

AS 7502:2016



Road Rail Vehicles



Rolling Stock Standard



This Australian Standard® AS 7502 Road Rail Vehicles was prepared by a RISSB Development Group consisting of representatives from the following organisations:

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This standard was issued for public consultation and was independently validated before being approved.

Development of the standard was undertaken in accordance with RISSB's accredited process. As part of the approval process, the Standing Committee verified that proper process was followed in developing the standard.

RISSB wishes to acknowledge the positive contribution of subject matter experts in the development of this standard. Their efforts ranged from membership of the Development Group through to individuals providing comment on a draft of the standard during the open review.

I commend this standard to the Australasian Rail Industry as it represents industry good practice and has been developed through a rigorous process.



Paul Daly
Chief Executive Officer
Rail Industry Safety and Standards Board

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1 Introduction

1.1 Purpose

To set the known good practice core requirements for the safe design, construction, testing, maintenance, decommissioning and modifications of road rail vehicles.

To provide a minimum list of Network Registration requirements.

To give industry a means of reducing currently unacceptable risks relating to road rail vehicles.

1.2 Scope

This standard applies to all road rail vehicles.

Network registration of road rail vehicles by Rail Infrastructure Managers is not covered.

Any matters not relating to road rail vehicles are not covered.

Operation of road rail vehicles with respect to network safe working rules and route standards is not covered.

Road rail vehicles used on cane railway and monorail networks are not covered.

1.3 Compliance

There are two types of control contained within RISSB Standards:

- (a) mandatory requirements
- (b) recommended requirements

Each of these types of control address hazards that are deemed to require controls on the basis of existing Australian and international Codes of Practice and Standards.

A mandatory requirement is a requirement that the standard provides as the only way of treating the hazard.

Mandatory requirements are identified within the text by the term shall.

A recommended requirement is one where the standard recognises that there are limitations to the universal application of the requirement and that there may be circumstances where the control cannot be applied or that other controls may be appropriate or satisfactory, subject to agreement with the Operator, Rail Infrastructure Manager and/or Rail Safety Regulator.

Recommended requirements are to be considered when compliance with the standards is being assessed.

Recommended requirements are identified within the text by the term should.

Hazards addressed by this standard are included in line with the text (eg 5.5.1.10, 5.5.1.12). Refer to the RISSB website for the latest Hazard Register Guideline: www.rissb.com.au

1.4 Competency

Competence of all persons verifying designs of, or modifications to road rail vehicles shall be in accordance with AS 7501:2013, Section 4, Independent Competent Person. (5.5.1.10, 5.5.1.12, 5.5.1.45, 5.5.1.46)

In accordance with the Rail Safety National Law, all:

- Designers

- Design verifiers
- Constructors
- Construction validators
- Operators
- Maintainers, and
- Certifiers

of road rail vehicles shall have relevant competencies to undertake their work. (5.5.1.10, 5.5.1.12, 5.5.1.45, 5.5.1.46)

1.5 Normative references

The following referenced documents are indispensable for the application of this Standard:

- (a) AS 1403 Design of Rotating Steel Shafts
- (b) AS 1418.10 Mobile Elevating Work Platforms
- (c) AS 1554 Structural Steel Welding
- (d) AS 1657 Fixed platforms, walkways, stairways and ladders - Design
- (e) AS 1664 Aluminium Structures
- (f) AS 2729 Rolling bearings - Dynamic load ratings and rating life
- (g) AS 3990 Mechanical Equipment – Steelwork
- (h) AS 4024 Safety of Machinery
- (i) AS 4100 Steel Structures
- (j) AS 7501 Rolling Stock Compliance Certification
- (k) ISO 3449 Earth-moving machinery -- Falling-object protective structures -- Laboratory tests and performance requirements
- (l) ISO 3471 Earth-moving machinery -- Roll-over protective structures -- Laboratory tests and performance requirements
- (m) ISO 10262 Earth-moving machinery -- Hydraulic excavators -- Laboratory tests and performance requirements for operator protective guards
- (n) ISO 12117 Earth-moving machinery -- Tip-over protection structure (TOPS) for compact excavators -- Laboratory tests and performance requirements
- (o) ISO 14122 Safety Of Machinery - Permanent Means Of Access To Machinery
- (p) UIC 510-2-2004 Trailing stock: wheels and wheelsets. Conditions concerning the use of wheels of various diameters
- (q) Australian Design Rules (ADR) 3rd Edition
- (r) National Heavy Vehicle Regulations
- (s) Safe Work Australia Code of Practice
- (t) Vehicle Standards Bulletin 6
- (u) Vehicle Standards Bulletin 14

