examination of the thing as may be necessary for compliance with this section is carried out; and

(e) take such action as is necessary to ensure, so far as is reasonably practicable, that there will be available in connection with the use of the thing adequate information about—

(i) the use for which the thing was designed, commissioned, manufactured, supplied, installed or erected; and

(ii) the results of any testing or examination referred to in paragraph (d); and

(iii) any conditions necessary to ensure, so far as is reasonably practicable, that the thing is safe if it is used for a purpose for which it was designed, commissioned, manufactured, supplied, installed or erected.

2.3 Compliance Responsibility

2.3.1 Train Operator Responsibility

The Train Operator is responsible that all locomotives and rolling stock that it operates are compatible with the ARTC nominated signalling requirements detailed in this standard.

The compliance of the locomotives and rolling stock to these nominated ARTC signalling requirements shall be Certified by the Train Operator or a delegated representative of the Train Operator.

The Train 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 must be undertaken by suitably qualified persons who have the required competencies to perform the tests and work on the equipment. Desk top 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 Train Operator that the referenced locomotives and rolling stock meet the nominated ARTC requirements.

The Train Operator shall complete the Certification prior to the locomotives or rolling stock operating on ARTC infrastructure.

The Train Operator must also maintain compliance with the requirements while at any time the locomotives or rolling stock are operating on ARTC infrastructure.

2.3.2 ARTC Responsibility

ARTC will make available access to ARTC infrastructure for the locomotives and rolling stock, under agreed and controlled conditions, for the conduct of Tests by the Train Operator or his delegated representative for the purpose of certification by the Train Operator that the locomotive and rolling stock meet the ARTC signalling interface requirements.

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

2.3.3 Certifier

The Certifier may be a person within the Train Operator organisation or a delegated representative of the Train Operator. A representative of the constructor of the locomotive or rolling stock may be a Certifier as the delegated representative of Train Operator.

The person or organisation undertaking the testing and Certification of the locomotives and rolling stock is responsible to the Train Operator for any work and certification undertaken. The Certifier shall be the agent of the Train Operator to the extent as advised by the Train Operator. All actions of the Certifier are the responsibility of the Train Operator.

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

All train operations for a test shall be performed by an accredited rail operator.

2.3.4 Certification documents

The Train 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 has previously been tested and certified for another train operator, then a Certifier may use the results of those tests. The Certifier must 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 must form part of the new set of Certification documents. The Certification documentation must be complete and 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 must 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 must form part of the new set of Certification documents. The Certification documentation must be complete and stand alone and not be dependent on other documents.

c. Where a class of locomotives has previously been tested and certified for a train operator, and is transferred or otherwise comes under the control of another train operator, then a Certifier may use the results of those tests. The Certifier must 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 must form part of the new set of Certification documents. The Certification documentation must be complete and stand alone and not be dependent on other documents

2.3.5 Train Operator Delegated Representative

The train 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 this ARTC signalling interface standard.

Where the locomotive is not owned or under the control of an accredited rail operator, the owner or builder 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 conformance to this ARTC signalling interface standard.

2.3.6 Vehicle Information Pack

The Train 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 WOS 01.

This shall include the following technical compliance reports

a. Signal Visibility

b. Train Detection

c. Electromagnetic compatibility

d. Traction system compatibility

2.3.7 Train Detection Testing

The Train Operator or delegated representative may request access to ARTC infrastructure to conduct testing to confirm compliance with this standard. The Train operator is responsible to arrange train paths for the conduct of testing.

The Train Operator or delegated representative shall submit a detailed plan of how the testing is to be undertaken. This Test Plan for signalling train detection shall show:

a. Where the testing is proposed to be undertaken;

b. The signalling or other equipment to be used for the tests (e.g. track circuits);

c. The test configuration;

d. The testing instruments to be used and confirmation of calibration;

e. The staff who will be involved in the testing and their competency certificates.

3 Risk Factors

3.1 Risks for locomotives and trains in general service

Risk factors identified in the interface between rolling stock and the signalling system are train detection, train braking and acceleration, wheel flange geometry and facing point adjustment, data transfer between signalling system and train or driver, and the ability of the driver to initiate appropriate responsive action.

