Australian STANDARD®

Wheels

RISSB RAIL INDUSTRY SAFETY AND STANDARDS BOARD

Rolling Stock Standard

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RISSB RAIL INDUSTRY SAFETY AND STANDARDS BOARD

This Australian Standard® AS 7514 Wheels was prepared by a Rail Industry Safety and Standards Board (RISSB) Development Group consisting of representatives from the following organisations:

ARTC	Downer EDI	John Holland Group
Queensland Rail	Pacific National	Rail Corp
V/Line	Trans Adelaide	Amsted Rail
KiwiRail	Metro Trains	Aurizon
Varley Group		

The Standard was approved by the Development Group and the Rolling Stock Standing Committee in Select SC approval date. On Select Board approval date the RISSB Board approved the Standard for release.

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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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RISSB RAIL INDUSTRY SAFETY AND STANDARDS BOARD

AS 7514:2018

Wheels

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Contents

Appendix Contents

1 Introduction

1.1 Purpose

This document describes requirements for Rolling Stock Wheels.

The main purpose of the requirements is to reduce the risk of derailment arising from wheel failure or damage to infrastructure caused by wheel defects.

1.2 Scope

This document covers the design, construction and maintenance of rolling stock wheels. It applies to:

New locomotive, freight, passenger and infrastructure rolling stock wheels, going into service after the date of publication.

Existing locomotive, freight, passenger and infrastructure rollingstock wheels, going into service after modification.

Operation of rolling stock is not covered.

Rolling stock used on light rail, cane railway and monorail networks are not covered.

Requirements for the assembly of wheels onto wheelsets and geometric tolerances of wheels fitted on wheelsets are not covered. These are covered in AS 7517.

Infrastructure maintenance rolling stock used for transportation of goods and material should be treated as freight rolling stock.

1.3 Compliance

There are two types of control contained within Australian Standards developed by RISSB:

(a) Requirements.

(b) Recommendations.

Requirements – it is mandatory to follow all requirements to claim full compliance with the Standard.

Requirements are identified within the text by the term ‘shall’.

Recommendations – do not mention or exclude other possibilities but do offer the one that is preferred.

Recommendations are identified within the text by the term ‘should’.

Recommendations recognise that there could be limitations to the universal application of the control, i.e. the identified control cannot be able to be applied or other controls can be appropriate / better.

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

Controls in RISSB standards address known railway hazards as included in an appendix.

1.4 Referenced documents

1.4.1 Normative references

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

(c) AAR Manual of Standards and Recommended Practices - Section G.

(d) EN 13262 Railway Applications - Wheelsets and Bogies - Wheels - Product Requirement.

(e) EN 13979-1 Railway Applications - Wheelsets and Bogies - Monobloc Wheels - technical approval procedure - Part 1: Forged and Rolled Wheels.

(f) ISO 1005-6 Railway Rolling Stock material - Part 6: Solid wheels for tractive and trailing stock - technical delivery conditions.

(g) ISO 1005/8 Railway Rolling Stock material - Part 8: Solid wheels for tractive and trailing stock - dimensional and balancing requirements.

(h) UIC 812-2 Solid wheels for tractive and trailing stock - Tolerances.

(i) UIC 812-3 Technical specification for the supply of solid wheels in rolled non-alloy steel for tractive and trailing stock.

(j) Australian Government Australian Design Rules for road vehicles.

(k) RISSB Guideline for the Safe Operation of Road-Rail.

(l) Tyre and Rim Association of Australia Standards Manual.

1.4.2 Informative references

The following referenced documents are used by this Standard for information only:

(a) AS 4292 Railway Safety Management.

(b) AS 7501 Railway Rolling Stock Compliance Certification.

(c) AS 7502 Road Rail Vehicles.

(d) AS 7504 Brake Blocks.

(e) AS 7507 Railway Rolling Stock - Rolling Stock Outlines - Part 4: Infrastructure Maintenance Rolling Stock.

(f) AS 7508 Track Forces and Stresses.

(g) AS 7515 Axles.

(h) AS 7517 Wheelsets Maintenance Rolling Stock.

(i) RISSB Wheel Defect Manual.

(j) ISO 1005-1 Railway Rolling Stock Material - Part 1: Rough-rolled tyres for tractive and trailing stock - Technical delivery conditions.

(k) ISO 1005/2 Railway Rolling Stock material - Part 2: Tyres, wheel centres and tyred wheels for tractive and trailing stock - dimensional, balancing and assembly requirements.

(l) ISO 1005/4 Railway Rolling Stock material - Part 4: Rolled or forged wheel centres for tyred wheels for tractive and trailing stock - quality requirements.

(m) UIC 810-1 Technical specification for the supply of rough rolled non-alloy steel tyres for tractive and trailing stock.

(n) UIC 810-3 Technical specification for the supply of non-alloy flat and sectional steel for tyre retention spring rings.

(o) UIC 812-1 Technical specification for the supply of rolled or forged steel wheel centres for tractive and trailing stock - quality requirements.

(p) UIC 812-4 Technical specification for the supply of tyred wheels for tractive and trailing stock - Tyre fitting and tolerances.

(q) UIC 812-5 Technical specification for the supply of rolled or forged steel wheel centres for tractive and trailing stock - Tolerances and surface roughness

1.5 Definitions

AAR: Association of American Railroads.

ARTC network: Interstate standard gauge network, plus New South Wales regional standard gauge network.

Aurizon Network: Narrow gauge network operated by Aurizon in Queensland.

AustralAsia network: Tarcoola to Darwin standard gauge network.

Back: The back face or side of a wheel is on the flange side, see Figure 1:1.

Batch: Wheels produced by a manufacture within the same heat.

Cane railway network: A railway system dedicated to hauling harvested sugar cane from farms to a raw sugar factory. Typically, 610 mm gauge. Conventional wheelset: A wheelset having two wheels and two outboard bearings.

Conventional wheelset: A wheelset having two wheels and two outboard bearings.

EN: European Standards.

Front: The front face or side of a wheel is on the non-flange side, see Figure 1:1.

Freight rolling stock: Hauled Rolling Stock used to transport goods, materials etc.

Gross mass: Nominal total mass of Rolling Stock including maximum payload, provisioning, maximum service capacity of crew and passengers.

Hub: The centre portion of a wheel that interfaces with the axle, see Figure 1:1.

Infrastructure maintenance rolling stock: Track machines and road-rail vehicle. Also, known as on track vehicle.

Light rail network: A passenger-carrying railway system operating with trams or other similar shorter length, lower speed and lower axle-load self-propelled vehicles. Typically used in urban areas and often having a shared right-of-way with road traffic.

Locomotive rolling stock: Self-propelled, non-passenger-carrying railway vehicles used for hauling or propelling other (typically freight or passenger) rollingstock.

Monorail Network: A passenger-carrying system in which vehicles travel over a single broad beam (rather than two narrow rails connected by sleepers as with conventional railway Rolling Stock).

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

Passenger Rolling stock: Rollingstock carrying people and facilities for these people. Excludes dedicated motive power units containing only a driving crew (i.e. locomotives).

PTA of WA narrow gauge network: Public Transport Authority of Western Australia narrow gauge Perth metropolitan network.

QR narrow gauge network: Queensland narrow gauge network operated by Queensland Rail.

QR standard gauge network: QLD/NSW border to Brisbane standard gauge network.

RailCorp network: Sydney metropolitan standard gauge network.

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

Rail Infrastructure Manager (RIM): Person or organisation who has effective control and management of the rail infrastructure. The RIM either owns the rail infrastructure or has a statutory/contractual right to use the rail infrastructure or control, provide or access to it.

Rail traffic crew: Competent Workers responsible for the operation of rail traffic.

Rim: The outer portion of a wheel that interfaces with the rail, see Figure 1:1.

Rim thickness: Distance from the underside of the wheel rim (back or front) to the running surface (tread).

Rim Width: Distance between the faces of the rim, see Figure 1:1.

Road-Rail Vehicle: A vehicle that can travel on a road and can also travel on rail by use of a rail wheel guidance system.

RSO: 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.

Tasmanian network: Tasmanian regional narrow-gauge network.

Track Machine: A flange wheeled vehicle used for infrastructure maintenance, construction and inspections. Separate to freight Rolling Stock (eg. wagons used for carrying rail, sleepers, spoil, ballast etc) and Road-Rail Vehicles.

TransAdelaide network: Adelaide metropolitan broad-gauge network.

UIC: International Union of Railways.

Victorian broad-gauge network: Victorian regional and Melbourne metropolitan broad-gauge networks.

Victorian standard gauge network: Victorian regional non-interstate standard gauge network.

Web: The section of a wheel between the hub and the rim, see Figure 1:1.

WestNet Rail network: West Australian regional narrow and standard gauge network.

Wheelset: An assembly consisting of axle, wheels and bearings, and where applicable brake discs, traction gears, traction motor support bearings or gearbox.

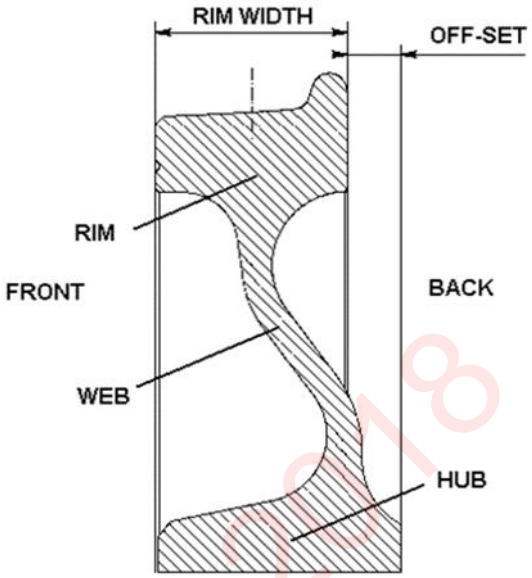


Figure 1:1- Definitions

2 Wheel design

The design process of a new wheel design comprises the following four aspects:

(a) Geometrical aspect - to assure compatibility with track and interchangeability of different solutions.

(b) Mechanical aspect - to ensure that no fatigue cracks will occur.

(c) Thermo-mechanical aspect - to manage wheel deformations and to ensure that braking will not cause wheel fracture.

(d) Acoustical aspect - to ensure that the solution chosen does not generate more noise than can be accepted for the application in question.

3 Geometrical assessment

3.1 Rim width

The rim width requirements given in Table 3:1 shall be met, unless otherwise approved by the relevant Rail Infrastructure Manager (RIM).

Network	Criteria	Rim width (mm)
ARTC	< 25 t axle load	127 to 140
ARTC	≥ 25 t axle load	138 to 140
ARTC	New wheel designs	138 to 140
Aurizon	≥20t <20t	138 to 140 126 to 128
AustralAsia		127 to 140
PTA of WA narrow gauge		127 to 130
QR narrow gauge	< 20 t axle load on new Rolling Stock	127 to 143
QR narrow gauge	≥ 20 t axle load on new Rolling Stock	140 to 143
QR standard gauge		127 to 140
RailCorp	< 25 t axle load	127 to 140
RailCorp	≥ 25 t axle load	138 to 140
Tasmania		127 to 140
TransAdelaide broad gauge		127 to 140
Victoria broad gauge		127 to 140
Victorian standard gauge		127 to 140
WestNet Rail standard gauge	New vehicles	138 to 140

Network	Criteria	Rim width (mm)
WestNet Rail standard gauge	Existing vehicles	127 to 140
WestNet Rail standard gauge	New vehicles	127 to 130

Table 3:1 – Rim width dimensions

Recommended rim width dimension for new wheel designs are 127 to 130 or 138 to 140 mm.

Infrastructure rolling stock with axle loads <10t are permitted a smaller rim width than given in Table 3:1, subject to Table 3:2, and provided the design is proven in similar service and application.