1.6 Definitions

Abrasive Brake Block (Trim Block): A Brake Block that may be used to remove minor wheel and tread irregularities.

Acceptance for On-Track Testing Certificate: The type certificate issued by the ICP following an assessment process on the rolling stock, and on which limitations applying to on-track testing are recorded. This certificate is a condition precedent to any dynamic movement of the rolling stock on a Network.

Access Lighting: Lighting of access equipment e.g.: ladders and steps.

Access restraint: A grabrail, guardrail, handhold or handrail provided on an Access Path or Access Way.

Access Way: Walkway, corridor, aisleway, ramp etc on rolling stock, that complies with OH&S requirements for workers use.

ADR: Abbreviation for 'Australian Design Rules' applied to motor vehicles.¹

AEI tag: An AAR compatible Automatic Equipment Identification tag is an RFID (radio frequency identification) device, mounted on the side of a vehicle, containing encoded information used to identify the vehicle to wayside equipment.

Agreement: A negotiated and usually legally enforceable understanding between two or more legally competent parties to build new rolling stock, modify existing rolling stock or transfer rolling stock to a different network.

Alarm: A visual or auditory indication that the value of a monitored parameter, component, system, or function is outside the specified acceptable range and immediate action is required. For the purposes of this document alarm is interchangeable with alert.

Approved Road Rail Vehicle: Road rail vehicles that are currently operating on a railway network and have demonstrated satisfactory dynamic behaviour in service.

Approved Wheel Profile: A wheel profile accepted by the Rail Infrastructure Manager as being compatible with the particular railway network.

ARL: Abbreviation for "Above Rail Level", as used in dimensions for height measured from top of rails, perpendicular to the plane of the rails.

AS 7500 Series of Australian Standards: Standards for Rolling Stock Operating in Australia. These standards, produced by RISSB, are a part of the Australian Code of Practice. Certification of the rolling stock, as covered by this standard is a part of the approval process necessary to reach the access agreement.

Automatic Brake: A continuous brake system for trains or sets that will self-apply in the event of loss of continuity (including train or set separation).

Automatic Park Brake (APB): A park brake able to self-apply in predetermined circumstances without direct human intervention.

AVSR: Abbreviation for 'Australian Vehicle Standards Rules'.

Back: The back face or side of a wheel is on the flange side.

¹ When a road vehicle is first used on Australian roads the relevant state or territory government legislation generally requires that it continue to comply with the relevant ADR as at the time of manufacture.

Body Roll: The angular translation of the body cross-section relative to the plane of the rails that may be expected to occur in response to cant excess, cant deficiency and/or track irregularities.

Bounce: The vertical translation of the vehicle body relative to the rails that may be expected to occur in response to track irregularities.

Brake Block: A friction element that is forced directly onto the tread of a vehicle wheel for the purpose of braking.

Brake Disc Pad: A friction element that is forced directly onto a brake disc for the purpose of vehicle braking.

Brake System: The braking equipment of a vehicle.

Braking Energy: The energy to be dissipated from the braking surface.

Braking Surface: An equipment surface at which vehicle braking may be developed by friction.

Broad Gauge: Track gauge of 1,600 mm (5' 3").

Cab: Driving cabs or any enclosed occupiable work space.

Cant: The height difference, at a common location, between the running surface of both rails. Also known as superelevation.

CCTV: Closed circuit television.

Certificate of Standards Compliance: The overarching certificate confirming that a unit of rolling stock has been designed, constructed and tested in accordance with the AS7500 series of standards.