Train detection is the technology and methods by which the signalling system ‘knows’ where a train is (the state of occupancy of any protected section of track). For track circuits, currently the dominant train detection technology, the principal risks are the ability of the train to make effective electrical contact between wheel and rail, and the sensitivity of adjustment of the track circuit. Secondary risks are maintenance of effective conductivity between rolling stock wheels on any axle, and the potential for electric traction systems to be the source of interference which renders the track circuits unsafe or unreliable.

Train braking poses the problem of matching signalling infrastructure design to train braking potential, so that the signalling system can provide sufficient warning for all trains approaching a ‘stop’ signal to stop safely before the obstruction that it protects. Identified risk factors include the value and variability of braking effort, propagation delay in initiating braking effort throughout the length of a train, and variations in train speed achievable

At rail junctions, there is a risk that mismatched wheel geometry may not effectively cause the train to follow a diverging route.

Finally, there is risk that the driver may not adequately perceive or respond to signalling indication.

3.2 Risks for locomotives and trains in restricted service

Where it is proposed that a locomotive or rolling stock is only used in restricted service or has a restricted usage on the network (route restricted or other), then an Engineering Waiver should be sought for the restrictions against the technical requirements of this standard.

The process is detailed in ARTC standard EGP-02-01 Engineering Waiver Management.

3.3 Risks for locomotives and trains in transition service

Where it is proposed that a locomotive or rolling stock is to be moved or transferred across the ARTC network and is not to operate, then a Waiver may be requested against this standard.

The process is detailed in ARTC standard EGP-02-01 Engineering Waiver Management.

4 Signalling Interface &Train Detection Requirements

All vehicles and trains operating on the Australian Rail Track Corporation network shall satisfactorily be detected by the existing signalling system.

Vehicles that do not operate the track circuits, such as track maintenance vehicles, shall only be operated under special operating conditions. Such vehicles should be fitted with insulated wheels to avoid intermittent shunting of track circuits.

Road Rail Vehicles shall have insulated wheels and shall not be wired to operate track circuits unless they have been tested to demonstrate reliable operation of all types of track circuits.

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

Locomotives and rolling stock shall correctly operate the track circuits. There shall be no vehicle generated disturbance effects that interfere with the operation of the track circuits or any of the signals equipment or systems.

Track circuits are the most common trackside signalling equipment. Trackside processor based signalling systems/equipment, telecommunication cables and lineside telecommunications systems may be affected by radiated electrical noise from the rolling stock if not compliant with the requirements of this standard.

4.1 Types of signalling train detection systems

The existing signalling train detection systems used on the Australian Rail Track Corporation 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.

Significant operating parameters of these track circuit types are shown in Appendix B.

4.2 Requirements

All rolling stock operating on the ARTC system shall be designed for effective detection by standard signalling track circuits having shunt sensitivity not less than 0.15 ohms.

Rolling stock operating on the ARTC system shall meet the following to be compatible with ARTC track circuits and train detection:

- Maximum resistance between rail contact surfaces of wheels on the same axles shall be not greater than 1 milliohm.
- The total rail-to-rail resistance of any one unit shall not exceed 1 milliohm, when measured on clean straight track at an open-circuit voltage not exceeding 1.0 volts rail to rail.
- At least one axle per unit shall be provided with the means to keep contact surfaces clear of any contaminant build-up, especially while rolling on straight track.
- This axle shall not be one providing traction current return on electric rolling stock.
- Worst case wheel tread profile shall maintain effective rail wheel electrical contact with both of the following:
  - Centre top 10mm of new or reprofiled rail, and
  - Inner 30 mm of top of worn or standard profile 53kg rail.
- 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.
- To guarantee the safety of trains on converging tracks at clearance points, the extremities of any vehicle must not extend past the outermost detectable axles by more than 3 metres.

4.3 Operation of Train Detection

The traction return current, at any frequency, shall not exceed the limits shown on drawing in Appendix A.

The minimum wheel size for reliable axle counter detection is 300mm diameter. Wheels smaller than this, require to be extensively tested to confirm the reliable detection.

4.4 Proof of Compliance

The Operator shall certify that any new rolling stock has been demonstrated to comply with the above requirements, by providing the following theoretical and empirical data. This is submitted as part of the Vehicle Information Pack.