Infrastructure rolling stock that are to be detectable by wayside axle counters shall have a rim width compliant with that network's criterion shown in Table 3:2.

Network	Rim width (mm)
QR narrow gauge	≥ 115

Table 3:2 - Rim width for axle counters

3.2 Wheel diameter

The requirements for minimum wheel diameter are given in AS 7508.

The RSO shall verify with the prevalent RIM as to the correct wheel diameter. See Table 3:3 for examples.

The wheel design should allow for a minimum worn rim thickness (t) of at least 20 mm for axle loads ≤ 25 tonnes and at least 22 mm for axle loads > 25 tonnes.

Rim thickness (t) is defined in Figure 5.2.

The P/D limits for wheel diameter are given in AS 7508.

For infrastructure rolling stock with axle loads < 5 tonnes, smaller worn rim thicknesses are allowed provided the design is proven in similar service and application.

Infrastructure rolling stock that are to be detectable by wayside axle counters and are to operate in a network listed below shall have a wheel diameter shown in table 4:1.

Network	Wheel diameter (mm)
ARTC NSW	≥ 300
QR narrow gauge	≥ 350

Table 3:3 - Wheel diameter for axle counters

3.3 Wheel web shape

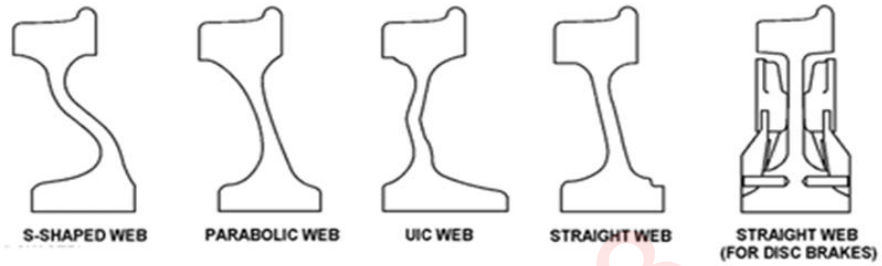


Figure 3:1 - Conventional wheel web shapes

The shape of the wheel web should be of curved web design except for those wheels to which brake discs or quill tubes are attached or where other restrictions may preclude the use of such a design.

A design proposal examples of a low stress wheel is shown in Appendix C.

Straight webbed wheels should be avoided if the vehicle is equipped with tread brakes.

Low stress wheels (S-shaped web or Parabolic web) should be preferred for all rolling stock where tread braking is performed, irrespective of class of material.

For infrastructure rolling stock able to travel at speeds greater than 60 km/h or weighing in excess of 20 tonnes gross the shape of the web should be of curved web design except for those wheels to which brake discs are attached or where other restrictions may preclude the use of such a design.

3.4 Hub axle interface

The off-set of the rim relative to the hub, shall ensure the correct distance between the wheel flanges of the assembled wheelset.

The flange side of the wheel hub should overhang the axle wheel seat.

3.5 Maintenance requirements

A last turning groove can be featured on the front face of the wheel rim.

Prior to manufacture, the intended purpose of the groove shall be agreed between the wheel designer and the Rolling Stock Operator.

The groove should serve a number of practical purposes, such as, the groove could be used as a definitive limit on the final turned diameter of the wheel; or it could be used as a means of locating a gauge to assess remaining tread thickness.

An example wear groove shape for new wheels is shown in Figure 5.2.

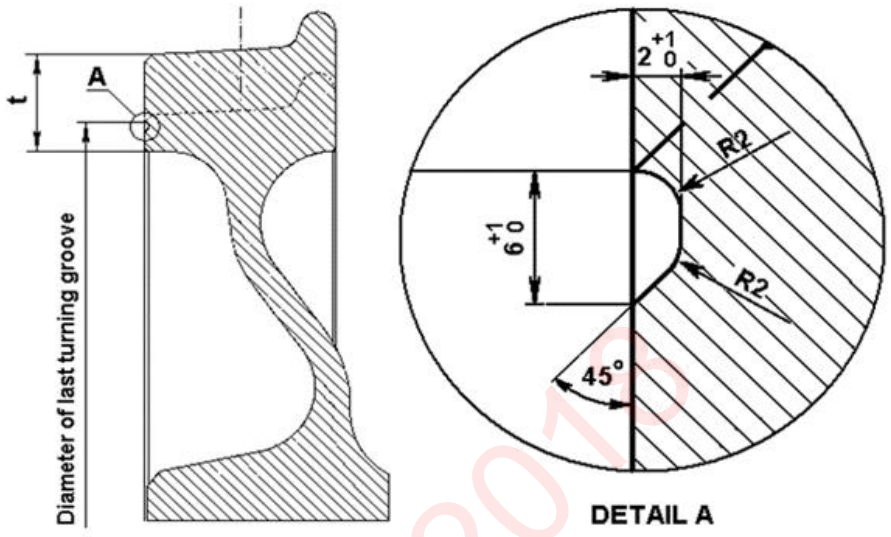


Figure 3:2 - Example wear groove shape

All new wheels which are required to be re-profiled in a portal lathe shall have a clamping surface for chucking of minimum 13 mm according to Figure 3:3.

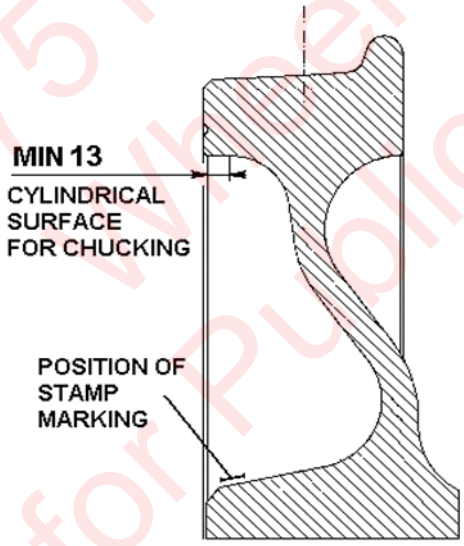


Figure 3:3 - Clamping surface and example position of marking

Wheel hubs may include provision for the oil injection method of removal from axles, with an example oil injection hole shown in Figure 3:4.

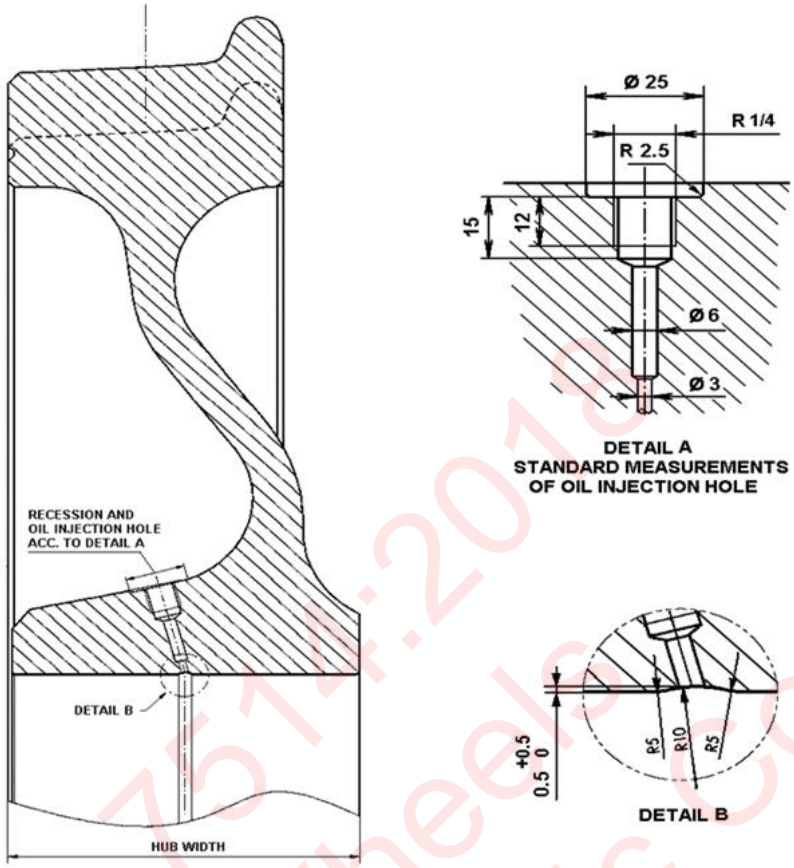


Figure 3:4 - Example oil injection hole

Oil injection grooves in wheel hubs, where fitted, shall have well rounded edges.

Where an oil injection port is featured, it shall also include a removable galvanised steel plug to prevent the entry of dirt and moisture that could lead to unintended axle damage at the time of wheel de-mounting.

4 Mechanical assessment

A formal design analysis shall be conducted for wheels produced to a shape or design not proven in similar service.

The formal design analysis of a wheel should be in accordance with EN 13979-1, or AAR standard S-660, or another equivalent standard.

For infrastructure rolling stock able to travel at speeds greater than 60 km/h or weighing in excess of 20 tonnes gross the formal design analysis of a wheel should be in accordance with EN 13979-1, or AAR standard S-660, or another equivalent standard.

If the forces on the wheel are likely to deviate substantially from the standardized load cases given in a standard, then the load cases can be derived from track force measurements.

5 Thermo-mechanical assessment

A thermo-mechanical assessment of new wheel designs shall be conducted where any of the following apply:

(a) Where tread brakes are used as service brakes.

(b) Where tread brakes are used as park brakes.

(c) Where there is a risk that the heat transferred from wheel mounted brake discs can overheat the wheel.

The thermo-mechanical assessment of a wheel should be in accordance with EN 13979-1, AAR standard S-660 or another equivalent standard.

6 Acoustical assessment

For operations where wheel-to-rail noise emissions, particularly wheel squeal, are known to be a problem, then a wheel design that attenuates noise emissions should be considered.

Methods of attenuating noise at the wheel include ring damping, tuned dampers, constrained layer damping and resiliently-mounted treads.

When it comes to deciding on noise reducing measures, note that track and vehicle are an integrated system and the most appropriate and cost-effective solution could be treating the track, or the vehicle, or both.

7 Wheel profile

Flanged wheel profiles should comply with Table 7:1. RSO are to verify the appropriate wheel profile and surface with the RIM.

Network	Rolling stock wheel profiles
ARTC	ANZR-1, WPR 2000 – used for coal operations. Not recommended for fright operations >80km/h.
AustralAsia	ANZR-1.
QR narrow gauge	LW3.
QR standard gauge	ANZR-1, WPR 2000 (not recommended for freight operations > 80 km/h).
RailCorp	WPR 2000 (preferred) ANZR-1 (allowable and mandatory for vehicles sensitive to hunting due to higher initial conicity of WPR 2000).
Tasmania	ANZR-1, WPR 2000 (not recommended for freight operations > 80 km/h).
Victorian broad gauge	ANZR-1

Network	Rolling stock wheel profiles
	ANZR-1 1 in 40. WPR 2000 (not recommended for freight operations > 80 km/h).
Victorian standard gauge	ANZR-1, WPR 2000 (not recommended for freight operations > 80 km/h).
WestNet Rail standard gauge	ANZR-1, WPR 2000 (not recommended for freight operations > 80 km/h), WR2.
WestNet Rail narrow gauge	ANZR-1, WR1.
Aurizon	LW3

Table 7:1 - Acceptable wheel profiles

Refer to Appendix A for details of Table 7:1 wheel profiles.

Operators shall gain the approval of the appropriate RIM for use of a rolling stock wheel profile not compliant with Table 7:1, including infrastructure maintenance rolling stock able to travel at speeds greater than 15 km/h or with an axle load in excess of 5 tonnes.

Flangeless driving wheels, where approved by the RIM, on steam locomotives should be tapered on both sides of the tread.