Certification: The process of certifying the compliance of the design and construction of rolling stock against the AS 7500 series of Australian standards and other standards where allowed by the AS 7500 series. Certification culminates with the issuing of the Certificate of Standards Compliance supported by the Design Compliance Certificate, Construction Conformance Certificate and the Acceptance for On-Track Testing Certificate.

Commission: To formally place into active service or use.

Complying Road Rail Vehicle: Road rail vehicle that has been demonstrated to comply with the requirements of this Standard.

Composition Brake Block: A Brake Block containing non-metallic friction material.

Console: The desk arrangement that forms part of the driving position in the driver's cab.

Construction: The processes of fabrication, manufacture, and assembly (includes installing components, connecting sub-systems), and the required quality control activities that generate construction records.

Construction Validator: Engineer registered by Engineers Australia (CPEng) or the Register of Professional Engineers Queensland (RPEQ) experienced and qualified to validate the construction and/or modification of road rail vehicle is constructed with sufficient integrity to safely operate on the rail.

Control: Device located in the cab used to regulate or operate the vehicle, communications or other equipment.

Critical Design Stress: Shall be taken as either the yield stress (0.2% proof limit), 80% of the ultimate stress or 80% of the critical buckling stress whichever is less.

Critical Speed: The lowest speed at which lateral instability is demonstrated. Can also be used to describe speed at which a resonant response occurs with cyclic track irregularities.

Decommissioning: Retirement from rail use by removing rail guidance equipment and associated systems.

Derailment: An incident in which one or more wheels run off the track.

Design: A sketch, drawing or set of drawings, schedule, specification, manual, model or other pattern that shows the shape and conceptual relationships of a part, tool, structure, machine, or other product. Communications needed to allow the object or component to be fabricated, constructed, modified, commissioned and/or operated and maintained.

Design Verifier: an engineer, registered by Engineers Australia (CPEng) or the Register of Professional Engineers Queensland (RPEQ) who is competent and experienced to verify the design of road rail vehicle is sufficiently safe to operate on rails.

Detectable: Rolling stock able to reliably shunt track circuits.

DIRN: The Defined Interstate Rail Network of Australia.

Driving Supervisory System: Vehicle equipment designed to maintain safety in the event of driver incapacitation, including vigilance control systems, operator enable (deadman) systems and trip gear.

Dynamic Behaviour: The performance of the vehicle when moving along the track.

Emergency Application: An application of a brake that is propagated at a higher rate than the normal rate of a service application and that may result in a rate of retardation that is higher than the normal rate of a service application and not less.

Emergency Equipment: Portable items carried onboard rolling stock for use in emergencies, incidents, accidents, failures etc.

Emergency Lighting: Lighting, powered from a separate source (eg. battery) to the vehicle's main power source, providing illumination for evacuation purposes.

Event Recorder: A device installed on road rail vehicles capable of recording multiple input parameters, in digital or analogue format, related to the operation of the road rail vehicle. Also known as a 'data logger' or 'data recorder'.

Existing Road Rail Vehicle: Road rail vehicle which is approved and/or registered to operate on the network concerned prior to the implementation of this standard.

Expendable Item: A feature on road rail vehicle that exceeds the required Rolling Stock Outline but is considered acceptable by both Rolling Stock Operator and Rail Infrastructure Manager due to the low consequence if struck.

Fail-Safe: The capability of an item or a system to ensure that any failure in a predictable or specified mode will result only in that item or system reaching and remaining in a safe condition.

Fatigue Limit: The maximum stress below which a cyclically applied load will not result in fatigue failure. Also known as the endurance limit.

Fatigue Load Cases: These load cases represent the loads that occur during normal operation. Also known as service or dynamic load cases.

Fixed access device: A step, stair, ladder or ramp.

Flashing Beacon: Rotating beacon light or Strobe light.

Friction Element: A sacrificial pad or block that is forced onto a braking surface to develop a braking force by friction.

Front: The front face or side of a wheel is on the non-flange side.

Function Check: Brake checking in the field performed for the purpose of confirming the serviceability of the brake system of a vehicle or vehicles.

