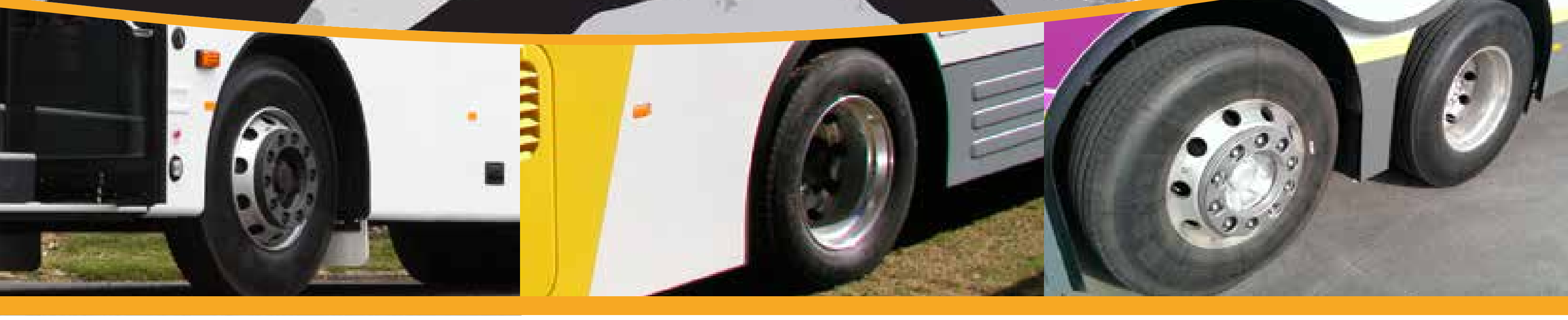
# MOVING PEOPLE

*Industry Advisory*

## Tyre Safety Advisory



*Bus and Coach Industry*

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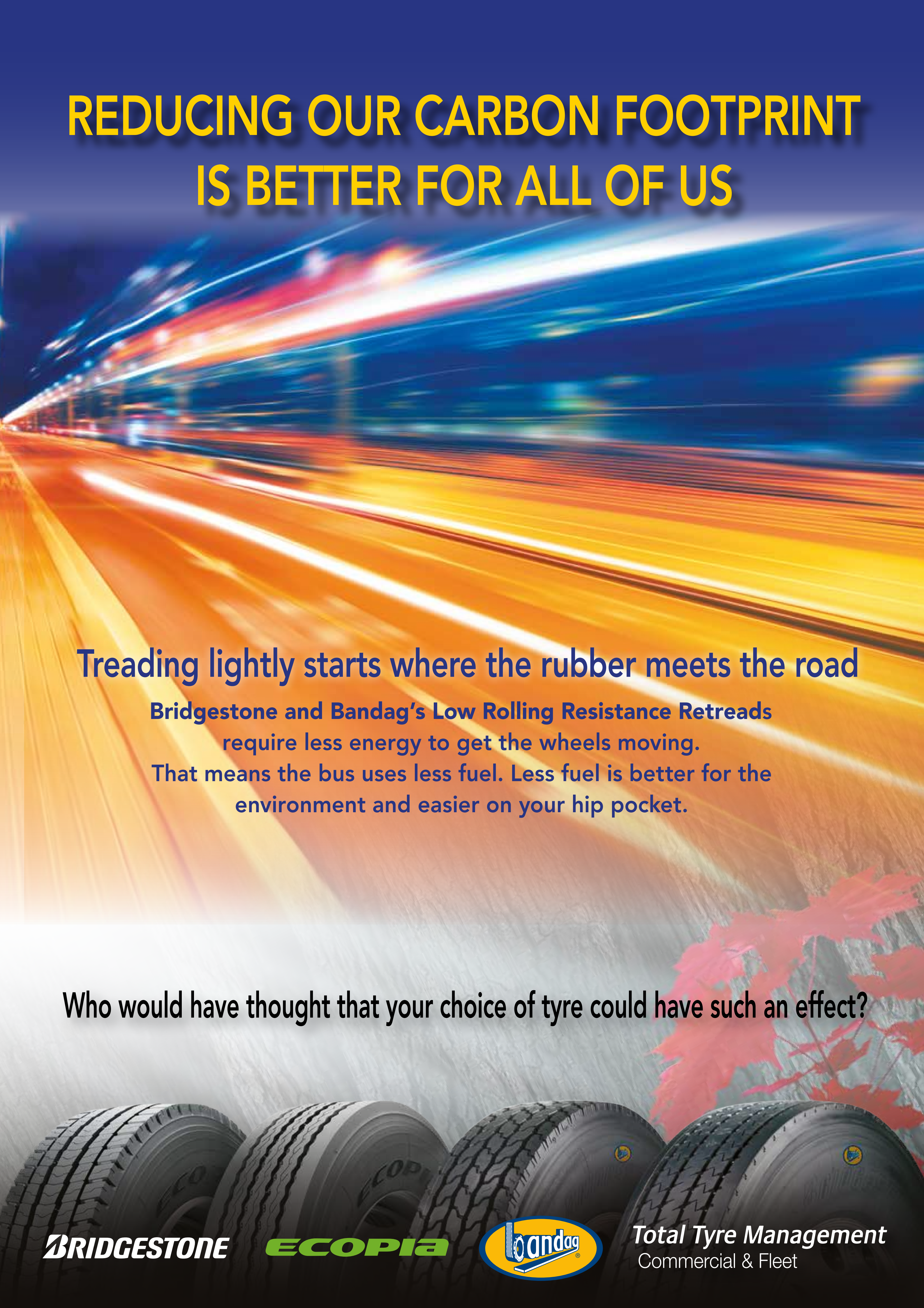
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# Preface

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# Acknowledgement

This Advisory has been developed by the Bus Industry Confederation (BIC) in conjunction with input from the BIC members, including manufacturers, suppliers and bus operators.

Special thanks to Bandag Manufacturing Pty Ltd for access to their retreading facility and to Luke Hardy, Technical Manager, Bus Industry Confederation, as primary author of this Advisory.

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# Section 1

## OVERVIEW


# BUS INDUSTRY CONFEDERATION

At the Bus Industry Confederation, we believe that the core strength of our Industry, and what sets it aside from others, is the unity of the businesses within it.

The Bus Industry Confederation puts your business in the picture and makes it a part of an industry effort to have our voice heard by governments and the wider community.

Our job is to ensure that governments keep growing the "public transport pie", to get more buses and coaches on the road, increase services and move more people. This has a direct impact on the profitability and viability of ALL businesses in the supply and operational chain of the bus and coach industry.

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For legal advice or information on industrial relations contact our industrial arm, Australian Public Transport Industrial Association (APTIA) on +61 2 9932 7106 or email enquiries@aptia.com.au.

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# 1.1 Introduction

This Advisory is intended to be a guide for operators and workshop managers to maintain and manage their tyres in a safe, compliant and cost effective manner and ensure that the tyres that are fitted to buses are compliant with the increasing axle mass limits.

This Advisory contains detailed information on a range of subjects from regulations and mass limits to retread practices and effective tyre life.

> **Tyre Components** – descriptions of the components that make up modern bus tyres, including a review of tyre industry terminologies and meanings.

> **Tyre Branding and Markings** – tyre branding, marking and symbols, what marks are required and what do they mean for both new tyres and retreads.

> **Tyre Types and Sizes** – types and sizes of tyres and their respective use.

> **Tyre Carrying Capacity** – with the increased mass limits granted to buses in most States of Australia, the carrying capacity of the tyres becomes a critical issue in terms of compliance and safety. Therefore, it is essential to review the mass limits that apply to different tyres both when new and as retreads.

> **Tyres and the NHVR Regulations** – what are the regulations and requirements for the fitting and maintenance of both new tyres and retreads.

> **Retread Tyres** – what are the main uses of retreads, where to fit retreads on buses, how many times to retread tyre cases and how to maximise tyre casing life.

> **Retreading Requirements** – what are the standards and regulations that govern retreading

> **Tyre Maintenance** – how and when to check, maintain and change tyres. Getting tyre pressures right and wheel nut tightening, checking supplier and related chassis recommendations.