8 Manufacturing process

Wheels shall be manufactured in accordance with the processes described in AAR specifications M 107/M 208, or EN 13262, or UIC 812-3, or another equivalent industry standard.

9 Material

Infrastructure maintenance Rolling Stock that are to be detectable by wayside axle counters and are to operate in a network listed in Table 9:1 shall have a wheel material compliant with that network's criterion shown in Table 9:1.

Network	Wheel material
QR narrow gauge	Steel or cast iron

The following wheel materials are recommended

(a) AAR M-107/M-208, class A, B, C and D;

(b) EN 13262, grade ER7, ER8 and ER9

(c) UIC 812-3, grade R7, R8 and R9;

(d) Microalloy Class B;

(e) Microalloy Class C.

Alternative materials which have been proven satisfactorily in similar service and application may be used subject to, approval of the RIM.

Microalloy class B and C cast and wrought steel wheels shall conform to the standard material requirements of AAR specification M-107/M-208. But shall have suitable alloy additions and modified heat treatment in order to achieve the properties in the below table 9.2.

	Microalloy Class B Cast Wheels	Microalloy Class B Wrought Wheels	Microalloy Class C Cast Wheels	Microalloy Class C Wrought Wheels
UTS	Min. 1100 MPa	Min. 1100 MPa	Min. 1170 MPa	Min. 1170 MPa
0.2% Proof Strength	Min. 700 MPa	Min. 700 MPa	Min. 760 MPa	Min. 760 MPa
Elongation	N/A	Min. 10%	N/A	Min. 10%
Reduction Area	N/A	Min. 30%	N/A	Min. 30%
Fracture Toughness	Min. 35 ksi sq rt inch (38.5 MPa sq rt meter)	N/A	Min. 35 ksi sq rt inch (38.5 MPa sq rt meter)	N/A
Hardness	321 to 363 HB	321 to 363 HB	341 to 388 HB	341 to 388 HB

Table 9:2 - Wheel material property values

Ultrasonic testing of the rim shall be performed either to the AAR M-107/M-208 criteria or with a reference block reflector Ø 1mm FBH (as per EN 13262:2004 Category 1).

Known vulnerabilities involving heavy tread braking and braking frequency cycles can be identified when using AAR Class C wheels without adequate train operation and maintenance controls in place.

Surface hardness, wear properties, sensitivity to shelling, fatigue and impact strength are the main properties that affect selection of the wheel material.

10 Machining and peening

All wheels shall be either fully machined or shot peened.

New wheels prior to fitment on a wheelset should be machined to tolerances and surface finish as given in AAR specification M-107/M-208, or ISO 1005/8, or EN 13262, or UIC 812-2, or another equivalent standard.

Suggested wheel shot peening specifications are:

(a) Minimum areas to be peened are the web surfaces extending half way into the hub and rim fillets on both sides of the web.

(b) Average Almen Value after peening of at least 0.25 mm (0.010 inch) measured at the critical stress locations.

11 Brake performance compatibility

Suggested combinations of wheel materials and brake block types, and corresponding dynamic coefficients of friction for the brake block types, are listed in Table 11:1.

Refer to AS7504 for bake block compatibility.

Type of brake block	Dynamic coefficient of friction	Class of wheel
Low friction	< 0.2	AAR Class A or equivalent.
Medium friction	0.2 – 0.25	AAR Class A or equivalent.
High friction	≥ 0.25	AAR Class A, B or C or equivalent.
Cast iron	-	AAR Class A, B or C or equivalent.

Table 11:1 – Suggested brake block/wheel combinations

12 Balancing

Wheels intended for use at a speed greater than 120 km/h shall be statically balanced to less than the value stated in 12:2.

Any imbalance shall be corrected by machining.

Operating speed, v (km/h)	Max. static imbalance (g*m)
v ≤ 120	-
120 < v ≤ 200	75
200 < v ≤ 250	50
v > 250	25

Table 12:1 – Permissible Imbalance-Freight, Locomotive and Infrastructure Rollingstock.

Operating speed, v (km/h)	Max. static imbalance (g*m)
v ≤ 100	-
100 < v ≤ 120	125
120 < v ≤ 200	75
200 < v ≤ 250	50
v > 250	25

Table 12:2 – Permissible Imbalance-Passenger Rolling Stock

13 Wheel corrosion protection

Wheels can be supplied with a coating that provides corrosion protection. If tread brakes are used, particularly in combination with AAR Class C wheels, a coating may be used that can function as a crude overheating indication.

Suggested temperature range specification for which the coating should start to change colour is 300°C to 360°C.

14 Identification and records

14.1 Branding of new wheel designs

New wheels shall be branded with the following marks:

(a) manufacturer's mark;

(b) cast number, or serial number which can be identified with the specific cast, or both cast and serial number;

(c) steel grade;

(d) month and two last figures of the year of production;

(e) for wheels operating at speeds over 100 km/h: position of residual imbalance and its symbol.

The wheel marking arrangement shall comply with one of the following:

(a) Be marked on the hub-web fillet as shown in Figure 3:3 - Clamping surface and example position of marking.

(b) Be marked on the hub front or back face according to AAR Specification M-107/M-208 Figure B.5 or ISO 1005-6.

(c) Be cast on the web as per ISO 1005-6 Figure 16.1.

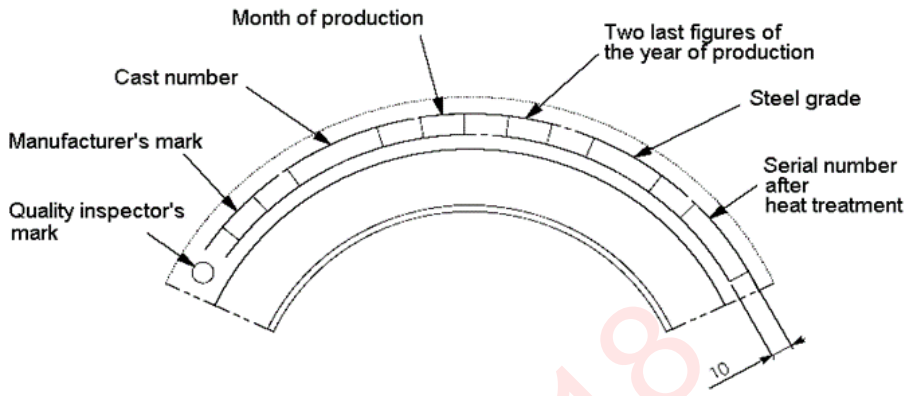


Figure 14:1 - Example marking on hub-web fillet

14.2 Branding of existing wheel designs

Replacement new wheels for existing wheel designs should be clearly branded on the hub or cast on the web with the following information:

(a) manufacturer's mark.

(b) cast number, or serial number which can be identified with the specific cast, or both cast and serial number.

(c) Steel grade.

(d) Month and two last figures of the year of production.

For wheels operating at speeds over 100km/h: position of residual imbalance and its symbol.

14.3 Branding method

Wheel stamp tools shall not have sharp edges.

Wheel marks should be stamped or cast.

Imbalance marks should be made by stamped, cast or by other means.

14.4 Records

The RSO shall keep or be able to access records of chemical and physical test results for each batch of steel used in the manufacture of new wheels.

The wheel steel batch records shall be retained until wheel disposal.

The wheel steel batch test results shall be traceable to the cast numbers or the serial numbers marked on the wheels.

15 Tyred and road wheels

15.1 Tyred wheel

The components of typical tyred wheels are shown in Figure 15:1.

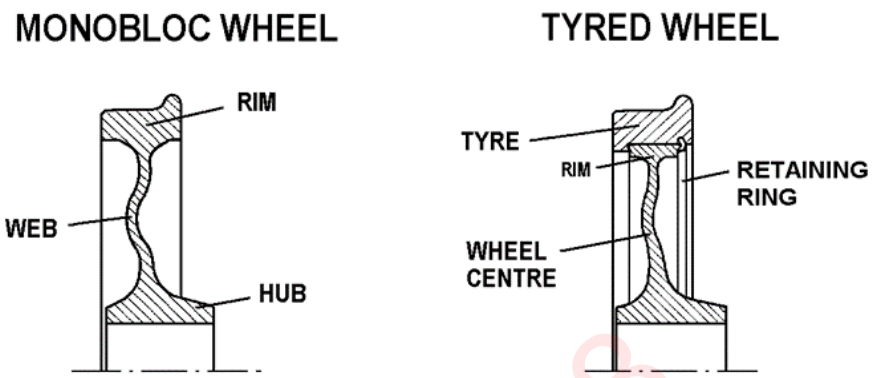


Figure 15:1 - Wheel types

Some example standards for tyred wheel components are–

(a) tyre: ISO 1005-1 and ISO 1005/2, or UIC 810-1;

(b) retaining ring: ISO 1005/2 or UIC 810-3.; wheel centre: ISO 1005/2 and ISO 1005/4, or UIC 812-1 and UIC 812-5.

(c) wheel centre: ISO 1005/2 & ISO 1005/4, or UIC 812-1 & UIC 812-5.

Tyred wheels shall be only used on heritage rolling stock where such vehicles were originally equipped with tyred wheels.

Tyred wheels shall be assembled so that all components remain in place for the service life of the wheel.

Some example procedures for tyred wheel assembly are described within ISO 1005/2 and UIC 812-4.

The tyre and the rim of the wheel centre should have two adjacent punch marks, as a tyre-rim displacement indicator.

Tyred rail wheels should only be used on vehicles if the wheels have been manufactured to a design which has been proven in a similar service and application.

15.2 Road wheels

This section applies to road wheels used on road-rail vehicles.

Road wheels shall comply with the relevant Australian Design Rules for road vehicles.

Any wheel rim modifications on road wheels shall comply with the Tyre and Rim Association of Australia Standards Manual.

Re-tread tyres shall not be fitted to road wheels that are used in rail mode.

For road wheels that provide traction or braking when in rail mode the tread surface shall completely cover the railhead always.

Refer to AS 7507 for Rolling Stock outline requirements for road wheels.

Road wheels should be maintained in accordance with the guidelines checklist rail road vehicles and AS 7502 Rail Road Vehicles.

16 Inspection- General

Operators shall develop and comply with criteria that define when and how wheels shall be routinely inspected.

The training of wheel inspectors should involve:

(a) recognition and assessment of wheel profile wear, tread damage, wheel overheating and cracking;

(b) the proficient use of measuring instruments and go no-go gauges.

The staff performing the inspections shall have written documentation and be trained on the inspection procedure and the action to be taken when defects are found.

Wheel inspections performed as part of normal train inspection and during changes of brake blocks/ brake pads in terminals and sidings may not generally cover the full wheel because of practical limitations on the access to all parts of the wheels.

If any defects are identified during the initial inspection, the whole wheel shall be closely examined.

Wheel inspections where the wheelsets are not fitted under a vehicle should include the full circumference and total surface of the wheels on both sides of the wheelset.

Refer to the RISSB Wheel Defect Manual

17 Inspection schedule

Wheel inspections should be carried out as follows:

(a) at all train and brake inspections;

(b) whenever brake blocks/brake pads are replaced;

(c) whenever a wheelset is in a repair facility for any attention to the wheelset, bogie or vehicle;

(d) for tyred wheels: also prior to each trip.

18 Dimensional limits

Operators shall develop and comply with criteria that define when a vehicle has to be removed from service due to wheel wear or exceeded dimensional limits.

Refer to the RISSB Wheel Defect Manual for suitable wheel wear and dimensional limits.

The equipment required to measure wheel dimensions shall be nominated in the wheel inspection procedures.

To facilitate inspection, go no-go gauges can be used.

Maximum permissible variation in wheel tread diameter between wheels is covered by AS 7517.

Where a visual inspection indicates that a wheel may be approaching or exceeding the dimensional limits, the wheel should be checked for wear using appropriate gauges.

The appropriateness of gauges shall be verified before use and their accuracy shall be regularly checked.