G: Gravitational constant.

Generic Shaft Design Method: A non-rolling stock specific design method for rotating shafts e.g.: AS 1403.

GPS: Global Positioning System.

Gross Vehicle Mass: Nominal total mass of road rail vehicle including maximum payload, provisioning, maximum service capacity of crew and passengers and wheels at nominal new diameter.

Ground Access Device: Access device that is placed on the level equal with the top of railway track sleepers.

Ground Level: A level equal with the top of railway track sleepers.

Ground Level Access: Access from a level equal with the top of railway track sleepers.

Ground Level Access Point: Access point on a level equal with top of railway track sleepers.

Guardrail: A rail or series of rails acting as an obstacle or barrier to a person falling from an elevated position, or to moving to a position of danger. A guardrail may also serve as a single or multiple handrail.

GVM: Abbreviation for Gross Vehicle Mass

Handbrake: A Park Brake operated by manual effort via a wheel or lever.

Haul Test: A test involving the haulage of stationary braked rolling stock for the assessment of friction element static coefficient of friction.

Headlamp: Lamp that forms part of a headlight

Headlight: Main bright light(s) on the front of road rail vehicles.

Heavy Duty RRV: An RRV weighing in excess of 20 tonnes gross/maximum service mass.

High-Rail Vehicle: A vehicle that is capable of running on both road and rail. Often these are standard road vehicles that have a pair of flanged rail wheels on the front and rear. Generally the vehicle accesses the rail via a level crossing, lowers the rail wheels onto the rails which will guide the vehicle without the need to steer, and is propelled by the road wheels that are in contact with the rails. High-rail equipment is fitted to inspection, personnel carrying vehicles and some track construction and maintenance machines.

Highway: All land that is a highway or public road for the purposes of the common law. To this end, the term is defined to include any land that is dedicated to the public for use as a highway.

Host Vehicle: The road based vehicle which has been modified to operate on railways.

Human Factors: The application of scientific information concerning humans to the design of objects, systems and environment for human use.

Infinite Life: No fatigue or fretting failure is permissible for the design at expected operating conditions. A component designed for infinite life will have a maximum design stress below the material's fatigue limit.

Infrastructure Maintenance Rolling Stock: Hauled or self-propelled rolling stock or equipment intended for use in connection with infrastructure maintenance. Includes Track Machines and Road-Rail Vehicles. Also known as On Track Vehicles.

Interstate Standard Gauge Network: Standard gauge track, mostly under control of ARTC, connecting the mainland Australian state capital cities. Refer to DIRN.

Light Duty RRV: An RRV weighing no more than 5 tonnes gross/maximum service mass.

Livery: Road rail vehicle exterior colour scheme and markings.

Luminance: A photometric measure of the luminous intensity per unit area of light travelling in a given direction, i.e. the amount of light that passes through or is emitted from a particular area.

Maintenance: Actions carried out during the service period to keep the axle bearing in a fit for purpose condition.

Major Derailment: All derailments exceeding the limits defining Minor Derailment.

Marker Light: Light indicating the front of a vehicle.

Maximum Service Mass: Represents the mass of the vehicle in full working order (includes crew). Also known as gross mass.

Medium Duty RRV: An RRV weighing between 5 tonnes and 20 tonnes.

MEWP: Abbreviation for Mobile Elevating Work Platform

Minor Derailment: Rolling Stock derailed for less than sixty (60) metres and less than sixteen (16) kilometres per hour.

Modification: Any change in design, which is interpreted as a change in configuration affecting the plant's function / systems / procedures, and / or any material addition / removal from the plant, and / or any replacement / repairing of parts that effect performance and hence safety.

Modified Road Rail Vehicle: Road rail vehicle where a change has been implemented that affects its compliance with the requirements in the standard.

Narrow Gauge: Track gauge of 1,067mm (3' 6").

Narrow gauge network: 1067mm gauge network.

NDT: Non-destructive testing such as magnetic particle inspections, ultrasonic testing or dye penetrant testing.

Network: A combination of track and other infrastructure controlled by a Rail Infrastructure Manager. Refer to 'railway network'.

