AUSTRALIAN RAIL TRACK CORPORATION LTD

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**Discipline**
**Engineering Standard - NSW**

**Category**
**Signalling**

**Title**
# Specification – Rolling Stock Signalling Interface Requirements

**Reference Number**
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The technical content of this document has been approved by the relevant ARTC engineering authority and has also been endorsed by the ARTC Safety Committee.

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## About This Standard

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.

The document defines the signalling compatibility requirements and the procedures for obtaining approval to operate a new vehicle or train consist on the ARTC network.

## Document History

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## Contents

# 1 Introduction

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.

The document defines the signalling compatibility requirements and the procedures for obtaining approval to operate a new vehicle or train consist on the ARTC network.

# 2 Applicable Standards

## 2.1 Australian Standards

| | |
|---|---|
| AS 4251.1 | *Electromagnetic compatibility - Generic emission standard Part 1: Residential, commercial and light industry.* |
| AS 4252.1 | *Electromagnetic compatibility - Generic immunity standard Part 1: Residential, commercial and light industry* |
| AS4292 | Railway Safety Management. |

## 2.2 ARTC Standards and Specifications

| | |
|---|---|
| RSU 100 | *Interface Requirements – Introduction* |
| RSU 160 | *Interface Requirements – Signalling Interface* |
| RSU 211 | *Common Requirements – Wheels, design and manufacture* |
| RSU 212 | *Common Requirements – Wheels, minimum operational requirements* |
| SCP 15 | *Trackside Equipment Installation* |
| SPS 11 | *Colour Light Signals* |

# 3 Definitions

- **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

# 4 Standards 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:

***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.*

## 5 Risk Factors

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.

# 6 Train Detection

### 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.



### Proof of Compliance

The Operator shall satisfy ARTC that any new rolling stock has been demonstrated to comply with the above requirement, by providing the following theoretical and empirical data.

- 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 approved test site.

### 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.

# 7 Train Braking

**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 curve specified for a given area.

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

- Rolling stock operating on lines designated for freight or mixed traffic shall have braking performance which meets or exceeds that defined by the GW 16 braking curve at all speeds up to 115 km/h under full service braking conditions.

- Service braking of rolling stock which operates on passenger only lines shall have braking performance which meets the GE62 braking curve at speeds up to 115 km/h, and the XPT braking curves between 115kph and 160 km/h.

- On rolling stock fitted with trip gear for emergency trainstop operation, emergency braking shall have emergency braking performance which meets the GE52 braking curve at speeds up to 115 km/h

- A consist whose braking distances exceed those in the GW 16 curve, may be approved for operation after computer simulations of its running over the proposed corridor demonstrate that, at the train speeds attainable in actual operation, the consist's braking will permit it to stop safely in the distances provided by the installed signalling infrastructure.

- The configuration of an approved consist shall be maintained within a range such that its braking distance, acceleration and attainable speed performance do not vary by more than 10% above those of the configuration submitted for approval.. Variations in configuration include changes to train length, gross mass, and the number and power of locomotives.

Alternatively, where the operator provides other approved means to guarantee that the train can not exceed the approved speed envelope at any location in the operating corridor, the train configuration may be varied in whatever manner the operator chooses.

**Proof of Compliance**

- The Operator shall, by provision of empirical test data or other means, satisfy

ARTC that any new rolling stock unit or consist has been demonstrated to comply with the above requirements.

- A train consist which does not meet the braking requirements of the GW 16 curve may be approved on the basis of computer simulations of its running over the proposed corridor. These simulations shall demonstrate that, in actual operation, the train can only attain speeds at which its braking will permit it to stop safely in the distances provided by the installed signalling infrastructure.

In applying for approval on this basis, the operator shall submit either copies of procedures which limit the variations to the approved consist, or else details and test data of the system which will control the consist's operating speed envelope in service.

**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 operation uneconomic, 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 curve (original Superfreighter braking). Until further notice, the GW 16 braking curve 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 16 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.

# 8 Facing Points and Wheel Geometry

### 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 RSU 212 *Wheels, minimum operational requirements.*

### Proof of Compliance

This is specified in RSU 212.

### 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 RSU 212 ensures a compatible flange dimensions are maintained.

# 9 Automatic Train Protection

### Requirement

Trains operating in an area where any form of Automatic Train Protection or Warning System is in service shall be equipped with compatible ATP interface and control equipment applicable to the particular type of train.

The train-borne trip gear shall be dimensioned and located to engage reliably with train stops installed in accordance with ARTC Signalling Specification SCP 15 *Trackside Equipment Installation.*

Currently, this requirement applies only to Electric Multiple Unit passenger stock operating within the Sydney and Newcastle metropolitan areas, which shall have trip gear actuated by the ARTC standard electromechanical train stops, fitted at each driving position.

### 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.

### Discussion

Mainly in areas of dense traffic, signalling system design is dependent on a measure of enforcement of trains stopping at signals, and of staying below set speed limits at certain locations.

To maintain system safety, any new rolling stock needs to be equipped with the interface and control equipment to enable those enforcement functions to be effective.

# 10 Traction System Compatibility

### 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 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.

Until the signalling system no longer includes track circuits of the 50Hz Double Rail type, rolling stock traction units may be 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.

### 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.

### 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.

# 11 Electromagnetic Compatibility

### 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.

### Proof of Compliance

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

### 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.

## 12 Signal Visibility

### 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 Specification SPS 11, *Colour Light Signals.*

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.

### Proof of Compliance

Operators may be required to provide design analysis to demonstrate that the required visibility has been provided.

### 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.

## 13 Driver Alertness and Competence

### Requirement

Rolling stock shall incorporate means to ensure that drivers remain alert with unimpaired capacity to interpret and respond correctly to signalling information. Systems provided for this purpose shall ensure that if the driver becomes incapacitated, the train will be brought to a safe condition.

### Proof of Compliance

Where applicable, the operator shall provide details of the design and operation of the systems provided to ensure driver alertness and capacity to respond.

### Discussion

Until such time as Automatic Train Operation systems are introduced, the safe operation of trains on the ARTC network depends on the driver of every train being fully alert and responsive to the information provided at every signal. Driver controls must provide the means to ensure the continued alertness and at capability of the driver.

## Appendix A

## Traction Return Compatibility Envelope -

## Acceptable In-Rail Currents at Signalling Frequencies