An Operator's wheel dimensional limit criteria shall be approved by the relevant RIM.

19 Non-destructive testing (NDT)

The need for, and frequency of, non-destructive testing of wheels in service will depend on the risk of wheel flange cracking, overheating and the risk of shattered rims.

Figure 19:1 shows an example of a shattered rim

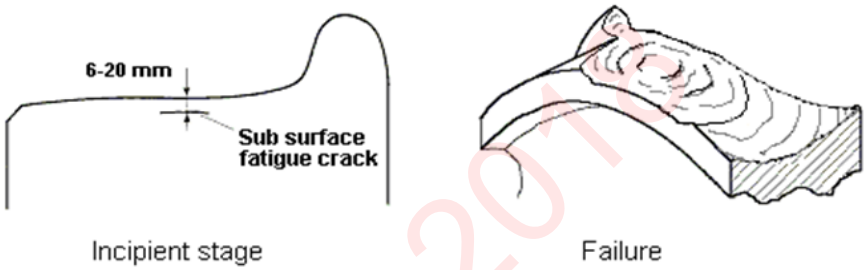


Figure 19:1 - Stages of development of a shattered rim

When changes are made to wheel designs or braking systems the RSO should review risk controls and frequency for NDT.

Non-destructive wheel tests shall be verified for effectiveness prior to implementation.

A typical means of verifying non-destructive wheel tests is by checking the method and equipment on a wheel or test piece with known defects.

20 In-service defects

RSOs shall develop and comply with criteria that define when a vehicle has to be removed from service due to wheel defects.

A wheelset shall be inspected if it produces a wayside wheel impact monitoring system alarm.

The following are typical in-service wheel defects that need condemning criteria;

(a) shelling;

(b) spalling;

(c) scaling;

(d) metal build-up;

(e) wheel flat;

(f) circularity defect;

(g) shattered rim;

(h) wheel tread roll over;

(i) tooling marks on the wheel inner rim or rim face;

(j) thermal cracks - type 1
cracks at the interface between the brake block and the wheel rim, including the external face of the wheel rim as a result of flanging brake block;

(k) thermal cracks - type 2,
cracks at the flange tip as a result of brake block that contact both the flange and the running surface;

(l) damage marks of all types;

(m) geometric defects on the flange guiding surfaces in turn-outs;

(n) overheating affecting the rim and the rim fillet;

(o) cracks or mechanical injuries in web or hub;

(p) lateral displacement or rotation of the wheel hub;

(q) on tyred wheels: Loose tyre rotation around the wheel centre;

(r) on tyred wheels: Detachment of retaining ring;

(s) on tyred wheels: Cracked spokes.

Refer to the RISSB Wheel Defect Manual for suitable in-service wheel defect limits.

When wheel defects are found action shall be taken to minimise the risk of wheel failure in service or damage to the track infrastructure.

The form and condition of the wheel flange is important because of the potential for wheel climb and derailment caused by irregular or deformed flanges, such as arises, wear grooves, surface finish, steps, etc.

Checking the flange crest and back is just as important as checking the flange's rail-side running surface.

An RSO's condemning limits for the in-service wheel defects that may affect the wheel to rail contact area shall be approved by the relevant RIM.

21 Actions following derailments

RSOs shall develop and comply with criteria that define when a wheel should be checked following a derailment.

Post-derailment wheel inspection criteria should include a requirement for wheels which have been involved in a derailment where a wheelset is derailed for more than 60 metres, or at a speed greater than 15 km/h, or other abnormal conditions, to be checked.

Post-derailment wheel checks should involve an assessment of bending or distortion using a three-point test of the rim to rim distance, or by measuring the run-out as the axle is revolved between centres or on its own bearings.

Post-derailment wheel checks should involve a detailed inspection for surface damage and cracking.

Tolerance requirements for the axle bending/distortion check are given in AS 7517.

22 Repairs

RSOs shall develop and comply with criteria that define when a wheel should be repaired or scrapped.

Restoration of the profile and the roundness of the wheel shall be done by turning by a re-profiling lathe or milling machine.

Machining tolerances for a re-profiled wheel on a wheelset are prescribed in AS 7517.

Witness marks are allowed under the following conditions:

(a) Depth is not greater than 1.2 mm.

(b) Position on the wheel profile is 10 mm or more above the tread line.

(c) Contour is smooth and blend evenly into the wheel profile.

If a full flange profile cannot be achieved, thin flange derivatives should be used.

The wheel rim shall not be turned below the last turning groove or a predetermined minimum allowable rim thickness.

Wheel turning should remove all marks, cracks and heat-affected material from the surface of the tread.

Wheels with damaged coating (e.g. due to overheating or bad flaking) and not scrapped, shall not have their coating full repaired as overheating damage can be cumulative.

Any repairing of the paint should be such that in the event of a second event, it is evident that the wheel has been subjected to more overheating.

Overheating details should be recorded for the wheelset if the wheel disc is not scrapped.

The RSO shall have in place a process to ensure existing wheels in service have a adequate surface finish. For example, many RSO use 12.5 microns for final surface finish.

23 Temporary repairs to wheel skids

The repair of wheel skids by welding is permitted as a temporary measure to allow recovery of a vehicle or wheelset with severe wheel skids.

All weld metal, including the heat affected zone, shall be removed by turning, and the tread surface inspected for possible flaws, prior to replacing the wheelset into service.

The wheel should be scrapped if it cannot be guaranteed that the heat affected zone has been removed and residual compressive stress has not been compromised.

Appendix A Wheel profiles

A.1 ANZR-1

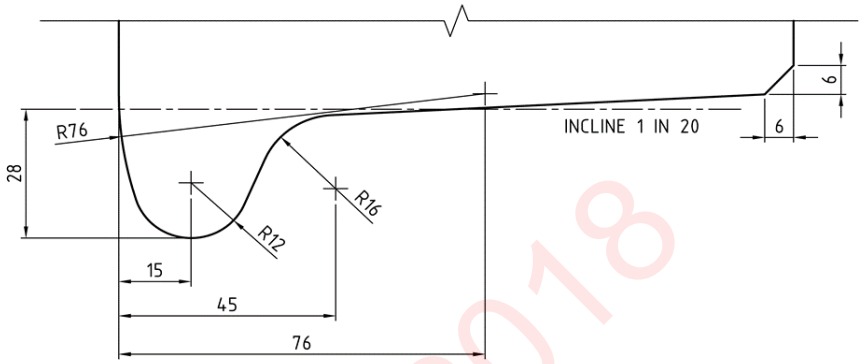


Figure A.1:1 - ANZR-1 full profile

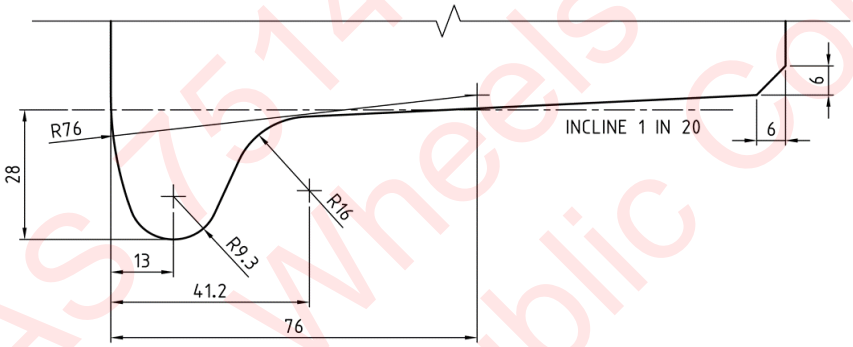


Figure A.1:2 – ANZR-1 7/8 profile

Refer to Appendix B for WPR 2000 7/8 profile.

A.2 ANZR-1 1 in 40

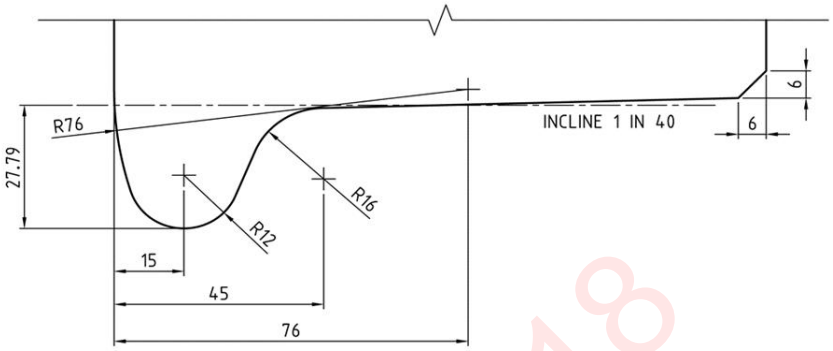


Figure A.2:1 - ANZR-1 1 in 40 profiles

A.3 WPR 2000

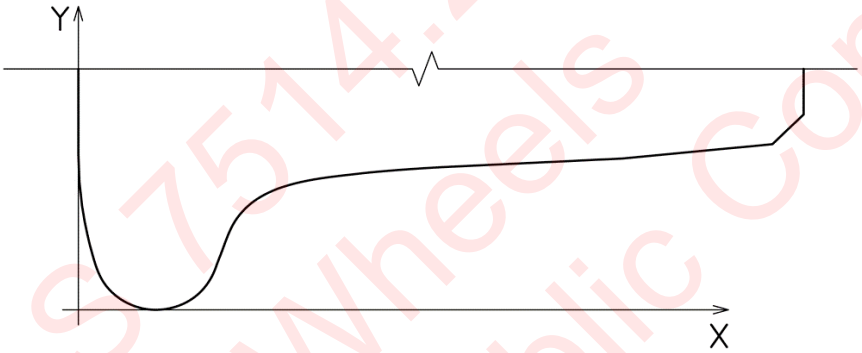
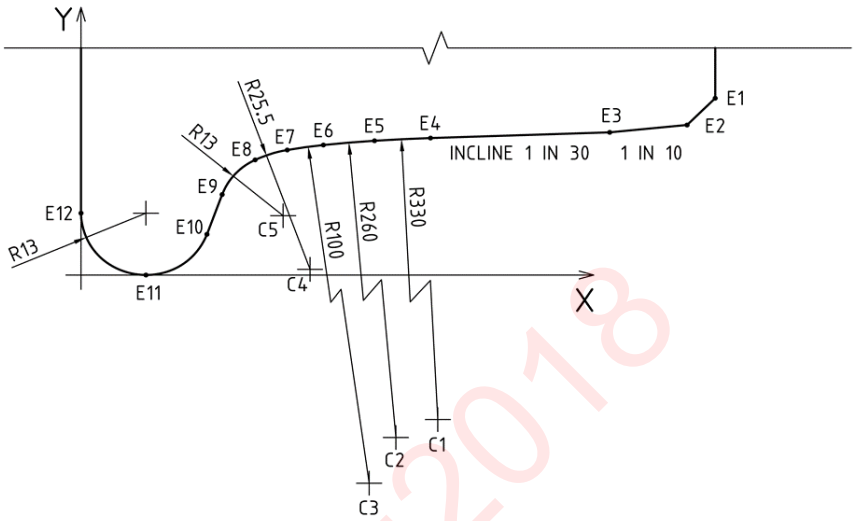


Figure A.3:1 - WPR 2000 full profile

Refer to appendix B for WPR 2000 full profile co-ordinates.