Network Registration: The process used by a Rail Infrastructure Manager to permit initiation of the train acceptance process.

New Wheels: A wheel, machined to an approved wheel profile that has travelled less than 500km on rails in service.

New Road Rail Vehicle: Road rail vehicles manufactured to a new design that has not been assessed against the requirements of this standard.

NHVR: Abbreviation for National Heavy Vehicle Regulations.

Non-Detectable: Rolling stock that does not shunt track circuits.

Off-Track Mode: Mode of operation where rail wheel equipment is retracted and stowed. Also called 'off-rail' mode, or 'road' mode.

Off-Tracking: Process whereby a road rail vehicle changes from on-rail operation to off-rail operation. Deemed to commence the instant the vehicle operator initiates retraction (raising) of the first set of rail wheel equipment, and ends when all rail wheel equipment on the vehicle is fully stowed.

On-Track Mode: Mode of operation where rail wheel equipment is deployed and vehicle is capable of travelling on the track. Also called 'rail mode'.

On-Tracking: Process whereby a road rail vehicle changes from off-rail operation to on-rail operation. Deemed to commence the instant the vehicle operator initiates deployment (lowering) of the first set of rail wheel equipment, and ends when all rail wheel equipment on the vehicle is fully deployed.

Operator: See Rolling Stock Operator.

Overhaul: Actions carried out at the end of the service period to return the item to a condition that should give reliable operation for a further full service period.

Owner: The person or body with legal title to the road rail vehicle.

Parameter: An individual measurable condition which the event recorder is capable of recording.

Parent Vehicle: the OEM vehicle to which rail guidance equipment is fitted. Also known as donor vehicle.

Park Brake: Braking equipment arranged to enable an individual vehicle to be secured at rest without reliance upon the stopping brake.

Rail Gear: See rail guidance equipment

Rail Guidance Equipment: Structures and equipment enabling a road vehicle to mount and travel on rail.

Rail Infrastructure Manager (RIM): in relation to rail infrastructure of a railway, means the person who has effective control and management of the rail infrastructure, whether or not the person—

- (a) owns the rail infrastructure; or
- (b) has a statutory or contractual right to use the rail infrastructure or to control, or provide, access to it.

Rail Safety Regulator: The National Rail Safety Regulator or an Acting National Rail Safety Regulator.

Railway Network: A railway system within Australia owned or managed by a Rail Infrastructure Manager. Some railway networks are connected to others and permit interoperability. Other railway networks are not connected to others.

Railway Track Signal: Small explosive device which is attached to the rail head to provide rolling stock and workers with an audible warning of a potentially hazardous situation. Explodes when run over by wheels. Also known as a "Railway Detonator", "Audible Track Warning Device" or "ATW".

Ramp: A fixture or portable device on an access way that provides a sloping surface giving access from one level to another.

Rear View Device: Rear view mirrors, video cameras or other vision assisting devices.

Recording Accuracy: The correctness of the measured data in relation to the physical value.

Recording Resolution: The minimum increments to which an event recorder can detect and record.

Reflective Delineators: Reflectors or reflective decals / sheeting.

Registration Notification: A confirmation from a Rail Infrastructure Manager that rolling stock has been registered on the network under their responsibility. Registration may be conditional.

Regulator: A government body responsible for ensuring compliance with particular laws, acts, regulations etc., e.g.: rail safety regulator.

RIM: Abbreviation for Rail Infrastructure Manager.

Rim: The outer portion of a wheel that interfaces with the rail.

Rim Width: Distance between the faces of the rim.

RISSB: The Rail Industry Safety and Standards Board is wholly owned by its funding members and is responsible for the development and management of the rail industry standards, rules, codes of practice and guidelines, all of which have national application.

Road Rail Vehicle (RRV): A road vehicle fitted with retractable rail guidance wheels. Also see “high-rail vehicle”.

Rolling Stock: Any vehicle that operates on or intends to operate on, or uses a railway track, including any loading on such a vehicle, but excluding a vehicle designed for both on- and off-track use when not operating on the track. Rolling stock is a collective term for a large range of rail vehicles of various types, including locomotives, freight wagons, passenger cars, track machines and road rail vehicles.