- Detailed design analysis of vehicle dimensions, bogie and braking system design, wheel profiles, 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.

Tests shall be conducted to ensure that the vehicle/train is effectively detected by the signalling system. Parameters for track circuits in use on the Australian Rail Track Corporation network are described in Appendix B.

Track maintenance vehicles and road/rail vehicles which operate under special operating conditions do not need to shunt the signalling systems. Refer to WOS 01.716 for track maintenance vehicles that operate the signal circuits.

4.5 Discussion

Effective train detection (by track circuits) is the result of one or many axles on a train making effective electrical contact with the surfaces of both rails, providing a low-impedance path to the track circuit current and thereby depriving a correctly adjusted receiver of energy. This depends on clean wheels making contact with clean rails, on correctly adjusted track circuit equipment.

The actual train detection performance at any particular location and time is a complex interaction of factors. The track circuit shunting performance of a piece of rolling stock is the result of a number of factors, individually and in combination. These factors include:

- Rail and wheel geometry

  A significant issue in recent years has been the match between rail and wheel profiles. One factor which appears to have exacerbated this problem is the existence of two quite different rail profiles (the previous standard, plus the new round-topped profile introduced with 60-kg rail, and being applied to reground 53-kg rail). Each of these profiles develops a different ‘contact band’ or polished section on which electrical contact is made for track circuit shunting. This is **matched** by the occasional presence of mismatched wheel profiles; either on locomotives visiting from other systems, or which have excessive wheel wear and tread hollowing. There have been cases of rail contact failure due to wheels ‘straddling’ the rail contact band, even with the heaviest diesel locomotive on the ARTC network.

- Rail and wheel metallurgy

  Metallurgical factors may play a part in the train detection equation. They may include the propensity of rail surfaces to oxidation, the ease with which wheel treads may pick up contaminants in rolling contact, and the relative hardness of rails and wheel treads, which may result in different tread wear rates and profiles.

- Rolling stock design and mass

  Generally, rolling stock detection effectiveness improves with increasing vehicle mass. Low vehicle mass is generally not a factor with freight trains, due to the mass of a typical locomotive. It may be a concern with lightweight diesel railcars.

  Secondly, the interaction of wheels and rail at the contact surface is very significant. Traditionally, rolling stock bogie design was relatively unsophisticated, producing large amounts of relative movement between wheels and rails, which resulted in a high degree of mutual cleaning and polishing of the contact surfaces.

  Improvements in wheel and rail design, initially with passenger rolling stock and more recently with freight stock (with steering bogies) have extended the life of wheels and rails at the expense of contact surface polishing. Moreover, wheels which roll without slippage, will pick up a layer of contaminant from the rail surface which can degrade their shunting effectiveness, even on clean rail.

- Electric traction

  It is a feature of rail-wheel contact, that once a current flow of any kind is established, any other current 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.

- Sanding

  Dry sand is an extremely effective electrical insulator. The use of sand or similar materials to improve rail / wheel friction must be applied and controlled in a manner which does not leave an insulating layer on the rail / wheel contact surface.

4.6 Interference tests

4.6.1 Type tests

Type tests shall be conducted using the train set to measure vehicle generated disturbance effects in signalling track circuits, telecommunication cables and lineside telecommunications systems. The types of signalling systems in use on the Australian Rail Track Corporation network are described in Appendix D.

The tests indicated below are the minimum required for compatibility testing and may be varied at the discretion of the Australian Rail Track Corporation.

4.6.2 Tests on vehicles 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 a complete power-brake run, for each type of substation.

4.6.3 Tests on track circuits

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:

- track circuit shunting performance
- traction current harmonics causing potential failure of track circuits (diesel electric locomotives)
- traction current harmonics causing potential false energisation of track circuits (diesel electric locomotives)
- traction unit impedance to traction supply (electric locomotives only)
- auxiliary power systems harmonic generation and impedance (electric & diesel electric locomotives)
- 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.

5 Train Braking Requirements

5.1 Requirement

All trains operating on the ARTC network must 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, must equal or better the braking table specified for a given area.

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

5.2 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 is placed into full service braking and until the train comes to a stop. Emergency braking is not to be used.. These tables are based on brakes on all wagons are working and no other adverse conditions that might affect stopping distance.