> **Tyre Life** – how to extend the life of tyres, what extends life expectancy for both the new tyre tread and the tyre carcass, what shortens tread and tyre life.

> **Vehicle Alignment** – effects of chassis alignments for both the front and rear axles of a bus.

> **Mounting and Fitting of Rims** – the main issues in relation to fitting tyres to rims and then fitting rims to buses, highlighting the safety related issues.

> **Waste Regulations and Requirements** – waste regulations for tyres.

# 1.2 Background to Tyres and the Bus Industry

As of January 2011, there were 94,131 registered buses in Australia.[1] These buses are operated by more than 3,000 bus companies across the country.[2]

The Australian bus industry services more than 1.5 billion passenger trips per year.[3] This equates to the bus industry providing 1.5 billion urban public transport passenger trips per year with the coach sector moving more than 1.6 million domestic travellers per year.[4]

To achieve this, buses operate more than 6 billion passenger kilometres per year.[5]

Although the actual sales figures were not available, a review of a report prepared for the Council of Australian Governments (COAG) estimated that there were around 3.2 million truck and bus tyres, both new and retreads, sold in Australia during 2009-2010.[6] Based on expected bus tyre life and the distance travelled by the bus Australian fleet, it is estimated that around 800,000 of these new and retread tyres were used on buses.[7]

1 Australian Government, Australian Bureau of Statistics, 2014, "Census of Motor Vehicle Use", Canberra
2 Bus Industry Confederation of Australia, Industry Survey, 2010, Canberra
3 Cosgrove, D. 2011, "Long Term Patterns of Australian Public Transport Use, Australasian Transport Research Forum 2011 Proceedings 28", 30 September 2011, Adelaide
4 Australian Government, Department of Resources, Energy and Tourism, Tourism Research Australia, 2008 "Transport Fact Sheet", Canberra
5 BITRE, Department of Infrastructure, Transport, Regional Development and Local Government, 2010, Research Report 129, "Public transport use in Australia's capital cities: Modelling and forecasting", page 35
6 Council of Australian Governments, Standing Council on Environment and Water, Study into domestic and international fate of end-of-life tyres Final Report, 17 May 2012
7 Review by the author based on tyre life cycles.

## 1.3 Definitions

The Tyre Industry uses industry specific terminologies to describe not only the components that make up tyres, but also to define sizes and specifications for both new and retreaded tyres. The following provides definitions for the specific "tyre industry terms" used in this Advisory.

**Axle Load** – the total load transmitted to the road by all the tyres on each separate axle of a bus.

**Bead** – the part of the tyre usually made of steel wires, wrapped or reinforced by Ply cords that are shaped to fit the wheel rim.

**Bead Area** – the area of a tyre between the fitting line (at the bottom of the sidewall) and the Bead Toe.

**Belts** – two or more layers of substantially inextensible cord material embodied circumferentially within a tyre immediately outside the carcass plies and under the tread.

**Belt Separation** – a parting of the rubber compound between the Belt layers or between the Belts and the Ply's.

**Bias Ply Tyres** – a tyre in which the Ply cords in the tyre carcass are laid at alternate angles that are substantially less than 90 degrees to the centre-line of the tread.

**Buffing** – the preparation of the surface of the tyre prior to the application of cement and rubber.

**Bus** – a bus or a coach over 4.5 tonne gross vehicle mass (GVM).

**Carcass** – the inner tyre structure except the tread and sidewall rubber.

**Cold Inflation Pressures** – the cold inflation pressures shown in each section are those taken with the tyres at the prevailing atmospheric temperature and do not include any inflation pressure build-up due to vehicle operation.

**Cord** – the strands that form the Ply's in the tyre.

**Groove** – the space between two adjacent tread ribs.

**Gross Vehicle Mass (GVM)** – the maximum laden mass of a vehicle as specified by the manufacturer including the vehicle's chassis, body, engine, engine fluids, fuel, seats, passengers and accessories.

**Inner Tube** – a balloon made from an impermeable material, such as soft, elastic synthetic rubber, to prevent air leakage. The inner tubes are inserted into the tyre and inflated to retain air pressure.

**Kilopascals (kPa)** – measures air pressure in force per unit area, to convert kPa to PSI multiply the kPa figure by 0.145.

**Not Worth Retreading (NWR)** – a tyre case that has some form of damage or has reached its effective life limit and is determined to be NWR.

**Maximum Load Rating** – is the maximum load the tyre is designed to carry in single or dual configuration. The maximum load rating may be identified on the tyre sidewalls in kilograms, or by means of a Ply rating or a service description.

**Ply** – a layer of substantially parallel, rubber-coated cords forming a structure which is part of the tyre carcass.

**Ply Rating** – an obsolescent term used to identify a given tyre with its maximum recommended load when used in a specific type of service. It is an index of tyre strength, and does not necessarily represent the number of cord Ply's in a tyre.

**Precured Retreading** – the process by which a previously cured and patterned tread is cured to the casing.

**PSI** – pounds per square inch of air pressure.

**Radial Ply Tyre** – a pneumatic tyre in which the Ply cords, which extend from Bead to Bead, are laid at substantially 90 degrees to the centre-line of the tread, the carcass being stabilised by circumferential Belts comprising two or more layers of substantially inextensible cord material.

**Regrooving** – where the grooves of the tyre are manually cut deeper to extend the tyres tread life. This is only done on tyres that have been constructed with an extra thickness of rubber designed for recutting or regrooving and require appropriate labelling.

**Regroovable** – only tyres marked regroovable are permitted to be regrooved.

**Regrooved Tyre** – a tyre on which the tread pattern has been renewed or a new tread has been produced by cutting into the tread of a worn tyre to a depth equal to or deeper than the moulded original groove depth.

**Retreading** – a retreading process in which tread rubber is applied only to the tread area of the buffed casing (this is the normal process used on bus tyres).

**Retreader** – a company, contractor and or supplier that operates a plant that retreads tyres.

**Remoulding** – a retreading process in which new rubber is applied to the casing extending from Bead area to Bead area.

**Rim** – the wheel rim that the tyre is mounted on.

**Rim Protector** – a feature (e.g. a protruding circumferential rubber rib) incorporated into the lower sidewall area of the tyre which is intended to protect the rim from damage.

**Service Description** – the combination of load index and speed category symbols.

**Shoulder** – the transitional area of a tyre between the side wall and the crown.

**Sidewall** – the portion of a tyre between the shoulder and the Bead area.

**Sidewall Rubber** – a layer of rubber to protect the Ply cords of the tyre carcass from service damage.

**Speed category** – the symbol assigned to a tyre by a tyre manufacturer to denote the maximum vehicle speed for which the use of the tyre is rated.

**Spreader** – a machine that is used to spread the beads of the tyre apart to allow clear access to the internal section of the tyre casing.

**Stabiliser Ply** – the layers of ply laid over the end of the radial ply where the radial ply is turned up outside of the bead and under the rubber chafer. The stabiliser ply reinforces and stabilises the bead-to-sidewall transition zone of the tyre casing.

**Toe-in** – also known as positive toe, exists when the tyres are closer together at the front of the tyres than at the rear of the tyres looking at the axle in plain view and facing forward.

**Toe-out** – also known as negative toe, exists when the tyres are closer together in the rear than in the front of the tyres looking at the axle in plain view and facing forward.

**Tyre Casing** – the main structure of the tyre that extends from the bead to the tread area. The casing carries the new tyre tread and can also be fitted with a new tread as part of a retreading process.

**Tyre Design Load** – the base or reference load assigned to a tyre at a specific inflation pressure and service condition; other load-pressure relationships applicable to the tyre are based upon this base or reference load.

**Target Pressure** – the tyre pressure determined by the operator as being the best compromise pressure that the tyres need to operate on. The front tyres typically have a higher target pressure than rear or drive tyres.

**Tread** – the portion of the tyre which comes into contact with the road.

**Treadwear Indicator** – an indicator incorporated into the tread of a tyre which gives a visual indication when the tread has worn down to the limit of wear on the tyre. These are located within the grooves themselves.

**Tubeless Tyre** – a tyre designed for use without an inner tube.

**Tyre Carcass Construction Symbol** – these symbols relate to the type of 'Carcass' construction used in the manufacture of the tyre:

- the symbol "D" – Diagonal Ply
- the symbol "R" – Radial Ply.