Rolling Stock Operator: means a person who has effective control and management of the operation or movement of rolling stock on rail infrastructure for a railway, but does not include a person by reason only that the person drives the rolling stock or controls the network or the network signals.

Rolling Stock Outline: A generic term for the three-dimensional size of a railway vehicle including its movements that consists of three specific parts, the static outline, kinematic outline and swept outline.

Rollover: Derailment mechanism where the road rail vehicle rolls over onto its side, pivoting about the wheels on that side.

Routine Test: A test conducted on every vehicle that will be registered to operate - see also type test.

RSSB: UK Railway Safety and Standards Board.

RRV: Abbreviation for road rail vehicle.

Runaway: Unintended movement of a vehicle.

Safeworking System: An integrated system of operating procedures and technology for the safe operation of trains and the protection of people and property on or in the vicinity of the railway.

Service Application: An application of the stopping brake that is propagated within a vehicle at a normal rate that is pre-determined and that results in a normal rate of retardation according to driver demand.

Service Braking: Normal manipulation of the stopping brake during vehicle running.

Service Period: The period of time in service use until scheduled withdrawal for the next overhaul.

Shall: Indicates that a statement is mandatory.

Should: Indicates a recommendation.

Signalling Detection System: A system that detects the presence of a train or any other on track vehicle intended to be detected on a section of track. Systems include track circuits, axle counters, treadles and global positioning systems.

Standard Gauge: Track gauge of 1,435mm (4' 8½").

Static Brake Test: A brake test performed on a vehicle whilst it is stationary.

Static Wheel Load: Nominal wheel load on flat level track.

Stop Light: Light indicating a brake application.

Supplier: A manufacturer of road rail vehicle or road rail vehicle equipment.

Swept Outline: The swept outline is the static outline of the vehicle in plan view, including the inner and outer curve throw on a 100m radius horizontal curve.

Tail Light: Red light indicating the rear of a vehicle.

Tare Mass: The mass of the road rail vehicle in the lightest condition under which it will be operated. This includes provisioning with sand and water but fuelled to no more than one-third of capacity.

Testing: The process of verifying that the road rail vehicle meets requirements, including but not limited to static factory testing and dynamic on-track testing.

Trailer: Vehicle which is towed or propelled by a road rail vehicle whilst the road rail vehicle is in rail mode. Trailers do not conform to the definition of road rail vehicles.

Transition: Process whereby a road rail vehicle changes from off-rail operation to on-rail operation, and vice versa.

Travel Mode: Mode of operation of road rail vehicles where rail gear is deployed and infrastructure maintenance equipment is securely stowed. Vehicle is able to move at travel speed.

Travel Speed: Speed vehicle travels at whilst in travel mode, generally whilst travelling to/between/from work sites. Normally higher than work speed.

Type Test: A test conducted on one vehicle or train that is typical of all vehicles or trains constructed to the same specifications.

Underframe: A metal framework carrying the main body structure of a vehicle usually located under the floor level.

UTC: Coordinated Universal Time

Vehicle: Generically used to denote a means of transportation, and specifically used to denote a single item of railway rolling stock (e.g. individual locomotive, carriage, wagon, track machine).

Vertical Access Device: A means of access between two levels.

Vigilance System: A system that will react by directly initiating an emergency brake application if an acknowledgment input is not received within a specified time increment.

Visibility Lights: Lights, fitted below the headlights, to improve rolling stock's ability to be seen and to assist the crew in viewing of the immediate area in front of the vehicle. Also known as ditch lights or crossing lights.

Web: The section of a wheel between the hub and the rim.

Wheel Pair: Two wheels which oppose each other on the same end of a vehicle, often but not always connected by an axle.

Work Closure: A section of railway track closed off to normal traffic and undergoing maintenance, construction or inspection.

Work Lighting: Lights fitted to allow effective and safe operation when in working mode (as opposed to when travelling). Typically fitted to road rail vehicles.