Trains with stopping distances exceeding these limits must 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 Train Operating Conditions manual for allowable maximum speeds.

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

5.3 Discussion

AS4292.4 para 2.2 (d) (xix) quoted previously identifies the risks posed by mixing trains of markedly different acceleration, speed and braking performance in one system, whose design must of necessity be optimised for one type of traffic. This situation applies particularly in the urban and interurban areas.

Risk factors here are of two types:

- 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.

Recent analyses have shown that at the present time, the signalling infrastructure, augmented by some local speed restrictions which have been imposed on particular train types, is generally capable of managing trains whose braking meets or exceeds the GW 16 braking table (original Superfreighter braking). Until further notice, the GW 40 braking table is adopted as the standard to which all new services must 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.

5.4 Train Stops

Train stops are installed on rail networks that interface to ARTC. The locomotive and rolling stock loading gauge reserves an area for the train stop equipment. This area is not to be infringed by any other equipment on the locomotive.

Fixed train stops may be installed on the ARTC network at the interfaces with these other networks.

5.5 Applicable Train Brake Tables for Network

The various train braking tables (refer Appendix E) will be applied to various parts of the ARTC network based on engineering and operations requirements.

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. ESD-05-03 supersedes SDS-03 Braking Distance.

6 Facing Points and Wheel Geometry Requirements

6.1 Requirement

The safe movement of trains over facing points shall be guaranteed by the operator ensuring that all vehicles comply with the requirements of ARTC Standard WOS 01.212 *Wheels, minimum operational requirements.*

6.2 Proof of Compliance

This is specified in WOS 01.212.

6.3 Discussion

A critical factor in the safe operation of trains is their ability to pass safely through sets of points. At facing points, the combination of wheel flange dimensions, points blade design and points adjustment and detection ensure that wheels will follow the intended straight or diverging path, without ‘splitting’ the points or derailing.

Signalling maintenance procedures ensure the correct points geometry is maintained; compliance with WOS 01.212 ensures a compatible flange dimensions are maintained.

7 ATMS and ATP Requirements

7.1 Requirement

Trains operating in an area where any form of Automatic Train Protection or 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.

Note: at this time these are proposed requirements and specific technical requirements are not available.

7.2 Proof of Compliance

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

8 Traction System Compatibility Requirements

8.1 Requirement

Trains 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, or to components of the electrical traction supply finding a low-impedance path to the traction return system.

The signalling noise compatibility diagram *(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. ARTC does not have electrical traction overhead wiring on its tracks. However, it does run parallel to other networks with electrical traction. The tracks are cross bonded and spurious currents and noise may cross between the networks.

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 must ensure that they are rendered safe as soon as possible.

8.2 Diesel Electric Locomotives

Non-Electric Traction locomotives, which have a diesel-electric configuration, 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 Proof of Compliance

The operator must 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

8.4 Discussion

Signalling track circuits 'share' the running rails with the electric traction return currents. Track circuits operate at currents and voltages generally less than 1 ampere and 3 volts. In contrast, the traction system operates at a nominal supply voltage of 1500 volts DC, at currents up to 6000 ampere. Even a very small portion (one-tenth of one percent) of the traction current is of the same order of magnitude as the track circuit current; tight control of traction noise levels is crucial to ensuring the continued safe and reliable operation of the signalling system.

9 Electromagnetic Compatibility Requirements

9.1 Requirement

Trains 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, trains shall comply with current national Electromagnetic Compatibility standards.

- EN 50121:2006 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 50121:2006Railway 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.

9.2 Proof of Compliance

Operators are required to provide evidence of testing carried out to measure the electromagnetic emission characteristics of the proposed rolling stock.

9.3 Discussion

Current signalling systems are based to an increasing degree on microprocessors, data communications and other sensitive electronics, whose operation can be affected by electromagnetic interference. Systems which may be susceptible include track circuits, vehicle identification systems, and transmission based train control and signalling systems.

10 Signal Visibility Requirements

10.1 Requirement

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

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.

10.2 Locomotive Cab sightlines to signals

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

10.3 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 unit 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.