A.4 LW3



A.5 WR1

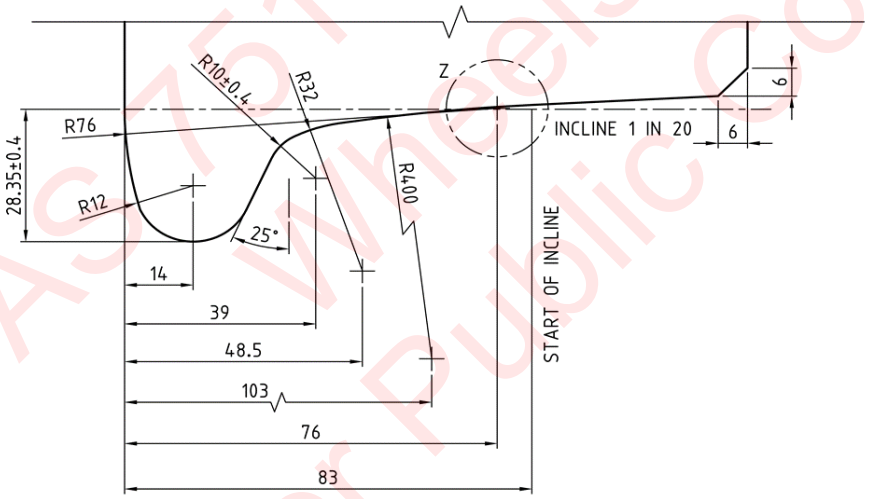


Figure A.5.1 - WR1 profile

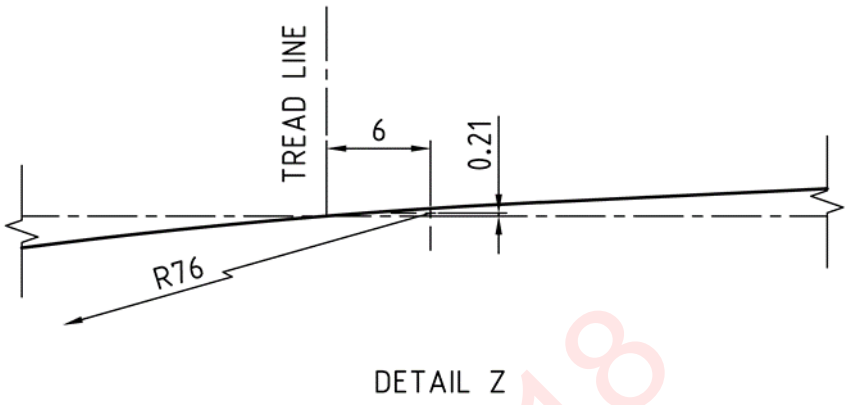


Figure A.5.2 - WR1 profile Z section cut out

A.6 WR2

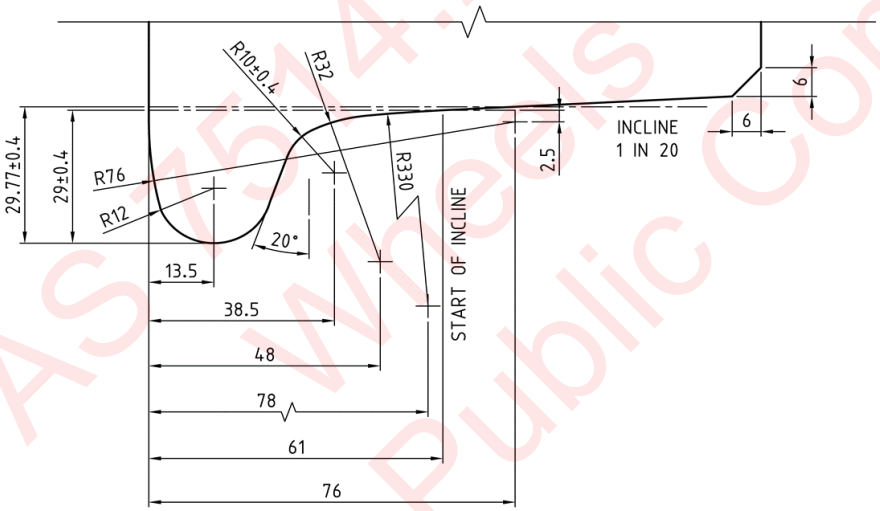


Figure A.6:1 - WR2 profile

A.7 2M-40

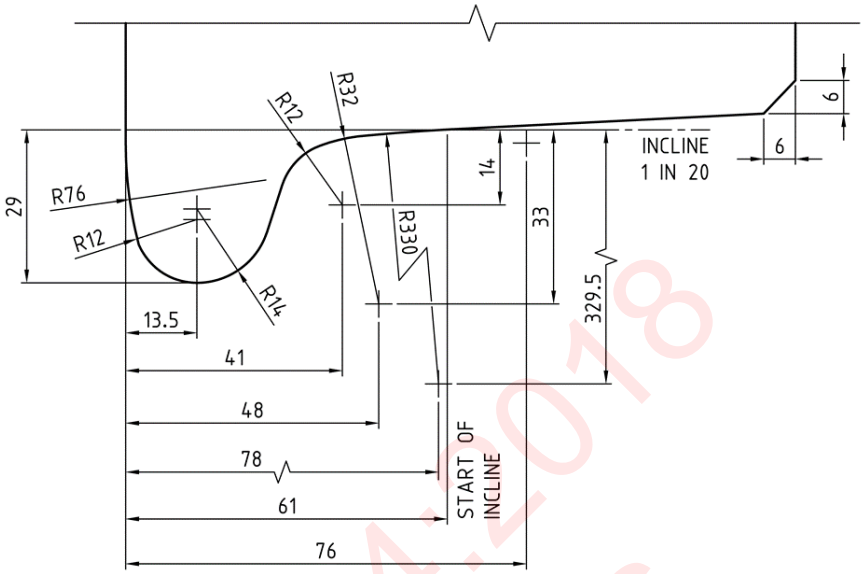


Figure A.7:1 – 2M-40 profile

A.8 2M-41

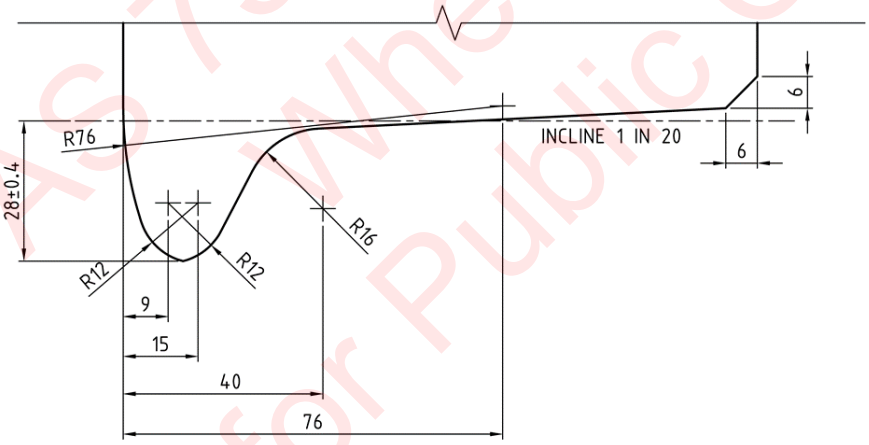
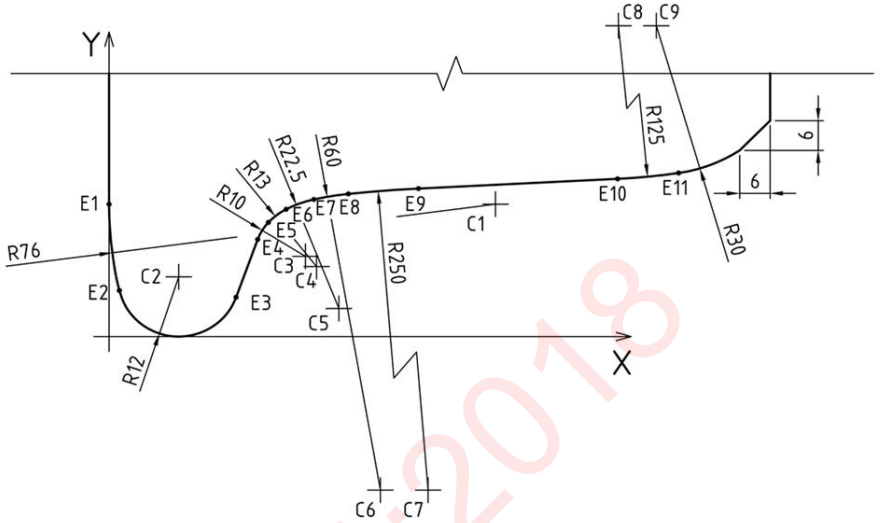
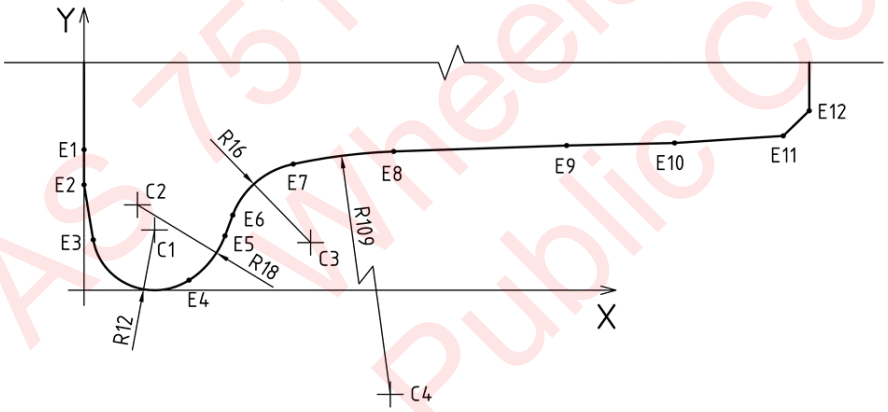


Figure A.9:1 - – 2M-41 profile

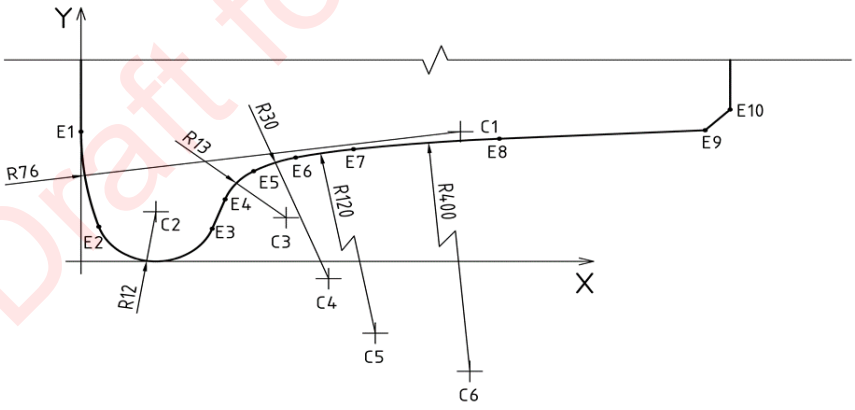
A.9 WA electric railcar



A.10 MP1

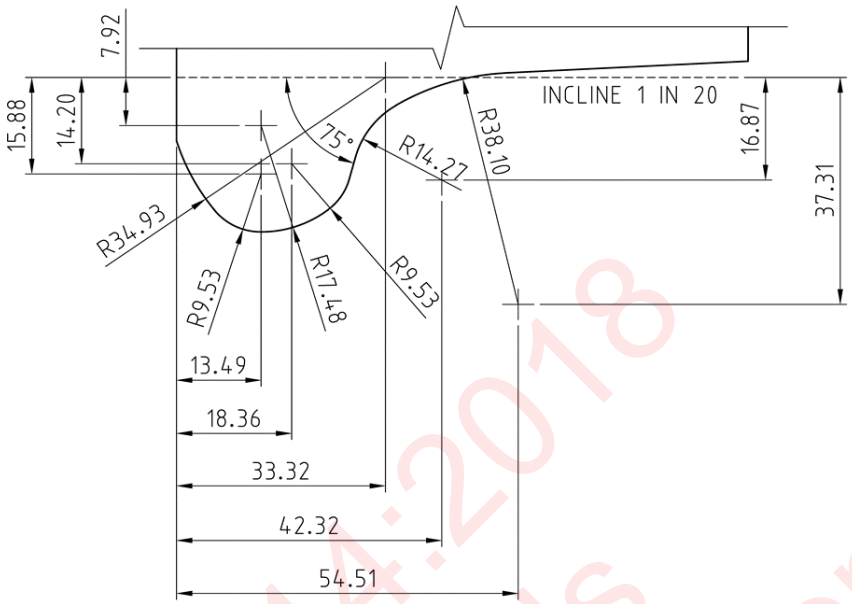


A.11 MP2

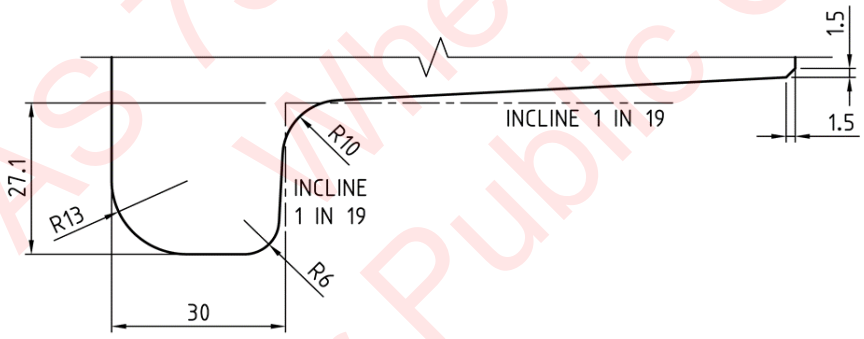


Refer to Appendix B for MP2 profile co-ordinates.