Work Mode: Mode of operation of road rail vehicles where rail gear is deployed and infrastructure maintenance equipment is operational. Vehicle is able to move at working speed, which is generally lower than travel speed.

Work Speed: Speed vehicle travels at whilst in work mode. Infrastructure maintenance equipment may be deployed and operational. Normally lower than work speed.

Yaw: Rotation about the vertical axis.

2 Road Rail Vehicle Classification

2.1 Types of Road Rail Vehicles

Road rail vehicles can be classified into 3 main types, depending on their braking and traction arrangement, as follows:

- (a) Type 1 - Self Powered Rail Wheels
- (b) Type 2 - Friction Drive
- (c) Type 3 - Direct Drive

It is possible that some road rail vehicles may fall into two or more classification types. Typically the difference in classification type may be between travel and work modes.

2.2 Type 1 - Self Powered Rail Wheels

Braking and traction is provided exclusively through the rail wheels. All road wheels (or crawler tracks etc.) are lifted fully clear of the rails when in rail mode, and there is no contact between road wheels (or crawler tracks etc.) and rail wheels.

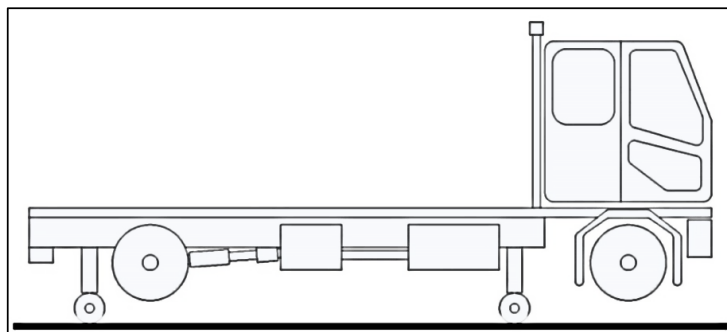


Figure 1- Type 1 vehicle

2.3 Type 2 - Friction Drive

Braking and traction is provided indirectly, from the road wheels to the rail wheels.

Braking and traction is achieved through one of three methods as follows:

Type 2(a) - Contact from the road wheel onto the rail wheel tread and/or rail wheel flange.

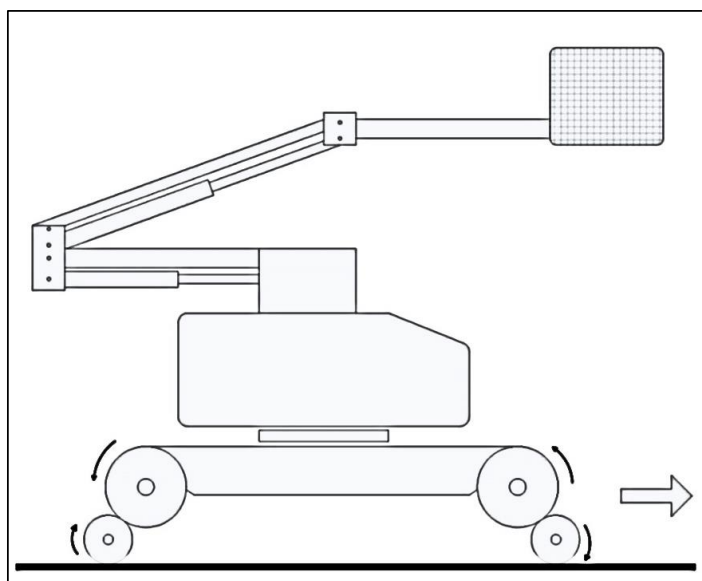


Figure 2 – Type 2(a) vehicle

Type 2(b) - Contact from the road wheel onto a rail wheel axle extension hub.