10.4 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

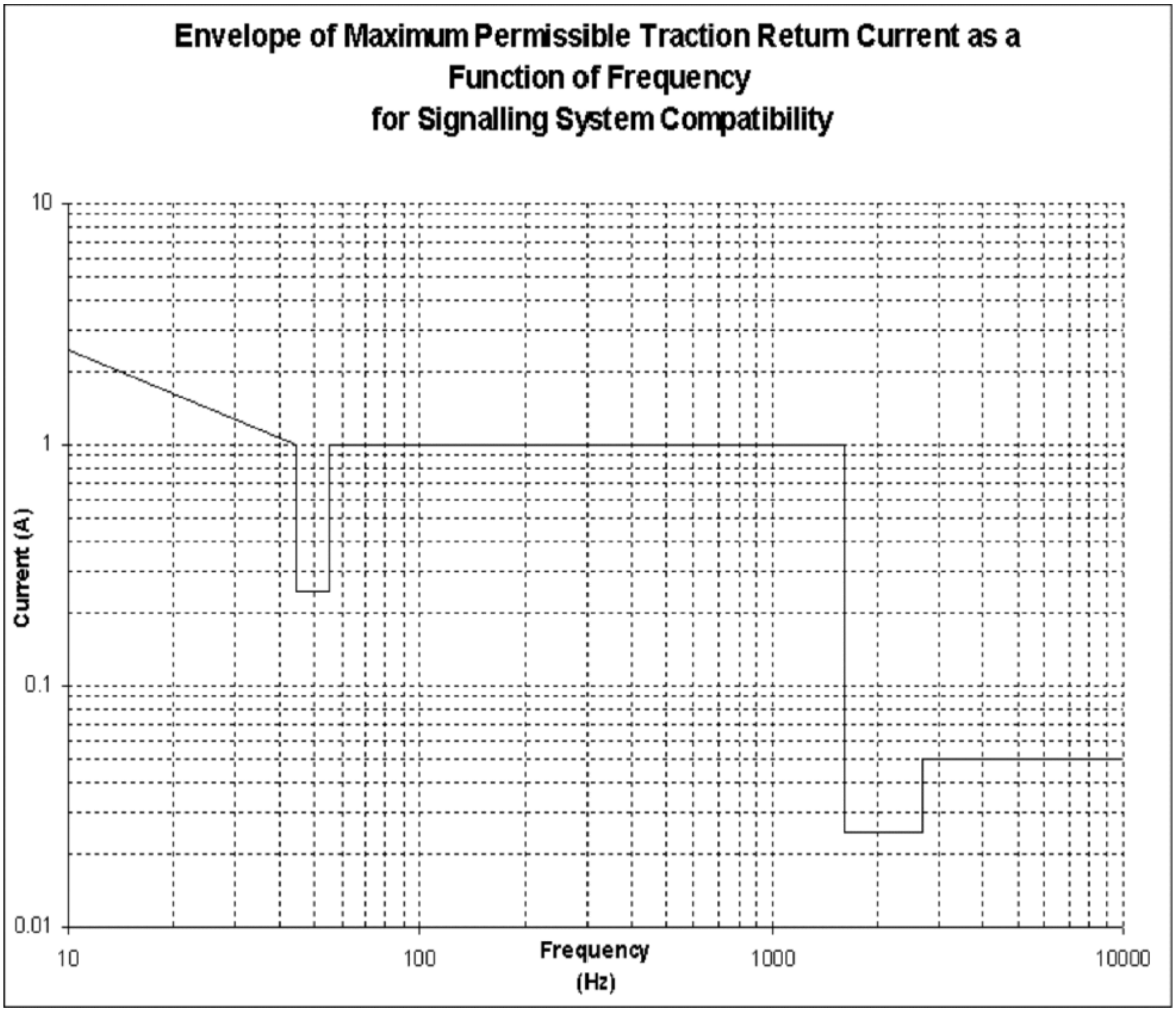
ARTC's objective is to have the top red indication on a main signal at the driver's eye height. Different trains and locomotives have the driver's seat at different heights above rail. The above information is to assist ARTC in developing a database to determine and update the weighted mean height of the driver's eye above rail.

10.5 Discussion

Present day signalling systems rely on effective sighting of signalling indication by drivers. This visibility requirement is directed at ensuring that the driver has sufficient field of vision to see all necessary signals, and no impediments to seeing all colour-light signals correctly.