**Tyre Pyrolysis** – subjecting either shredded or whole tyres to a high temperature of 400 to 450 degree Celsius. During pyrolysis plastic and tyre breaks down into smaller molecules of pyrolysis oil, pyrolysis gas and carbon black.

**Undertread** – the rubber between the bottom of the tread grooves and the outer layer of carcass reinforcing cord.

# Section 2

# THE TYRE SPECIFICATION, ITS TERMINOLOGY AND COMPONENTS

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**WA**
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## 2.1 Introduction

The tyre industry uses its own terminologies to describe not only the components that make up tyres, but also to define tyre sizes and specifications. The industry also uses a mixture of imperial and metric dimensions to define elements such as wheel diameter and tyre sizes. The retreading sector of the tyre industry also use a precise set of terms to describe retreads and the retreading process.

This Section reviews the more common terminologies used within the tyre industry.

## 2.2 Typical Bus Tyre Sizes and Coding

The typical types of tyres in use on larger buses (ie, 12 mtr and over) have over the years, progressed from standard aspect type tyres to lower profile and wider aspect type tyres. The wider aspect tyres are becoming more common as they offer increases in load capacity whilst still maintaining ground clearances and providing good tyre life.

The common sizes of tyres in use are:

- the standard aspect 11R22.5
- the lower profile 275/70R22.5 size tyres
- the wider aspect 295/80R22.5 size tyres.

The coding used in these tyre sizes are summarised in the following (noting that the tyre industry uses a mixture of metric and imperial measurements).

> Typical Standard Aspect Tyre – 11R22.5 where:

- the “11” is the cross section of the tyre in inches
- the “R” is code for Radial
- and the 22.5 is the wheel rim diameter in inches.

> Typical Low Profile Tyre – 275/70R22.5 where:

- the “275” is the cross section of the tyre in millimetres (mm)
- the “70” is the aspect ratio
- the “R” is code for Radial
- the 22.5 is the wheel rim diameter in inches.

The larger aspect or high profile tyres, such as the 295’s or larger, provide increased carrying capacity whilst maintaining the higher profile and this is reviewed in Section 3.5 of this Advisory.

## 2.3 Typical Bus Tyre Construction Differences

Route bus tyres differ from highway coach tyres in a number of areas. For buses used in stop start route operations, the tyre manufacturers offer metro or city bus type tyres that are specifically designed to better meet the city operating environment. The tyres on city buses experience lower average speeds than the typical highway type tyres fitted on coaches, but they do experience far more sidewall impacts, more braking and manoeuvring load as well as more heat from the wheel rims.

The ways in which tyres are designed in order to meet these requirements vary greatly, but the types of characteristics of route bus tyres include:

- wear resistant tread compounds
- extra deep treads to extend tread life
- reinforced and or thicker sidewalls and ribbings to protect against curbing
- tread designs that offer quiet running and low vibrations
- all position tread designs (this is unlike truck tyres where there tends to be separate tyre types for the steer, drive and trailer positions).

The retreading industry also provides a range of bus specific retreads that meet city route bus type operational environments.

# 2.4 Tyre Components

This Section reviews the components that make up a modern bus tyre, defining the purpose of each component and how they combine within the tyre itself.

## The Areas within a Tyre

Following are the main areas that make up a modern bus radial tyre, as shown in Figure 1.

> 1. Crown – the area of the tyre that contacts the road surface.

> 2. Shoulder – the transition area between the crown and tread skirt.

> 3. Tread Skirt – the intersection of tread and sidewall.

> 4. Sidewall – the area from the top of Bead to the bottom of the tread skirt.

> 5. Stabiliser Ply – the layers of Ply laid over the radial Ply turned up outside of the Bead and under the rubber chafer that reinforces and stabilises the Bead-to-sidewall transition zone.

> 6. Bead Heel – the area of Bead that contacts the rim flange, the “sealing point” of the tyre/rim.

> 7. Bead Toe – the inner end of the Bead area.

## The Components of a Tyre

Following are the main components that make up a modern bus radial tyre, as shown in Figure 1.

> A. Liner – the Liner is a layer or layers of rubber in tubeless tyres that resist air diffusion. The liner in the tubeless tyre replaces the inner tube of the tube-type tyre.

> B. Bead Core – the Bead Core is made of a continuous high-tensile wire wound to form a high-strength unit. The Bead core is the major structural element in the plane of tyre rotation and maintains the required tyre diameter on the rim.

> C. Chafer – the Chafer is a layer of hard rubber that resists rim chafing.

> D. GG Ring – the GG Ring is used as reference for proper seating of Bead area on rim.

> E. Apexes – the Apexes are rubber pieces with selected characteristics used to fill in the Bead and lower sidewall area and provide smooth transition from the stiff Bead area to the flexible sidewall.

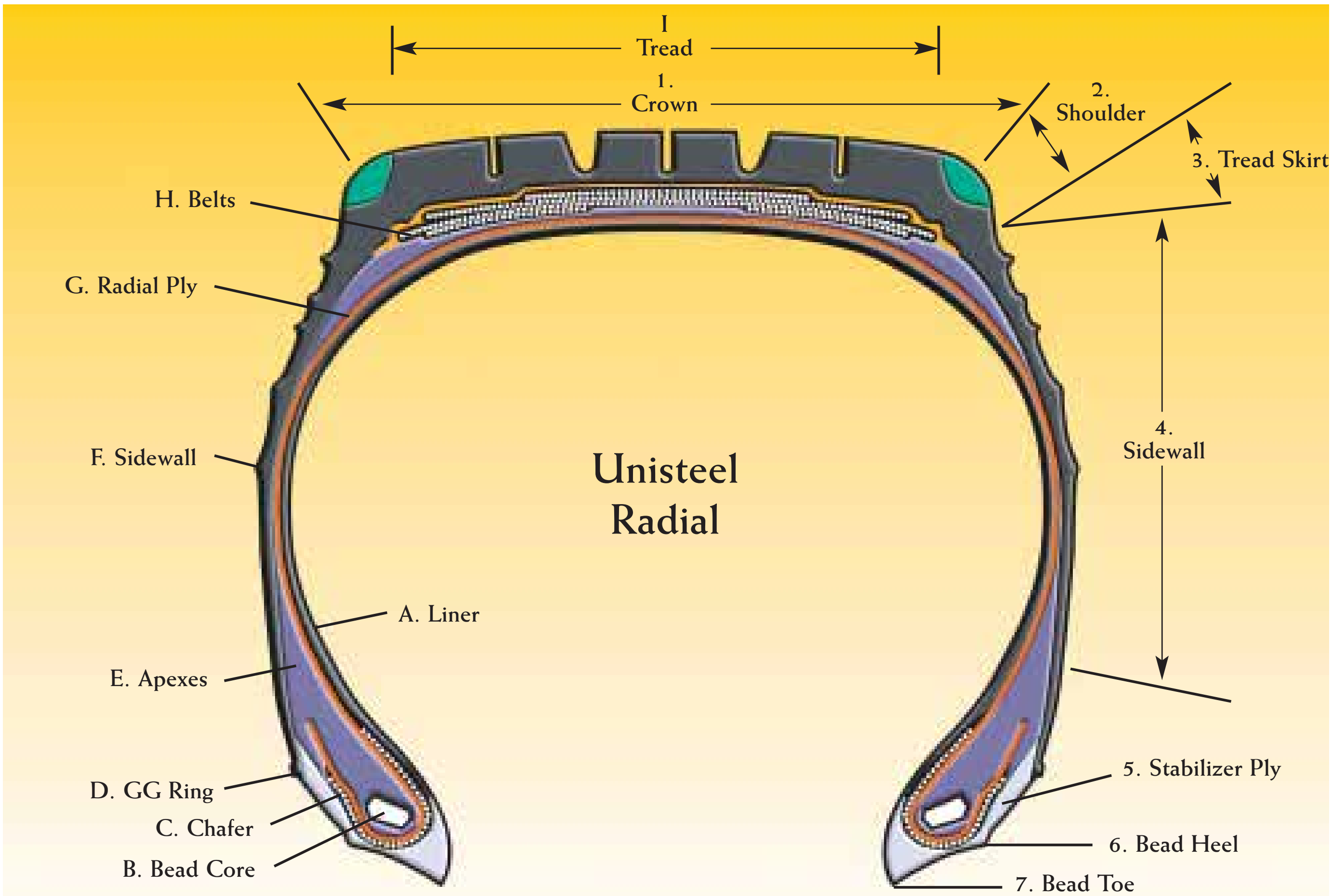
> F. Sidewall – the Sidewall rubber must withstand flexing and weathering and provide protection for the Ply. For bus tyres, the side wall is normally increased in strength and thickness so as to better resist impact with gutters.