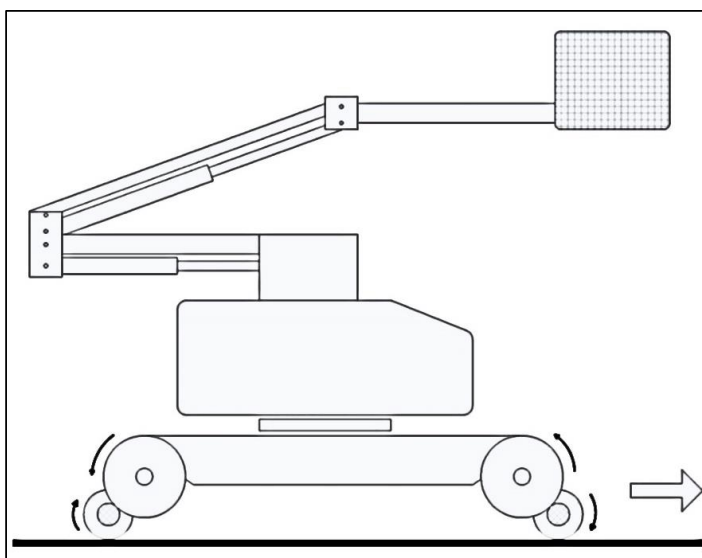


Figure 3 – Type 2(b) vehicle

Some Type 2(b) Vehicles incorporate epicyclic, or planetary gearing systems, such that forward gearing of the host vehicle results in forward rotation of the rail wheels, without use of an intermediate idler wheel. In this manner the full forward gearbox speed range of the host vehicle can be translated as forward motion at the rail wheels.

Type 2(c) - Contact from the road wheel onto the rail wheel via an intermediate "idler" wheel.

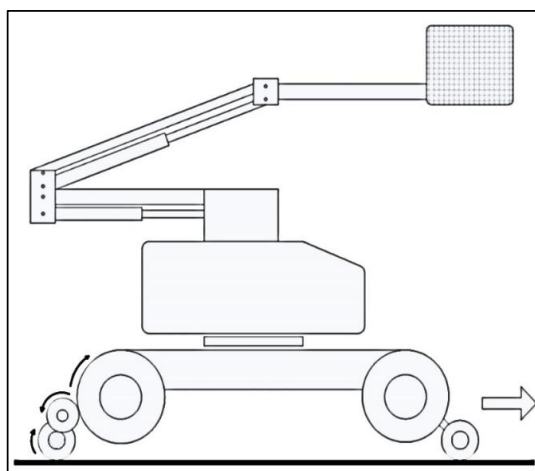


Figure 4 – Type 2(c) vehicle

2.4 Type 3 - Direct Drive

Braking and traction is provided by at least one pair of road wheels remaining in direct contact with the rail when in rail mode. Some road wheels may be lifted clear of the rail by rail wheels (front elevated), or all road wheels may remain in contact with the rail.

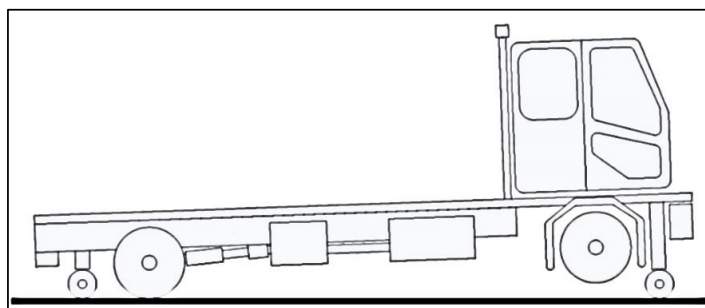


Figure 5 – Type 3 vehicle (front elevated)

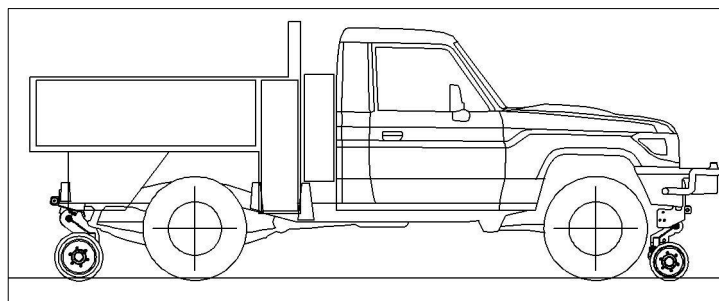


Figure 6 – Type 3 vehicle