11 Appendix A - Traction Return Compatibility Envelope

11.1 Acceptable In-Rail Currents at Signalling Frequencies



12 Appendix B – Track Circuit Parameters

Track Circuit Type	Frequency	Modulation	Operating Track Voltage	Receiver/Relay			Maximum Track Circuit Length		Nominal Shunt Value
				Minimum Operation	Maximum Drop-away	Normal Working Level	Double Rail	Single Rail	
DC	DC	N/A	1 to 3 V	0.4 V	0.3 V	1 V	2000 m	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	600 m	1.5 ohm
DC - 'Westrak'	50 - 400 Hz	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	1000 m	300 m	0.06 to 0.5 ohm
AF jointless	1700, 2000, 2300, 2600 Hz	FSK, +/-10 to 15 Hz	3 to 5 V	200 mV	180 mV	400 mV	900 m 2000 m compensated	N/A	0.15 to 0.5 ohm
AF jointed	380 to 510 Hz (10 frequencies)	FSK, +/-10 Hz	3 to 20 V	1.7 V	1.5 V	3 to 12 V	400 m	250 m	0.5 ohm
AF overlay	800 to 5000 Hz (various frequencies)	N/A	0.3 to 1.3 V	-----	0.05 V	0.3 V	800 m	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	3000 m	500 m	025 to 0.5 ohm
Coded	2 second pulse train, DC or AF burst	N/A	+/- 1 V			+/- 0.6 V	9000 m	N/A	0.06 to 0.15 ohm
Level crossing detector	Steady AF, 1 in 4 kHz	N/A	3 to 5 V				1000 m	N/A	0.06 to 0.15 ohm

Table F1.1. Operating parameters for different types of track circuits

13 Appendix C - Signal Visibility

13.1 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 1.