> G. Radial Ply – the Radial Ply, together with the Belt plies, withstands the loads of the tyre under operating pressure. The plies must transmit all load, driving, braking and steering forces between the wheel and the tyre tread.

> H. Belts – the steel cord Belt plies provide strength, stabilise the tread, and protect the air chamber from punctures.

> I. Tread – the Tread rubber provides the interface between the tyre and the road. Its primary purpose is to provide traction and wear.

**Figure 1: Radial Tyre Cross Section showing the major tyre components and areas within a typical bus tyre.**



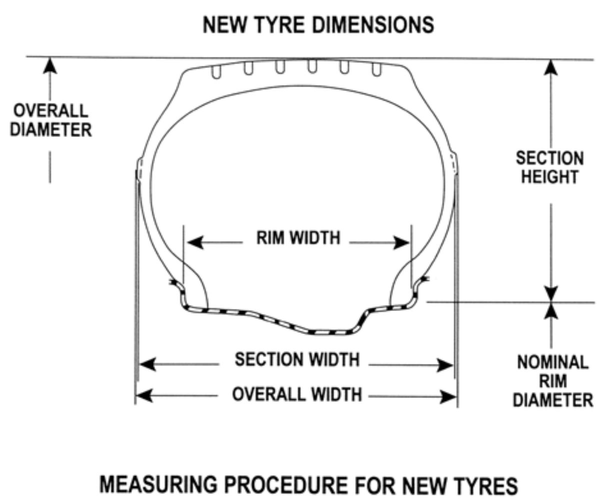

Source: Radial Truck Tyre And Retread Service Manual [8]

## The Main Dimensions of a Tyre

Following are the main dimensions of a modern bus radial tyre, as shown in Figure 2.

- Rim Width – rim width is the specific rim width assigned to each tyre size designation and is measured as the linear distance between the flanges of the rim.
- Section Width – the linear distance between the outsides of the sidewalls of an inflated tyre excluding extensions due to markings, decorations or protective bands, ribs, or protectors.
- Overall Width – the linear distance between the outsides of the sidewalls of an inflated tyre including extensions due to markings, decorations or protective bands, ribs, or Rim Protectors.
- Overall Diameter – the diameter of an inflated tyre at the outermost surface of the tread.
- Nominal Rim Diameter – the nominal rim diameter is a size code figure for reference purposes only, as indicated on the tyre and rim size designations.

**Figure 2: Wheel and Tyre Cross Section showing the major tyre dimensions.**




Source: The Tyre and Rim Association of Australia, Standards Manual 2014[9]

8 The Goodyear Tire and Rubber Company, "Radial Truck Tyre And Retread Service Manual 700-862-932-505 000000" 10/04, available from: https://www.goodyeartrucktires.com/pdf/resources/service-manual/retread_all_v.pdf, first viewed 19 September 2015

9 The Tyre and Rim Association of Australia - Standards Manual - 2014, page IV General Information

## 2.5 Tyre Sidewall Codes

There are a range of markings on the side wall of a tyre and these markings define details such as the tyre size, specification and rating. These markings and codes also denote the approvals for the specific tyre, plus other details such as manufacture dates, country of origin and compliances applicable to the tyre.

Following are the typical codes and approval marks on the sidewall of a bus tyre, as shown in Figure 3.

> 1. Brand – this denotes the brand of the tyre, in this case Bridgestone.

> 2. Pattern – the tread pattern used on the specific tyre.

> 3. Tyre Size – the size of the specific tyre, in this case the size is 295/80R22.5.

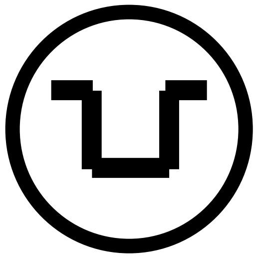
> 4. Service Description Load Capacity and Speed Symbol[10] – 152/148 M, equates to the maximum load carrying capacity for the tyre. The capacity for this tyre is 3550 kg when used in a single configuration and 3150kg when used in a dual configuration.[11] A complete table of the load indices for tyres as determined by the European Union[12] and adopted in the Australian Vehicle Regulations, is given in Appendix A of this Advisory. It should be noted that the ratings given in the table in Appendix A are the maximum ratings set at the maximum Cold Inflation Pressure.

> The maximum Load Capacity for a tyre is also linked to a maximum speed, that is the "M" used in the 152/148 M is the speed rating for this tyre when operating at the nominated maximum load of 152/148. The list of speed rating symbols for bus tyres are given in Table 1.[13]

> 5. Date of Manufacture – the date of manufacture is provided within the DOT ID number. The typical number format being DOT AABB CCC WWYY, and these code sets are defined as:

- DOT – US Department of Transport
- AABB – Manufacturer factory code
- CCC – Optional Manufacturer code
- WW – Week of manufacture, the week number being 1 to 52
- YY – Year of manufacture, for example 12 would be 2012.

> 6. Regroovable – shows that the tyre can be regrooved. This can also be in the form of a symbol.[14]



> 7. Country of Origin – shows the country of manufacture, in this case Japan.

> 8. Maximum Load and Pressure – the inflation pressure to carry the tyre's maximum load. It should be noted that in Australia, the maximum tyre pressure might exceed the legal pressure limit of 825 kPa (120 PSI) as defined by the NHVR, see Section 3.[15] The maximum load is also listed for the tyre in single and dual configuration in Table 3, Section 3.

> 9. Ply Rating – this term is used to identify the index of tyre strength which relates to the tyres load carrying capacity and not necessarily the number of cord plies in the tyre.[16] In this case the tyre has a Ply rating of 16 PR.

> 10. Load Range – the load range is equivalent to the Ply rating, as required under the United States Tyre and Rim Association, but for the Australian market, the figures identified at Point 4 – Service Description are the more useful figures for tyre users. In this case the tyre has a load range of "J".

> 11. E-Mark – denotes compliance with Directive E/ECE/324 and the number within the circle denotes the country the approval has been granted.[17]