A.12 HRS1



A.13 Square flange RRV



Appendix B Wheel profile co-ordinates

B.1 WPR 2000 140mm width full profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
1	0.000	31.365	81	28.900	15.104	161	48.750	26.864
2	0.200	25.855	82	29.000	15.374	162	49.000	26.901
3	0.700	21.074	83	29.250	15.990	163	49.250	26.937
4	1.200	17.913	84	29.500	16.538	164	49.500	26.972
5	1.700	15.380	85	29.750	17.034	165	49.750	27.007
6	2.200	13.211	86	30.000	17.489	166	50.000	27.041
7	2.700	11.287	87	30.250	17.910	167	50.250	27.075
8	3.200	9.544	88	30.500	18.302	168	50.500	27.108
9	3.700	7.961	89	30.750	18.669	169	51.000	27.172
10	4.200	6.769	90	31.000	19.014	170	51.500	27.233
11	4.700	5.843	91	31.250	19.339	171	52.000	27.292
12	5.200	5.075	92	31.500	19.647	172	52.500	27.351
13	5.700	4.416	93	31.750	19.939	173	53.000	27.409
14	6.200	3.842	94	32.000	20.217	174	53.500	27.465
15	6.700	3.333	95	32.250	20.481	175	54.000	27.521
16	7.200	2.881	96	32.500	20.733	176	54.500	27.575
17	7.700	2.476	97	32.750	20.973	177	55.000	27.629
18	8.200	2.113	98	33.000	21.202	178	55.500	27.682
19	8.700	1.787	99	33.250	21.422	179	56.000	27.733
20	9.200	1.495	100	33.500	21.632	180	56.500	27.784
21	9.700	1.234	101	33.750	21.833	181	57.000	27.834
22	10.200	1.002	102	34.000	22.025	182	57.500	27.883
23	10.700	0.797	103	34.250	22.209	183	58.000	27.930
24	11.200	0.618	104	34.500	22.385	184	58.500	27.977
25	11.700	0.463	105	34.750	22.554	185	59.000	28.023
26	12.200	0.331	106	35.000	22.716	186	59.500	28.068
27	12.700	0.222	107	35.250	22.870	187	60.000	28.112
28	13.200	0.136	108	35.500	23.019	188	60.500	28.155
29	13.700	0.071	109	35.750	23.160	189	61.000	28.197

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
30	14.200	0.027	110	36.000	23.297	190	61.500	28.238
31	14.700	0.004	111	36.250	23.430	191	62.000	28.279
32	15.200	0.002	112	36.500	23.560	192	62.500	28.318
33	15.700	0.020	113	36.750	23.686	193	63.000	28.357
34	16.200	0.060	114	37.000	23.808	194	63.500	28.396
35	16.700	0.121	115	37.250	23.928	195	64.000	28.433
36	17.200	0.203	116	37.500	24.044	196	64.500	28.470
37	17.700	0.308	117	37.750	24.156	197	65.000	28.506
38	18.200	0.435	118	38.000	24.266	198	65.500	28.541
39	18.700	0.585	119	38.250	24.372	199	66.000	28.575
40	19.200	0.759	120	38.500	24.476	200	66.500	28.609
41	19.700	0.959	121	38.750	24.576	201	67.000	28.642
42	20.200	1.185	122	39.000	24.673	202	67.500	28.674
43	20.700	1.440	123	39.250	24.767	203	68.000	28.705
44	21.200	1.726	124	39.500	24.858	204	68.500	28.736
45	21.700	2.045	125	39.750	24.946	205	69.000	28.766
46	22.200	2.400	126	40.000	25.032	206	69.500	28.795
47	22.700	2.796	127	40.250	25.114	207	70.000	28.823
48	23.200	3.239	128	40.500	25.194	208	70.500	28.851
49	23.700	3.735	129	40.750	25.271	209	71.000	28.878
50	24.200	4.295	130	41.000	25.345	210	72.000	28.929
51	24.700	4.935	131	41.250	25.416	211	73.000	28.979
52	25.200	5.679	132	41.500	25.484	212	74.000	29.029
53	25.700	6.568	133	41.750	25.550	213	75.000	29.079
54	26.200	7.686	134	42.000	25.613	214	76.000	29.129
55	26.300	7.961	135	42.250	25.673	215	77.000	29.179
56	26.400	8.236	136	42.500	25.731	216	78.000	29.229
57	26.500	8.510	137	42.750	25.786	217	79.000	29.279
58	26.600	8.785	138	43.000	25.839	218	80.000	29.329
59	26.700	9.060	139	43.250	25.891	219	81.000	29.379
60	26.800	9.335	140	43.500	25.942	220	82.000	29.429

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
61	26.900	9.609	141	43.750	25.992	221	83.000	29.479
62	27.000	9.884	142	44.000	26.042	222	84.000	29.529
63	27.100	10.159	143	44.250	26.091	223	85.000	29.579
64	27.200	10.434	144	44.500	26.140	224	87.500	29.704
65	27.300	10.708	145	44.750	26.188	225	90.000	29.829
66	27.400	10.983	146	45.000	26.235	226	92.500	29.954
67	27.500	11.258	147	45.250	26.281	227	95.000	30.079
68	27.600	11.533	148	45.500	26.327	228	97.500	30.204
69	27.700	11.807	149	45.750	26.372	229	100.000	30.329
70	27.800	12.082	150	46.000	26.417	230	102.500	30.454
71	27.900	12.357	151	46.250	26.461	231	105.000	30.579
72	28.000	12.632	152	46.500	26.504	232	110.000	31.079
73	28.100	12.906	153	46.750	26.547	233	115.000	31.579
74	28.200	13.181	154	47.000	26.589	234	120.000	32.079
75	28.300	13.456	155	47.250	26.630	235	125.000	32.579
76	28.400	13.731	156	47.500	26.671	236	130.000	33.079
77	28.500	14.005	157	47.750	26.711	237	134.000	33.479
78	28.600	14.280	158	48.000	26.750	238	136.000	35.479
79	28.700	14.555	159	48.250	26.789	239	138.000	37.479
80	28.800	14.830	160	48.500	26.827	240	140.000	39.479

B.2 WPR 2000 130mm width full profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
1	0.000	31.365	81	28.900	15.104	161	48.750	26.864
2	0.200	25.855	82	29.000	15.374	162	49.000	26.901
3	0.700	21.074	83	29.250	15.990	163	49.250	26.937
4	1.200	17.913	84	29.500	16.538	164	49.500	26.972
5	1.700	15.380	85	29.750	17.034	165	49.750	27.007
6	2.200	13.211	86	30.000	17.489	166	50.000	27.041
7	2.700	11.287	87	30.250	17.910	167	50.250	27.075
8	3.200	9.544	88	30.500	18.302	168	50.500	27.108
9	3.700	7.961	89	30.750	18.669	169	51.000	27.172
10	4.200	6.769	90	31.000	19.014	170	51.500	27.233
11	4.700	5.843	91	31.250	19.339	171	52.000	27.292
12	5.200	5.075	92	31.500	19.647	172	52.500	27.351
13	5.700	4.416	93	31.750	19.939	173	53.000	27.409
14	6.200	3.842	94	32.000	20.217	174	53.500	27.465
15	6.700	3.333	95	32.250	20.481	175	54.000	27.521
16	7.200	2.881	96	32.500	20.733	176	54.500	27.575
17	7.700	2.476	97	32.750	20.973	177	55.000	27.629
18	8.200	2.113	98	33.000	21.202	178	55.500	27.682
19	8.700	1.787	99	33.250	21.422	179	56.000	27.733
20	9.200	1.495	100	33.500	21.632	180	56.500	27.784
21	9.700	1.234	101	33.750	21.833	181	57.000	27.834
22	10.200	1.002	102	34.000	22.025	182	57.500	27.883
23	10.700	0.797	103	34.250	22.209	183	58.000	27.930
24	11.200	0.618	104	34.500	22.385	184	58.500	27.977
25	11.700	0.463	105	34.750	22.554	185	59.000	28.023
26	12.200	0.331	106	35.000	22.716	186	59.500	28.068
27	12.700	0.222	107	35.250	22.870	187	60.000	28.112
28	13.200	0.136	108	35.500	23.019	188	60.500	28.155
29	13.700	0.071	109	35.750	23.160	189	61.000	28.197
30	14.200	0.027	110	36.000	23.297	190	61.500	28.238

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
31	14.700	0.004	111	36.250	23.430	191	62.000	28.279
32	15.200	0.002	112	36.500	23.560	192	62.500	28.318
33	15.700	0.020	113	36.750	23.686	193	63.000	28.357
34	16.200	0.060	114	37.000	23.808	194	63.500	28.396
35	16.700	0.121	115	37.250	23.928	195	64.000	28.433
36	17.200	0.203	116	37.500	24.044	196	64.500	28.470
37	17.700	0.308	117	37.750	24.156	197	65.000	28.506
38	18.200	0.435	118	38.000	24.266	198	65.500	28.541
39	18.700	0.585	119	38.250	24.372	199	66.000	28.575
40	19.200	0.759	120	38.500	24.476	200	66.500	28.609
41	19.700	0.959	121	38.750	24.576	201	67.000	28.642
42	20.200	1.185	122	39.000	24.673	202	67.500	28.674
43	20.700	1.440	123	39.250	24.767	203	68.000	28.705
44	21.200	1.726	124	39.500	24.858	204	68.500	28.736
45	21.700	2.045	125	39.750	24.946	205	69.000	28.766
46	22.200	2.400	126	40.000	25.032	206	69.500	28.795
47	22.700	2.796	127	40.250	25.114	207	70.000	28.823
48	23.200	3.239	128	40.500	25.194	208	70.500	28.851
49	23.700	3.735	129	40.750	25.271	209	71.000	28.878
50	24.200	4.295	130	41.000	25.345	210	72.000	28.929
51	24.700	4.935	131	41.250	25.416	211	73.000	28.979
52	25.200	5.679	132	41.500	25.484	212	74.000	29.029
53	25.700	6.568	133	41.750	25.550	213	75.000	29.079
54	26.200	7.686	134	42.000	25.613	214	76.000	29.129
55	26.300	7.961	135	42.250	25.673	215	77.000	29.179
56	26.400	8.236	136	42.500	25.731	216	78.000	29.229
57	26.500	8.510	137	42.750	25.786	217	79.000	29.279
58	26.600	8.785	138	43.000	25.839	218	80.000	29.329
59	26.700	9.060	139	43.250	25.891	219	81.000	29.379
60	26.800	9.335	140	43.500	25.942	220	82.000	29.429
61	26.900	9.609	141	43.750	25.992	221	83.000	29.479