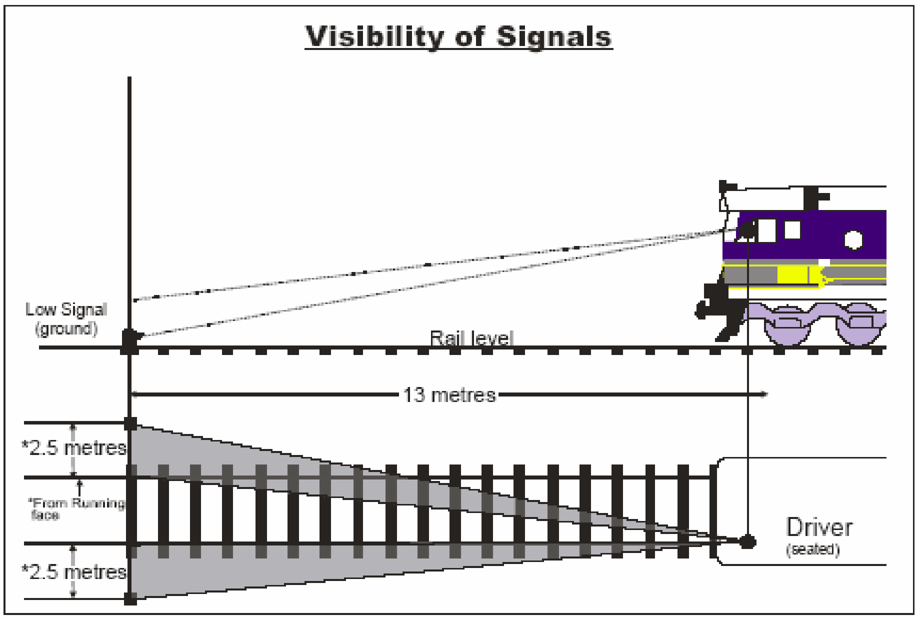


Figure 1

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 2

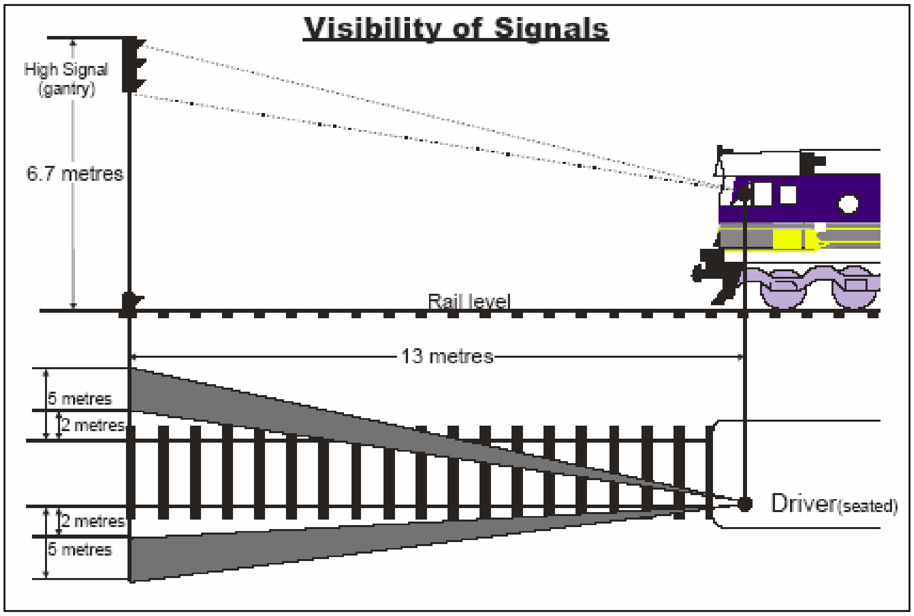


Figure 2

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 3.

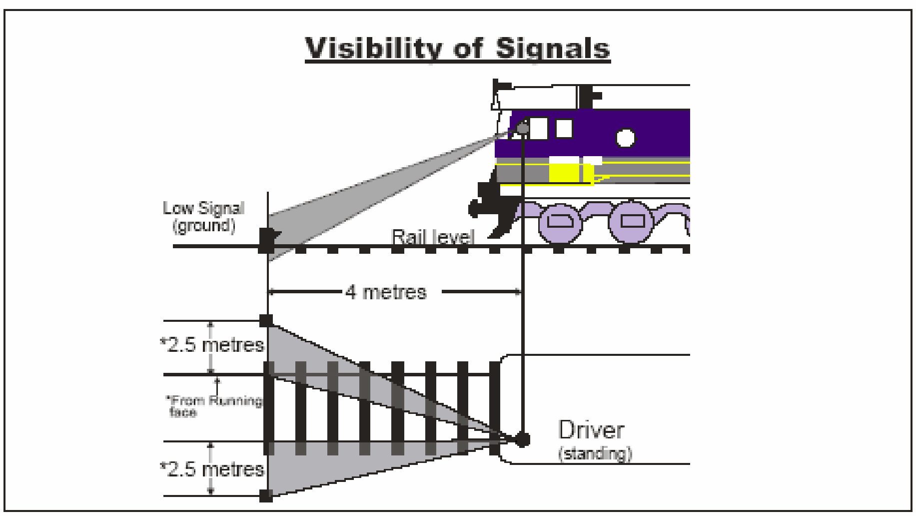


Figure 3

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 must be accompanied by a second person who is qualified in safeworking.

14 Appendix D - Types of Signalling Systems

14.1 Introduction

Vehicles and trains shall generate no energy capable of interfering with the Australian Rail Track Corporation signalling and communications equipment.

14.2 Signalling and communication equipment

14.2.1 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 mm^2 to 70 mm^2 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.

14.2.2 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). On the suburban lines, 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 in electrical traction areas may operate at various voltages between 10 volts and 120 volts DC or 120 volt 50 Hz.

Cable and linewire 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.

14.2.3 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 Australian Rail Track Corporation boundary and is often located in troughing close to the rails.
- In the Sydney metropolitan area many of the cable routes are above ground in troughing and drawings are not available. 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.

14.2.4 Railway 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. Train working and emergency telephones are used in some tunnels e.g. City Circle and Eastern Suburbs and the transmission circuit is single twisted pairs in trough or conduit.

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

14.2.5 Telemetry and remote control

A variety of signalling remote control and indication systems, (SCADA, RTU, Telemetry), are in use in lines around Sydney currently electrified or proposed for electrification. 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.

15 Appendix E – Train Braking Tables

15.1 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-05-3, Train Braking Application Design, Appendix A, which include an allowance of 15%,

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