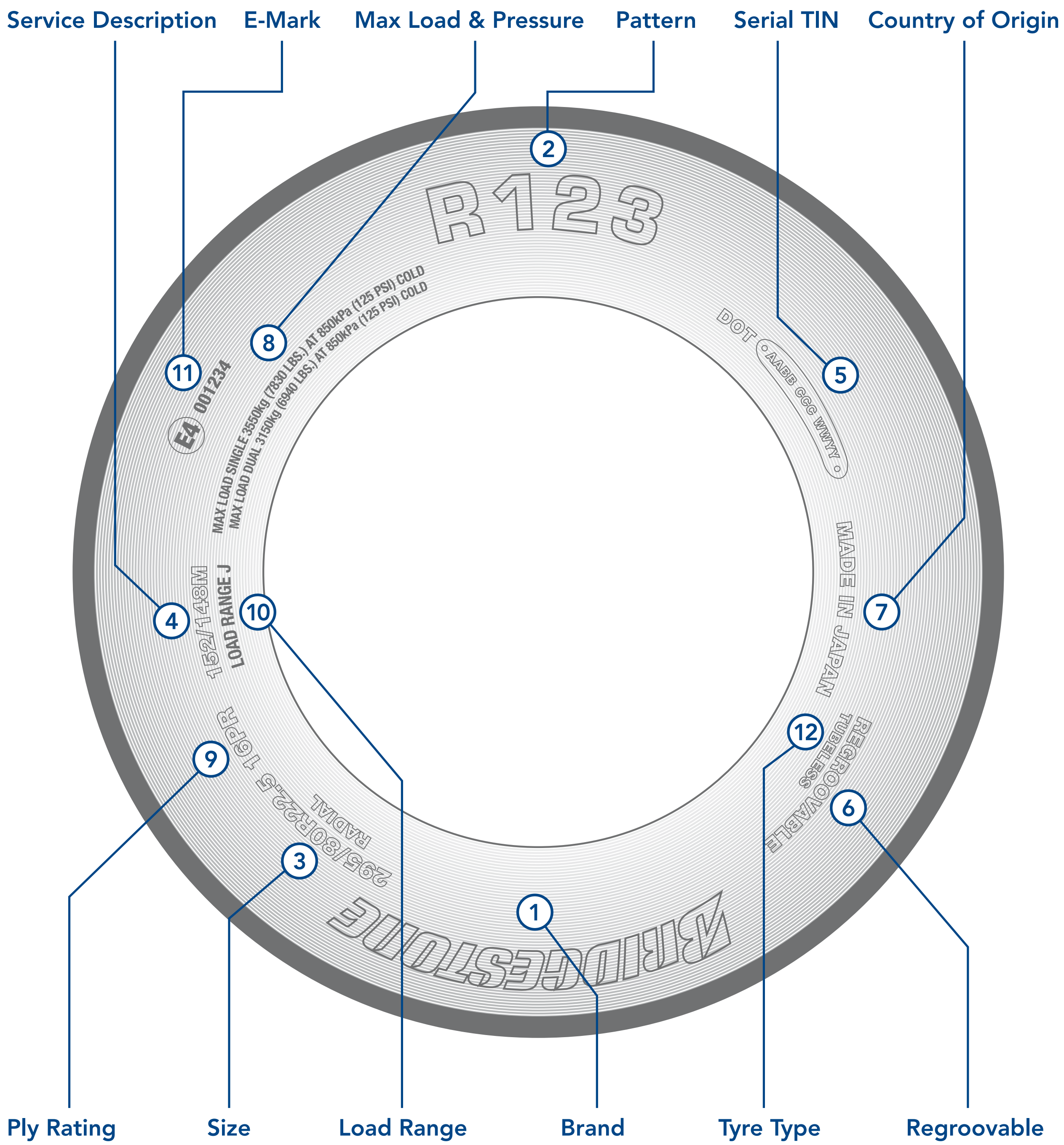
> 12. Tyre Type – tubeless, indicates that the tyre does not require an inner tube.

**Table 1: List of speed rating symbols for bus tyres**

| Speed Symbol | Speed (km/h) |
|---|---|
| E | 70 |
| F | 80 |
| G | 90 |
| J | 100 |
| K | 110 |
| L | 120 |
| M | 130 |

10 Standards Australia, AS 1973-1993, 'Pneumatic Tyres—Passenger Car, Light, Truck and Truck/Bus—Retreading and Repair Processes', 15 November 1993
11 The Tyre and Rim Association of Australia Standards Manual 2014, page VI
12 United Nations, Agreement, Regulation No. 109, Rev.2/Add.108/Rev.1 (June 2010), "Uniform Provisions Concerning The Approval For The Production Of Retreaded Pneumatic Tyres For Commercial Vehicles And Their Trailers", Annex 4
13 United Nations, Agreement, Regulation No. 54, Rev.3/Add.53/Rev.1 (March 2013), "Uniform provisions concerning the approval of pneumatic tyres for commercial vehicles and their trailers", Clause 2.28.2
14 United Nations, Agreement, Regulation No. 109, Rev.2/Add.108/Rev.1 (June 2010), "Uniform Provisions Concerning The Approval For The Production Of Retreaded Pneumatic Tyres For Commercial Vehicles And Their Trailers", Clause 3.2.9
15 Heavy Vehicle National Law Act 2012 Heavy Vehicle (Vehicle Standards) National Regulation Current as at 10 February 2014 Reprint.
16 The Tyre and Rim Association of Australia Standards Manual 2014, Page V
17 United Nations, Agreement, Regulation No. 54, Rev.3/Add.53/Rev.1 (March 2013), "Uniform provisions concerning the approval of pneumatic tyres for commercial vehicles and their trailers", Clause 5.4.1.R Annex 2

Figure 3: Typical Sidewall Branding and Codes



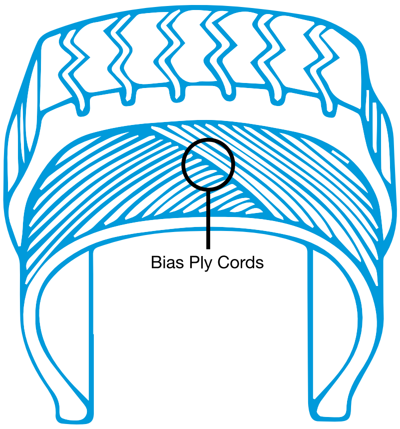
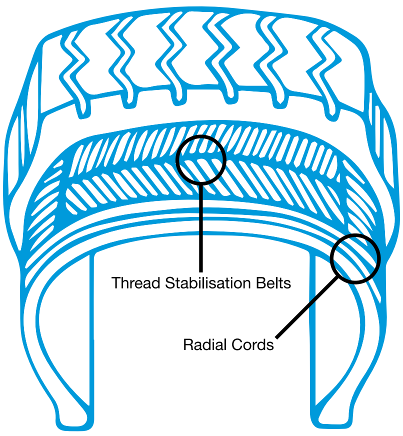

Source: Bandag Tread Data Guide [18]

18 Bandag Manufacturing Pty Ltd, “Bandag Tread Data Guide”, 10/2010, available from: http://www.bandag.com.au/lib/pdf/mf277.pdf, first viewed 19 September 2015

# 2.6 Bias Compared to Radial Type Tyres

There are two basic types of tyre construction which are bias and radial type tyres. The radial type tyre is the modern type of tyre and the one normally used on bus fleets. Table 2 shows the basic differences between the two construction types.

**Table 2: Bias and Radial Tyres**

| | |
|---|---|
|   | **Bias Tyre**<br>A Bias (or Cross Ply) tyre construction utilises body Ply cords that extend diagonally from bead to bead, usually at angles in the range of 30 to 40 degrees, with successive plies laid at opposing angles forming a crisscross pattern of cords that are below the tread. The design allows the entire tyre body to flex easily, providing the main advantage of this construction, a smooth ride on rough surfaces. This cushioning characteristic also causes the major disadvantages of a bias tyre: increased rolling resistance and less control and traction at higher speeds. |
|   | **Radial Tyre**<br>A Radial tyre construction utilises body Ply cords extending from the Beads and across under the tread so that the cords are laid at approximately right angles to the centreline of the tread, and parallel to each other (or at right angles to the direction of travel). These cords are then stabilised by belts that run around the circumference of the tyre directly beneath the tread. The Belts may be cord, or more commonly, steel. The advantages of this construction include longer tread life, better steering control, and lower rolling resistance. Disadvantages of the radial tyre include a harder ride at low speeds on rough roads and in the context of off-roading, decreased “self-cleaning” ability and lower grip ability at low speeds. |

# Section 3

# COMPLIANCE REGULATIONS FOR TYRES ON HEAVY VEHICLES AND EFFECTS OF INCREASED MASS LIMITS ON TYRES

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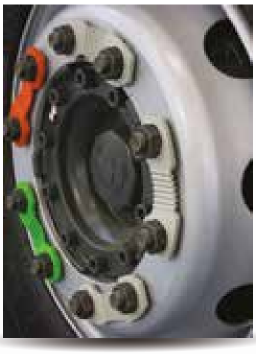

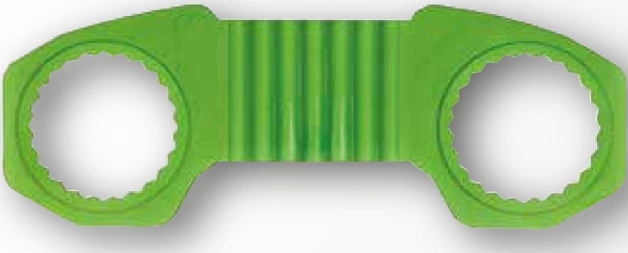

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## 3.1 Introduction

The tyres fitted to buses are subject to two basic sets of compliance regulations.