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
62	27.000	9.884	142	44.000	26.042	222	84.000	29.529
63	27.100	10.159	143	44.250	26.091	223	85.000	29.579
64	27.200	10.434	144	44.500	26.140	224	87.500	29.704
65	27.300	10.708	145	44.750	26.188	225	90.000	29.829
66	27.400	10.983	146	45.000	26.235	226	92.500	29.954
67	27.500	11.258	147	45.250	26.281	227	95.000	30.079
68	27.600	11.533	148	45.500	26.327	228	97.500	30.204
69	27.700	11.807	149	45.750	26.372	229	100.000	30.329
70	27.800	12.082	150	46.000	26.417	230	102.500	30.454
71	27.900	12.357	151	46.250	26.461	231	105.000	30.579
72	28.000	12.632	152	46.500	26.504	232	110.000	31.079
73	28.100	12.906	153	46.750	26.547	233	115.000	31.579
74	28.200	13.181	154	47.000	26.589	234	120.000	32.079
75	28.300	13.456	155	47.250	26.630	235	124.000	32.479
76	28.400	13.731	156	47.500	26.671	236	126.000	34.479
77	28.500	14.005	157	47.750	26.711	237	128.000	36.479
78	28.600	14.280	158	48.000	26.750	238	130.000	38.479
79	28.700	14.555	159	48.250	26.789			
80	28.800	14.830	160	48.500	26.827			

B.3 WPR 2000 140mm width 7/8 profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
1	0.000	31.365	81	27.000	18.127	161	47.000	26.933
2	0.200	25.855	82	27.250	18.494	162	47.500	26.997
3	0.700	21.074	83	27.500	18.839	163	48.000	27.058
4	1.200	17.913	84	27.750	19.164	164	48.500	27.117
5	1.700	15.380	85	28.000	19.472	165	49.000	27.176
6	2.200	13.211	86	28.250	19.764	166	49.500	27.234
7	2.700	11.287	87	28.500	20.042	167	50.000	27.290
8	3.200	9.544	88	28.750	20.306	168	50.500	27.346
9	3.700	7.961	89	29.000	20.558	169	51.000	27.400
10	4.200	6.769	90	29.250	20.798	170	51.500	27.454
11	4.700	5.843	91	29.500	21.027	171	52.000	27.507
12	5.200	5.075	92	29.750	21.247	172	52.500	27.558
13	5.700	4.416	93	30.000	21.457	173	53.000	27.609
14	6.200	3.842	94	30.250	21.658	174	53.500	27.659
15	6.700	3.333	95	30.500	21.850	175	54.000	27.708
16	7.200	2.881	96	30.750	22.034	176	54.500	27.755
17	7.700	2.476	97	31.000	22.210	177	55.000	27.802
18	8.200	2.113	98	31.250	22.379	178	55.500	27.848
19	8.700	1.787	99	31.500	22.541	179	56.000	27.893
20	9.200	1.460	100	31.750	22.695	180	56.500	27.937
21	9.700	1.130	101	32.000	22.844	181	57.000	27.980
22	10.200	0.860	102	32.250	22.985	182	57.500	28.022
23	10.700	0.660	103	32.500	23.122	183	58.000	28.063
24	11.200	0.470	104	32.750	23.255	184	58.500	28.104
25	11.700	0.360	105	33.000	23.385	185	59.000	28.143
26	12.200	0.250	106	33.250	23.511	186	59.500	28.182
27	12.700	0.140	107	33.500	23.633	187	60.000	28.221
28	13.200	0.090	108	33.750	23.753	188	60.500	28.258
29	13.700	0.070	109	34.000	23.869	189	61.000	28.295
30	14.200	0.120	110	34.250	23.981	190	61.500	28.331

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
31	14.700	0.230	111	34.500	24.091	191	62.000	28.366
32	15.200	0.340	112	34.750	24.197	192	62.500	28.400
33	15.700	0.470	113	35.000	24.301	193	63.000	28.434
34	16.200	0.660	114	35.250	24.401	194	63.500	28.467
35	16.700	0.850	115	35.500	24.498	195	64.000	28.499
36	17.200	1.130	116	35.750	24.592	196	64.500	28.530
37	17.700	1.460	117	36.000	24.683	197	65.000	28.561
38	18.200	1.780	118	36.250	24.771	198	65.500	28.591
39	18.700	2.160	119	36.500	24.857	199	66.000	28.620
40	19.200	2.580	120	36.750	24.939	200	66.500	28.648
41	19.700	3.064	121	37.000	25.019	201	67.000	28.676
42	20.200	3.560	122	37.250	25.096	202	67.500	28.703
43	20.700	4.120	123	37.500	25.170	203	68.500	28.754
44	21.200	4.760	124	37.750	25.241	204	69.500	28.804
45	21.700	5.504	125	38.000	25.309	205	70.500	28.854
46	22.200	6.393	126	38.250	25.375	206	71.500	28.904
47	22.700	7.511	127	38.500	25.438	207	72.500	28.954
48	22.800	7.786	128	38.750	25.498	208	73.500	29.004
49	22.900	8.061	129	39.000	25.556	209	74.500	29.054
50	23.000	8.335	130	39.250	25.611	210	75.500	29.104
51	23.100	8.610	131	39.500	25.664	211	76.500	29.154
52	23.200	8.885	132	39.750	25.716	212	77.500	29.204
53	23.300	9.160	133	40.000	25.767	213	78.500	29.254
54	23.400	9.434	134	40.250	25.817	214	79.500	29.304
55	23.500	9.709	135	40.500	25.867	215	80.500	29.354
56	23.600	9.984	136	40.750	25.916	216	81.500	29.404
57	23.700	10.259	137	41.000	25.965	217	84.000	29.529
58	23.800	10.533	138	41.250	26.013	218	86.500	29.654
59	23.900	10.808	139	41.500	26.060	219	89.000	29.779
60	24.000	11.083	140	41.750	26.106	220	91.500	29.904
61	24.100	11.358	141	42.000	26.152	221	94.000	30.029

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
62	24.200	11.632	142	42.250	26.197	222	96.500	30.154
63	24.300	11.907	143	42.500	26.242	223	99.000	30.279
64	24.400	12.182	144	42.750	26.286	224	101.500	30.404
65	24.500	12.457	145	43.000	26.329	225	103.000	30.479
66	24.600	12.731	146	43.250	26.372	226	105.000	30.579
67	24.700	13.006	147	43.500	26.414	227	110.000	31.079
68	24.800	13.281	148	43.750	26.455	228	115.000	31.579
69	24.900	13.556	149	44.000	26.496	229	120.000	32.079
70	25.000	13.830	150	44.250	26.536	230	125.000	32.579
71	25.100	14.105	151	44.500	26.575	231	130.000	33.079
72	25.200	14.380	152	44.750	26.614	232	134.000	33.479
73	25.300	14.655	153	45.000	26.652	233	136.000	35.479
73	25.300	14.655	153	45.000	26.652	233	136.000	35.479
74	25.400	14.929	154	45.250	26.689	234	138.000	37.479
75	25.500	15.199	155	45.500	26.726	235	140.000	39.479
76	25.750	15.815	156	45.750	26.762			
77	26.000	16.363	157	46.000	26.797			
78	26.250	16.859	158	46.250	26.832			
79	26.500	17.314	159	46.500	26.866			
80	26.750	17.735	160	46.750	26.900			

B.4 WPR 2000 1300mm width 7/8 profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
1	0.000	31.365	81	27.000	18.127	161	47.000	26.933
2	0.200	25.855	82	27.250	18.494	162	47.500	26.997
3	0.700	21.074	83	27.500	18.839	163	48.000	27.058
4	1.200	17.913	84	27.750	19.164	164	48.500	27.117
5	1.700	15.380	85	28.000	19.472	165	49.000	27.176
6	2.200	13.211	86	28.250	19.764	166	49.500	27.234
7	2.700	11.287	87	28.500	20.042	167	50.000	27.290
8	3.200	9.544	88	28.750	20.306	168	50.500	27.346
9	3.700	7.961	89	29.000	20.558	169	51.000	27.400
10	4.200	6.769	90	29.250	20.798	170	51.500	27.454
11	4.700	5.843	91	29.500	21.027	171	52.000	27.507
12	5.200	5.075	92	29.750	21.247	172	52.500	27.558
13	5.700	4.416	93	30.000	21.457	173	53.000	27.609
14	6.200	3.842	94	30.250	21.658	174	53.500	27.659
15	6.700	3.333	95	30.500	21.850	175	54.000	27.708
16	7.200	2.881	96	30.750	22.034	176	54.500	27.755
17	7.700	2.476	97	31.000	22.210	177	55.000	27.802
18	8.200	2.113	98	31.250	22.379	178	55.500	27.848
19	8.700	1.787	99	31.500	22.541	179	56.000	27.893
20	9.200	1.460	100	31.750	22.695	180	56.500	27.937
21	9.700	1.130	101	32.000	22.844	181	57.000	27.980
22	10.200	0.860	102	32.250	22.985	182	57.500	28.022
23	10.700	0.660	103	32.500	23.122	183	58.000	28.063
24	11.200	0.470	104	32.750	23.255	184	58.500	28.104
25	11.700	0.360	105	33.000	23.385	185	59.000	28.143
26	12.200	0.250	106	33.250	23.511	186	59.500	28.182

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
27	12.700	0.140	107	33.500	23.633	187	60.000	28.221
28	13.200	0.090	108	33.750	23.753	188	60.500	28.258
29	13.700	0.070	109	34.000	23.869	189	61.000	28.295
30	14.200	0.120	110	34.250	23.981	190	61.500	28.331
31	14.700	0.230	111	34.500	24.091	191	62.000	28.366
32	15.200	0.340	112	34.750	24.197	192	62.500	28.400
33	15.700	0.470	113	35.000	24.301	193	63.000	28.434
34	16.200	0.660	114	35.250	24.401	194	63.500	28.467
35	16.700	0.850	115	35.500	24.498	195	64.000	28.499
36	17.200	1.130	116	35.750	24.592	196	64.500	28.530
37	17.700	1.460	117	36.000	24.683	197	65.000	28.561
38	18.200	1.780	118	36.250	24.771	198	65.500	28.591
39	18.700	2.160	119	36.500	24.857	199	66.000	28.620
40	19.200	2.580	120	36.750	24.939	200	66.500	28.648
41	19.700	3.064	121	37.000	25.019	201	67.000	28.676
42	20.200	3.560	122	37.250	25.096	202	67.500	28.703
43	20.700	4.120	123	37.500	25.170	203	68.500	28.754
44	21.200	4.760	124	37.750	25.241	204	69.500	28.804
45	21.700	5.504	125	38.000	25.309	205	70.500	28.854
46	22.200	6.393	126	38.250	25.375	206	71.500	28.904
47	22.700	7.511	127	38.500	25.438	207	72.500	28.954
48	22.800	7.786	128	38.750	25.498	208	73.500	29.004
49	22.900	8.061	129	39.000	25.556	209	74.500	29.054
50	23.000	8.335	130	39.250	25.611	210	75.500	29.104
51	23.100	8.610	131	39.500	25.664	211	76.500	29.154
52	23.200	8.885	132	39.750	25.716	212	77.500	29.204
53	23.300	9.160	133	40.000	25.767	213	78.500	29.254
54	23.400	9.434	134	40.250	25.817	214	79.500	29.304
55	23.500	9.709	135	40.500	25.867	215	80.500	29.354
56	23.600	9.984	136	40.750	25.916	216	81.500	29.404
57	23.700	10.259	137	41.000	25.965	217	84.000	29.529