> The first set of compliance regulations is the Australian Design Rules (ADR's), which are national regulations and applicable to all States and Territories.

> The second set of regulations include:

- State based regulations controlled by the Road Authorities in each State for buses
- National based regulations controlled by the National Vehicle Regulator (NHVR) for buses over 4.5t GVM.[19]

The NHVR introduced a new set of vehicle laws under the Heavy Vehicle National Laws (HVNL). This Section discusses the issues within the national vehicle laws that relate to tyres.

## 3.2 Australian Design Rules (ADR)

The ADR's detail the requirements for bus tyres in Vehicle Standard (ADR 42/04 – General Safety Requirements) 2005. The key issues in regards to tyres and this ADR are:

- that new tyres must meet either Australian Standard 2230-1990 "Pneumatic Tyres Light Truck and Truck/ Bus-New" or a number of internationally recognised standards and or regulations (noting that these are listed in the ADR)
- that manufacturers only fit tyres that meet the vehicles rated GVM limits at a maximum cold tyre pressure of 825 kPa for radial Ply tyres.[20]

## 3.3 Heavy Vehicle National Law (HVNL)

The NHVR was established to administer one set of laws for heavy vehicles over 4.5t GVM under the HVNL.

The HVNL and supporting regulations commenced in the Australian Capital Territory, New South Wales, Queensland, South Australia, Tasmania and Victoria on 10 February 2014. The Northern Territory and Western Australia have not signed up to the HVNL at the time of publication of this Advisory.

19 National based regulations exclude Western Australia and the Northern Territory that continue to operate under State based regulations. State based regulations apply for buses less than 4.5t GVM for all other States.
20 Vehicle Standard, Australian Design Rule 42/04, "General Safety Requirements", Clause 25.1.2

## 3.4 National Regulations for Bus Tyres

Under the NHVR, the overriding document that sets the regulations and standards for heavy vehicles is the Heavy Vehicle (Vehicle Standards) National Regulation 2014 (National Regulations). Part 2 General Safety Requirements,[21] sets out a range of requirements for bus tyres. The following summarises the NHVR requirements, specifically in relation to bus tyres.

> Tyre Size and Capacity

Section 23 of the National Regulations[22] states that all buses must:

- be fitted with tyres that have sufficient size and capacity to carry the gross mass of the bus.
- ensure that the tyres capacity is determined at the cold tyre inflation pressures.

Furthermore, the National Regulations set the maximum cold tyre pressure at 825 kPa for a radial tyre, or a maximum pressure of 120 PSI.

Note: See Definitions for the conversion of kPa to PSI.

> Tyre Suitability

Section 26 of the National Regulations[23] states that all buses must have a rated speed that is either at least 100 km/hr or one that matches the buses' maximum speed.

> Tyre Retreading

Section 27 of the National Regulations[24] states that all buses must only use retreads that comply with AS 1973-1993 'Pneumatic Tyres—Passenger Car, Light, Truck and Truck/Bus—Retreading and Repair Processes'.

> Tyre treads

Section 28 of the National Regulations[25] states that all buses must:

- have a tread depth of at least 1.5 mm deep and across at least 75% of the tyre width
- not be fitted with tyres that have been regrooved or treated by recutting unless the tyre was constructed to allow these practices and that the tyre is labelled "Regroovable".

21 Heavy Vehicle National Law Act 2012 Heavy Vehicle (Vehicle Standards) National Regulation, February 2014 Reprint, page 26
22 Heavy Vehicle National Law Act 2012 Heavy Vehicle (Vehicle Standards) National Regulation, February 2014, page 37
23 Heavy Vehicle National Law Act 2012 Heavy Vehicle (Vehicle Standards) National Regulation Current as at 10 February 2014, page 38
24 ^ibid
25 Heavy Vehicle National Law Act 2012 Heavy Vehicle (Vehicle Standards) National Regulation Current as at 10 February 2014, page 39

## *Example of Tread Wear Indicators*

The Tread Wear Indicators are located in the tread groove and are used to show when the tread depth is at its wear limit.


## *Example of Tread Wear*

The two outer tyres are at their wear limits, whereas the centre tyre is well beyond the legal tread depth limit of 1.5 mm.

## 3.5 Increased Mass Limits and its Effect on Tyres

In recent years a number of the States have gazetted increased mass limits on both two and three axle buses and coaches. This has been welcomed by the bus and coach industry as these new limits reflect the increased loads being experienced by bus operators due to the increased per passenger mass (ie., the increasing average weight of the Australian population).

The increased mass limits vary across States and the BIC is working with the regulators in an attempt to address these variations, but from a tyre perspective the combination that most effects the tyre compliance are two axle buses operating up to 18 tonne.

As is allowed in Victoria, New South Wales and Western Australia, two axle buses can operate up to 18 tonne, but the individual axle limits are:

- front Axle up to 7 tonne
- rear Axle up to 12 tonne
- with a combined GVM limit of 18 tonne.

From a tyre perspective, the maximum load rating for the tyres in both the single tyre and dual tyre configuration needs to be reviewed to confirm that the tyres can meet the increased allowable axle limits.

The maximum tyre load limits shown in Table 3 are at the maximum Cold Inflation Pressure of 825 kPa or 120 PSI. Therefore operators need to consider the tyres load carrying capacity at the actual pressures they are going to use, noting that the tyres load carrying capacity varies according to the pressure used.

The tyre supplier would be able to provide the tyre loads for the specific tyre sizes and pressures as used by an operator. But operators can always check by referring to Section 2.5 which explains where and how load (and speed) capacity is marked on the sidewall of the tyre and also how to convert these numbers to a load capacity in kg.

Note: The rated speed for a tyre should also be considered to ensure that the tyres meet the maximum bus operating speed.

**Table 3: Maximum Tyre Load Limits at 825 kPa Cold Inflation Pressure**

| Tyre Size | Tyre Maximum Load rating in single tyre configuration (S) kg | Maximum Axle Mass Limit Single Tyre Configuration (Front Axle) kg | Tyre Maximum Load rating in dual tyre configuration (D) kg | Maximum Axle Mass Limit Dual Tyre Configuration (Rear Axle) kg |
|---|---|---|---|---|
| Maximum Allowable Axle Mass | | 7000 | | 12000 |
| 11R22.5 | 3000 | 6000 | 2725 | 10900 |
| 275/70R22.5 | 2900 | 5800 | 2650 | 10600 |
| 295/80R22.5 | 3450 | 6900 | 3150 | 12600 |

Note (1): The figures provided are at the maximum allowable cold inflation pressure of 825 kPa or 120 PSI.

Note (2): Individual tyre manufacturers have tyres that can vary from these maximums and therefore operators should consult their tyre supplier for the specific maximums.

Note (3): Operators can also refer to the Service Description Load Capacity and Speed Symbol code on the side of their tyres which provides the maximum load limits for the specific tyre, refer to the Section 2 on Tyre Sidewall Codes within this Advisory.

Note (4): A retreaded tyre, noting the retreading process is discussed in Section 4, retains the same load rating as when the tyre was new.[26]

Note (5): The maximum axle load capacity is the lesser of the axle, suspension or tyre rated capacities.

Source: The Tyre and Rim Association of Australia Standards Manual.[27]

26 Standards Australia, AS 1973-1993, "Pneumatic Tyres—Passenger Car, Light, Truck and Truck/Bus—Retreading and Repair Processes"

27 The Tyre and Rim Association of Australia Standards Manual 2014, B -17 and B – 19.

# Section 4

## TYRE RETREADING

# 4.1 Tyre Retreading Requirements under Australian Standards

As required by the NHVR, all buses must only use retreads that comply with AS 1973-1993 'Pneumatic Tyres—Passenger Car, Light, Truck and Truck/Bus—Retreading and Repair Processes'. To assist operators in checking the compliance of retreads in use, the following outlines the requirements of AS 1973-1993.[28]

## Inspection of Tyres Before Retreading or Repair

The Standards require that all retreads be thoroughly inspected internally and externally prior to any retreading occurring. In summary, these inspections need to include the following:

- tyres that have been treated with liquid puncture sealant, or other substances which impair the inspection process, shall be thoroughly cleaned out for visual inspection
- any existing repair shall be closely inspected
- tyres that show the following types of damage shall be rejected as being unsuitable for retreading or repairing:

    a. any tyres with damage which, after preparation, would be beyond accepted repair limits

    b. carcass break-up, or evidence that the tyre has been run in an underinflated condition

    c. carcass separation, except for separation restricted to a protective breaker

    d. oil or other chemical attack

    e. broken, exposed or kinked Bead wire bundle

    f. tread groove cracking or age rubber cracking extending into the carcass

    g. tyres that have been treated with liquid puncture sealant and which exhibit any penetration damage through the inner liner.

## All Retreads Must Be Suitably Marked

Retreads need to be marked with specific information and the required markings are detailed in this Section noting that some markings are required to be on one sidewall of the tyre, and other markings are required to be on both sidewalls of the tyre.

### *Example of excessive wear*

This tyre tread has excessive edge wear and is beyond its wear limit and therefore cannot be retreaded

### *Example of inspected tyre case*

This tyre case has been inspected and is ready for retreading, noting that the case shows no prior retread labels

28 Standards Australia, AS 1973-1993, "Pneumatic Tyres—Passenger Car, Light, Truck and Truck/Bus—Retreading and Repair Processes"

## *Example of Retread Labelling*

This tyre shows the correct labelling for 1 retread where the first letter of the original tyre manufacturer's name has been removed (ie. "B" in Bridgestone)


## *Example of Retread Labelling*

This tyre shows the correct labelling for 2 retreads with the progressive removal of the second letter of the original tyre manufacturer's name (ie. "R" in Bridgestone)


## *Suitable Retread Marking*

> **Marking Required on One Side of the Retread** – Each retreaded tyre shall bear on at least one side wall or shoulder the following marking:

- the nominal size of the tyre
- the word 'RADIAL' or 'R' in the size designation, for a radial Ply tyre
- the word 'TUBELESS' if applicable
- the maximum load rating, Ply rating, or service description for the tyre.

> **Marking Required on Both Sides of the Retread** – Each retreaded tyre shall bear on both side walls or shoulders the following marking:

- the word 'RETREAD' or 'REMOULD' if applicable.

> **Identification of the number of retreads** – The number of retreads or remoulds for bus tyres shall be indicated by either:

- the progressive removal of one letter of the original tyre manufacturer's name from one sidewall only of the tyre. If there are insufficient letters in the manufacturer's name, only then shall the letters be progressively removed from the other side of the tyre, or
- a clear indication (on the inside or outside of the tyre) of the total number of retreads.

> **Identification of the Retread Speed Limit** – For bus tyres, retreads if so designed can retain the original maximum speed limit and to avoid the adding of a new speed limit (as is required on light vehicle retreads). The retention of the original speed category on both side walls is sufficient to satisfy this requirement.

> **Method and position of marking** – All new marking (except for date code) on a retreaded tyre shall be in letters not less than 4 mm high, be permanently and legibly marked in the shoulder or upper side wall of the tyre, and be durable for the life of the retread.

- date coding shall be a digit week/year code
- branding with a hot iron is permitted.

> **Removal of Marking** – The following information shall be removed from the tyre during retreading:

- the word 'TUBELESS' if a tyre originally designated as tubeless has been converted to tube type
- the word 'REGROOVABLE' if the retread is not designed for regrooving.

> **Marking on Repaired Tyres** – Repaired tyres shall be marked as follows:

- all major repairs shall be marked, in a legible and permanent manner, with the identification of the repairer and the date on which the repair was carried out.

Note: Marking is not required for unreinforced repairs.

# 4.2 The Seven Steps in the Tyre Retreading Process

## Overview

Tyre Retreading is a manufacturing process and any retreaded tyre is only as good as the workmanship and the quality control in the plant that manufactured it. Therefore it is recommended that operators conduct a site visit of the Retreader or by other means, satisfy themselves that the Retreader is using appropriate processes and procedures during the course of retreading the tyres.

Although the retreading process varies according to the respective manufacturer's plant processes, the basic steps involved in the process are outlined in this Section.

| | |
|---|---|
| Step 1 | Casing Inspection involves the inspection of the tyre casing to ensure it can be retreaded. This is conducted by visual examination and by sonic testing. If the tyre does not pass this or the later inspection stages, it is considered to be Not Worth Retreading (NWR) and becomes a NWR casing. |
| Step 2 | Buffing. If the tyre passes inspection in Step 1, the old tread on the tyre casing is removed by buffing. |
| Step 3 | Casing Repairing – Any repairs required are performed on the tyre. |
| Step 4 | Casing Cement or Gum Application – A casing of rubber based cement or gum is applied to the buffed tyre case before the tread is applied. |
| Step 5 | Tread Application – fitting of new tread rubber to the tyre casing. |
| Step 6 | Curing – Bonding of the pre-cure tread to the tyre itself. |
| Step 7 | Final Inspection and Painting – The tyre is inspected and then painted after the QA process is complete. |

## Step 1 Casing Inspection

Tyre Inspection is conducted both by visual examination and by sonic testing. If the tyre does not pass this or the later inspection stages, it is considered to be NWR or not Worth Retreading.

## Step 2 Buffing

Once past inspection, the old tread on the tyre casing is removed by buffing leaving a smooth surface.

## Step 3 Casing Repairing

Any repairs required are performed on the tyre. In this case, a puncture under the treat is being repaired.

## Step 4 Casing Cement or Gum Application

Gum is being applied to the tyre casing prior to the fitting of the new retread.

## *Step 5 Tread Application*


The new tread is being fitted to the tyre casing prior to curing.

## *Step 6 Curing*

Prior to curing, the tyre is fitted inside an elastic envelope that is sealed to the tyre bead area to ensure a good bond between the new tread and the casing.

The tyre is then placed in an autoclave-type device that applies heat and pressure, and over time, causes the bonding layer in the built tyre to cure; permanently adhering the new tread to the prepared casing.

### *Step 6 Continued Curing*

Once the curing process has taken place, the outer envelope is removed.

### *Step 7 Final Inspection and Painting*

The tyre casing is fitted with a new retread and once the tyre successfully passes inspection and the QA process, the tyre is painted.

# The Process

The following seven retreading steps are typical processes used within the retread Industry. When reviewing these steps, it should be noted that each plant and supplier uses their own respective processes, procedures and level of automation.

## Step 1 Casing Inspection

The inspection of the tyre case is to determine whether the used tyre is retreadable as presented. If not, the Retreader will make recommendations as to the condition of the used tyre. The first inspection process should determine:

- whether the case can be retreaded as presented and is in accordance with the Standards
- whether the tyre case can be effectively repaired and then retreaded
- whether the tyre case is scrap or Not Worth Retreading (NWR).

Normally NWR tyres are returned to the operator for review and signoff, or if this is not the case, the operator should have some process in place to confirm the condition of the NWR's.

Due to the economic and safety implications of the initial inspection process, the Retreader's Tyre Inspector(s) should be skilled and trained workers. Apart from using skilled staff, the inspection process may also use electronic, ultrasonic, or other automated inspection equipment.

## Step 2 Casing Repairing

The repair person's role is to make structural repairs to damaged areas of the tyre casing so that the casing will last through a new tread life. The case repairing area should:

- be a separate and clean area with good lighting
- include wall charts showing procedures, patch usage, cure times and the Retreader's recommendations and procedures which must be followed
- include repair materials that have current manufacture date codes or expiration date codes
- purchase all repair materials, cements, and supplies from the same manufacturer. It is a questionable practice to mix brands since not all products are compatible
- ensure that the Retreader identifies the repairs undertaken (Retread plant name and date of repair)
- ensure that a high RPM grinder is used for grinding steel
- ensure that a low speed grinder is used on rubber. Use of a higher RPM grinding tool would scorch the rubber, reducing adhesion. (Gummy rubber build-up on buffing rasp and smoke generated at the buffed surface are indications of scorching).