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
58	23.800	10.533	138	41.250	26.013	218	86.500	29.654
59	23.900	10.808	139	41.500	26.060	219	89.000	29.779
60	24.000	11.083	140	41.750	26.106	220	91.500	29.904
61	24.100	11.358	141	42.000	26.152	221	94.000	30.029
62	24.200	11.632	142	42.250	26.197	222	96.500	30.154
63	24.300	11.907	143	42.500	26.242	223	99.000	30.279
64	24.400	12.182	144	42.750	26.286	224	101.500	30.404
65	24.500	12.457	145	43.000	26.329	225	103.000	30.479
66	24.600	12.731	146	43.250	26.372	226	105.000	30.579
67	24.700	13.006	147	43.500	26.414	227	110.000	31.079
68	24.800	13.281	148	43.750	26.455	228	115.000	31.579
69	24.900	13.556	149	44.000	26.496	229	120.000	32.079
70	25.000	13.830	150	44.250	26.536	230	124.000	32.479
71	25.100	14.105	151	44.500	26.575	231	126.000	34.479
72	25.200	14.380	152	44.750	26.614	232	128.000	36.479
73	25.300	14.655	153	45.000	26.652	233	130.000	38.479
74	25.400	14.929	154	45.250	26.689			
75	25.500	15.199	155	45.500	26.726			
76	25.750	15.815	156	45.750	26.762			
77	26.000	16.363	157	46.000	26.797			
78	26.250	16.859	158	46.250	26.832			
79	26.500	17.314	159	46.500	26.866			
80	26.750	17.735	160	46.750	26.900			

B.5 LW3 140mm width profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
C1	80.9850	-301.0326	E1	140.0000	37.8657
C2	76.2745	-231.1912	E2	134.3781	32.2638
C3	59.2029	-72.1046	E3	114.8781	30.2638
C4	45.8694	1.1925	E4	69.9911	28.7842
C5	40.4753	12.4687	E5	58.7785	28.2194
			E6	48.5331	27.3245
			E7	41.3056	26.2808
			E8	34.8653	24.1960
			E9	28.2593	16.9150
			E10	25.2160	8.5537
			E11	13.0000	0.0000
			E12	0.0000	13.0000

B.6 LW3 127mm width profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
C1	80.9850	-301.0326	E1	127.0000	37.1523
C2	76.2745	-231.1912	E2	121.3781	31.5305
C3	59.2029	-72.1046	E3	105.8781	29.9805
C4	45.8694	1.1925	E4	69.9911	28.7842
C5	40.4753	12.4687	E5	58.7785	28.2194
			E6	48.5331	27.3245
			E7	41.3056	26.2808
			E8	34.8653	24.1960
			E9	28.2593	16.9150
			E10	25.2160	8.5537
			E11	13.0000	0.0000
			E12	0.0000	13.0000

B.7 WA electric railcar 127-130mm width profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
C1	76.0000	26.6517	E1	0.0000	26.6517
C2	13.6997	12.000	E2	2.0184	9.2528
C3	38.6170	16.1336	E3	24.9760	7.8958
C4	40.8066	14.0823	E4	29.2191	19.5537
C5	45.1832	5.6510	E5	31.3181	22.9693
C6	53.3579	-30.9470	E6	34.8181	25.6214
C7	73.3289	-219.8944	E7	40.2271	27.6096
C8	93.7578	156.5953	E8	47.0512	28.7206
C9	107.6219	62.6121	E9	60.8454	29.7936
			E10	100.0000	31.7513
			E11	112.0000	32.9333

B.8 MP1 140mm width profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
C1	13.616	12.000	41	35.735	23.341	97	88.203	28.647
C2	10.296	16.998	42	36.615	23.814	98	88.710	28.665
C3	43.745	9.490	43	36.955	23.998	99	89.188	28.682
C4	63.978	-81.282	44	37.523	24.231	100	89.722	28.701
E1	0.000	28.000	45	38.471	24.596	101	90.313	28.722
E2	0.000	21.000	46	39.482	24.912	102	90.820	28.740
E3	1.773	10.061	47	40.588	25.188	103	91.607	28.768
E4	20.255	20.004	48	41.535	25.429	104	92.339	28.794
E5	27.210	10.840	49	42.568	25.641	105	93.163	28.823
E6	28.711	14.964	50	43.534	25.831	106	94.000	28.844
E7	40.383	25.1633	51	44.549	26.005	107	95.000	28.868
E8	59.787	27.637	52	45.527	26.169	108	96.000	28.893
E9	93.163	28.823	53	46.534	26.327	109	97.000	28.918
E10	114.001	29.335	54	47.531	26.479	110	98.000	28.942
E11	135.000	30.755	55	48.546	26.623	111	99.000	28.967
E12	140.000	35.755	56	49.551	26.760	112	100.000	28.991
1	0.000	21.000	57	50.583	26.889	113	101.000	29.016
2	0.960	15.077	58	51.591	27.008	114	102.000	29.040
3	1.956	9.161	59	52.620	27.118	115	103.000	29.065
4	3.021	6.365	60	53.475	27.200	116	104.000	29.090
5	4.102	4.686	61	54.189	27.309	117	105.000	29.114
6	4.744	3.919	62	55.186	27.390	118	106.000	29.139
7	5.447	3.209	63	56.851	27.463	119	107.000	29.163
8	6.208	2.559	64	57.892	27.527	120	108.000	29.188
9	7.018	1.976	65	58.891	27.565	121	109.000	29.213
10	7.877	1.461	66	59.787	27.637	122	110.000	29.237
11	8.774	1.020	67	61.081	27.683	123	111.000	29.262
12	9.074	0.655	68	62.263	27.725	124	112.000	29.286
13	10.662	0.369	69	63.304	27.762	125	113.000	29.311
14	11.637	0.164	70	64.289	27.797	126	114.000	29.335

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
15	12.634	0.040	71	65.161	27.828	127	115.000	29.403
16	13.616	0.000	72	66.005	27.858	128	116.000	29.471
17	14.632	0.043	73	66.821	27.887	129	117.000	29.538
18	15.632	0.169	74	68.199	27.963	130	118.000	29.606
19	16.600	0.377	75	68.424	27.944	131	119.000	29.674
20	17.558	0.666	76	69.268	27.974	132	120.000	29.741
21	18.487	1.033	77	70.000	28.000	133	121.000	29.809
22	19.383	1.477	78	71.097	28.039	134	122.000	29.876
23	20.238	1.993	79	72.110	28.075	135	123.000	29.944
24	21.057	2.569	80	73.151	28.112	136	124.000	30.012
25	21.842	3.189	81	74.220	28.150	137	125.000	30.079
26	22.590	3.851	82	75.317	28.189	138	126.000	30.147
27	23.301	4.554	83	76.415	28.228	139	127.000	30.214
28	23.973	5.296	84	77.540	28.268	140	128.000	30.282
29	25.186	6.884	85	78.637	28.307	141	129.000	30.350
30	26.215	8.598	86	79.735	28.346	142	130.000	30.417
31	27.049	10.415	87	80.776	28.383	143	131.000	3.485
32	28.080	13.232	88	81.817	28.420	144	132.000	30.553
33	29.146	16.036	89	82.773	28.454	145	133.000	30.620
34	30.075	17.805	90	83.163	28.468	146	134.000	30.688
35	31.219	19.445	91	84.546	28.517	147	135.000	30.755
36	31.865	20.208	92	85.193	28.540	148	136.000	31.755
37	32.558	20.929	93	86.009	28.569	149	137.000	32.755
38	33.294	21.605	94	86.599	28.590	150	138.000	33.755
39	34.071	22.234	95	87.162	283.610	151	139.000	34.755
40	3.885	22.813	96	87.697	28.629	152	140.000	37.755

B.9 MP2 130mm width profile

Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)	Co-ord ID	X (mm)	Y (mm)
C1	76.000	31.365	35	32.312	20.158	85	80.819	29.495
C2	15.000	12.000	36	33.076	20.803	86	81.816	29.551
C3	41.077	10.557	37	33.887	21.388	87	82.803	29.604
C4	49.575	-4.166	38	34.740	21.909	88	83.819	29.656
C5	69.331	-91.971	39	35.618	22.389	89	84.819	29.706
C6	103.760	-369.847	40	36.510	22.839	90	85.799	29.755
E1	0.000	31.365	41	37.418	23.260	91	86.799	29.805
E2	3.562	8.371	42	38.339	23.650	92	87.799	29.855
E3	26.276	7.896	43	39.273	24.009	93	88.799	29.905
E4	28.860	15.000	44	40.215	24.336	94	89.799	29.955
E5	34.578	21.816	45	41.173	24.633	95	90.799	30.005
E6	42.991	25.102	46	42.138	24.897	96	91.799	30.055
E7	54.576	27.118	47	43.111	25.129	97	92.799	30.105
E8	83.779	29.654	48	44.086	25.343	98	93.799	30.155
E9	125.000	31.715	49	45.063	25.549	99	94.799	30.205
E10	130.000	36.715	50	46.047	25.748	100	95.799	30.255
1	0.000	31.365	51	47.029	25.938	101	96.799	30.305
2	0.945	19.415	52	48.008	26.119	102	97.799	30.355
3	1.893	14.507	53	48.995	26.293	103	98.799	30.405
4	2.883	10.632	54	49.980	26.458	104	99.799	30.455
5	4.163	6.847	55	50.966	26.615	105	100.799	30.505
6	5.167	5.121	56	51.956	26.764	106	101.799	30.555
7	6.444	3.586	57	52.948	26.905	107	102.799	30.605
8	7.174	2.903	58	53.936	27.037	108	103.799	30.654
9	7.957	2.284	59	54.932	27.162	109	104.799	30.704
10	8.790	1.732	60	55.926	27.283	110	105.799	30.754
11	9.665	1.251	61	56.916	27.401	111	106.799	30.804
12	10.577	0.845	62	57.911	27.517	112	107.799	30.854
13	11.516	0.517	63	58.901	27.630	113	108.799	30.904
14	12.478	0.268	64	59.896	27.741	114	109.780	30.954

15	13.454	0.100	65	60.886	27.849	115	110.780	31.004
16	14.381	0.016	66	61.881	27.955	116	111.780	31.054
17	14.421	0.014	67	62.881	28.059	117	112.780	31.104
18	16.515	0.096	68	63.876	28.160	118	113.780	31.154
19	17.484	0.260	69	64.866	28.258	119	114.780	31.204
20	18.448	0.506	70	65.862	28.354	120	115.780	31.254
21	19.390	0.832	71	66.863	28.448	121	116.780	31.304
22	20.302	1.235	72	67.859	28.539	122	117.780	31.354
23	21.179	1.713	73	68.849	28.627	123	118.780	31.404
24	22.012	2.262	74	69.845	28.713	124	119.780	31.454
25	22.798	2.879	75	70.847	28.797	125	120.780	31.504
26	23.530	3.560	76	71.843	28.878	126	121.760	31.553
27	24.203	4.299	77	72.833	28.956	127	122.760	31.603
28	25.352	5.931	78	73.829	29.032	128	123.760	31.653
29	26.215	7.732	79	74.832	29.106	129	124.760	31.703
30	27.242	10.552	80	75.829	29.177	130	125.542	32.257
31	28.267	13.371	81	76.818	29.245	131	126.956	33.671
32	29.350	16.168	82	77.829	29.312	132	128.370	35.085
33	30.349	17.899	83	78.818	29.375	133	129.784	36.499
34	30.944	18.701	84	79.814	29.436			

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