## Step 3 Buffing

The buffing operation is used to size, shape, and texturise the crown of the casing in preparation for the application of a new tread:

- all casings are buffed to pre-determined crown widths and radiuses, as well as a range of specific dimensions used by the Retreader
- buffers are typically computer or template controlled
- all exposed cords (fabric or steel) are "finished" to remove all fuzz and frayed ends
- all exposed cords (fabric or steel) are coated with cement or other similar treatment promptly after completion of the buffing process. Steel cords are typically coated within 15 minutes
- all untexturised areas such as tread grooves and irregular wear spots are hand-treated to remove oxidation and surface dirt.

## Step 4 After Buff Preparation

Items listed in this category include a number of interim steps between the major operations of buffing and tread application. Depending upon individual retread plant procedures, these steps might be performed individually or as part of the repairing, buffing, or tread application steps:

- an after-buff inspection is performed to ensure the buffing process has not uncovered any previously unnoticed defects
- all holes, cuts, and penetrations are probed to determine the severity of the injury and to ensure that all foreign material has been removed
- all dirt, rust, and foreign material must be removed; all separated and/or laminated rubber must be removed leaving a clean, solid surface for the filler material to adhere
- tyres are measured for proper mould fit or tread length in the case of some pre-cure methods
- cement is used to enhance the adhesion between the new tread and the prepared casing.

## Step 5 Tread Application

Tread application is the fitting of new tread rubber (which will become the tyre's new tread) onto the prepared casing. This rubber is sized to a specific width and thickness. The tread is then applied to the casing with the following considerations:

- all exposed cord (fabric or steel) are covered with cushion gum before the tread rubber is applied
- there are typically no more than two splices per tyre for pre-cure treads
- with pre-cure tread application, "stitching" is performed in such a way as to eliminate trapped air pockets
- adhesive surfaces of tread rubber and cushion, and the buffed surface of the tyre, are kept free of contamination from hands and other sources.
- The cured tread rubber, with the tread design already formed, is applied to the tyre with a thin layer of uncured cushion gum on its base to serve as an adhesive.

## Step 6 Curing

Curing finalises the bonding of the new tread to the tyre case and involves three critical elements of time, temperature and pressure. Retreaders control these factors to an optimum level to maximise tread adhesion, tread and casing life.

During the curing process, the tread rubber is placed in a heated, pressurised chamber where the cushion gum is cured to both the tread rubber and the casing, forming the bond between the two. It is essential that:

- all envelopes, diaphragms, and curing tubes need to be leak free
- tyres are stored in such a manner as to avoid distortion of the tread and/or casing before curing and immediately after.

## Step 7 Final Inspection & Finish

After curing, a final inspection is made of the finished retread. At this time, the finished tyre may be trimmed of rubber flashing or overflow, painted, and tagged for delivery. During this process:

- the inspection area should be well lighted
- the tyre should be inspected on a spreader
- tyres are typically inspected immediately after completion of the cure cycle, while still hot; separations and other flaws that are visible while hot but may disappear as the tyre cools
- the inside of the tyre is inspected to ensure that all patches are properly bonded and that no bubbles, dimples, or buckles are evident in the patch or tyre liner
- the outside of the tyre is inspected for appearance
- all staples are removed from pre-cure tread splices and wicking material
- checks are made to ensure that the correct codes and or markings are on the sidewall of the tyres
- finished retreads are painted and all crayon marks painted over to give the final product an appealing appearance.

# Section 5

## TYRE FLEET COSTS AND EVALUATING THE OPTIONS

# 5. Tyre Fleet Costs

Tyres are not only critical to the safety and reliability of a bus, or fleet of buses, tyres also form a significant portion of the operating costs. A study by the World Bank[29] found that for the variable costs (or costs per distance travelled) for transit buses, fuel makes up 20 – 30% of these costs, lubricating oil 1 – 5%, spare parts 5 – 10% and tyres 5 – 10%.

In relation to local tyre costs there is not a lot of published Australian data, but the Los Angeles County Metropolitan Transportation Authority contracts out both the supply of their tyres and all tyre related maintenance for their 2,524 strong transit bus fleet.[30] This fleet travels around 105 million miles per year[31] and they have a contracted annual tyre cost of USD$6,985,550 for FY11.[32] This equates to a cost of approximately AUS$0.04 cents per km per bus.

This is similar to what may be expected for the complete tyre costs for Australian city bus operators, where typical costs would be around 5 to 6 cents per bus km depending on the operating environment and what tyre management practices are used.[33]

As tyre costs are a significant part of a buses operating cost, operators need to put in place appropriate tyre management and maintenance practices if they are going to minimise these costs.

Note these figures exclude the additional operational costs associated with excessive tyre failures, issues such as on-road breakdowns or reduced bus availability or increased downtime.

## 5.1 Full Life Tyre Costs

The cost of tyres is not solely based on the purchase price of the new tyre or even the cost of the retread. The costs associated with the full life cycle of the tyre needs to be considered when purchasing tyres and when determining what type of tyre management processes an operator is going to utilise.

There are a range of factors that need to be included when considering the full life cycle costs of a tyre. Table 4 shows the basic full life cost of a tyre. Table 5 shows a simplified analysis of the cost in cents per km over the life of the tyre during its various life cycles.

The following list assumes that new tyres are fitted to the front axle and retreads are used on the rear axles except when new tyres need to be run out on the rear of the bus due to tread wear patterns.

> The initial purchase price of the new tyre.

> The life of the tread on the new tyre.

> The new tyre tread wear patterns, what tyre rotation practices need to be in place to optimise the new tread life? Can the tyre live its full new tread life on the front axle of the bus or does it wear in such a way that it needs to be rotated to the rear axle?

> Does the NWR or failure rates for the tyre cases and or the susceptibility of the case to be damaged by things like impacts with gutters need to be considered?

> The likely cost of casing repairs?

> The likely frequency of on-road failures and the real costs of these failures?

> The life of the tyre case, how many times is it able to be successfully retreaded; typically cases may be retreaded two and possibly three times.

> The cost of the retread itself?

> The tread life of the retread on the specific tyre casing type?

> The disposal costs of the tyres (this is more associated with the supplier more so than the type of tyre used).

A range of other factors effect the full life tyre costs and some aspects have a larger effect on the costs than others.

It is recommended that Operators use the following tyre management practices:

- only new tyres be used on the steer axle
- retreads be used on the rear axle or axles
- tyres be retreaded up to two times
- consider tyre disposal costs incurred
- use one rotation cycle per new tyre set; that is the front tyres are rotated left to right during their tread life.

It is recommended by only fitting new tyres on the steer axles, the potential for tyre failures on this axle are significantly reduced. When new tyres are fitted to the steer axle, the cases from the removed steer axle tyres are then utilised as casing stock which can be retreaded 2 or 3 times and fitted to rear axles. Therefore there is no real increased tyre costs.

29 Measuring Road Transport Performance, World Bank Annex 1, available from: http://www.worldbank.org/transport/roads/rdt_docs/annex1.pdf, first viewed 19 September 2015

30 The Goodyear Tire And Rubber Company, Operations Committee July 15,2010 Contract No. Op31202523, "Bus Tyre Leasing & Maintenance Services", available from: http://media.metro.net/board/Items/2010/07_july/20100715OPItem8.pdf, first viewed 19 September 2015

31 Los Angeles County Metropolitan Transportation Authority, Transit Operations, John Roberts Deputy Executive Officer, Operations April 29, 2009, available from: http://caltransit.org/cta/assets/File/Webinar 20Elements/Terminal 20Inspection-Roberts.pdf, first viewed 19 September 2015

32 The Goodyear Tire And Rubber Company, Operations Committee July 15,2010 Contract No. Op31202523, "Bus Tyre Leasing & Maintenance Services", available from: http://media.metro.net/board/Items/2010/07_july/20100715OPItem8.pdf, first viewed 19 September 2015

33 Based on the authors experience.

**Table 4: Basic Full Life Tyre Cost**

| Tyre Life Stages | Cost / Longevity |
|---|---|
| New tyre | $600 per tyre |
| Retread | $250 per retread |
| Casing Repair | $50 per repair |
| Casing Disposal | $20 per disposal |
| New tyre tread life | 65,000 km |
| Retreaded tyre tread life | 45,000 km |

These estimates assume one repair in the life of the case and that tyre mounting and demounting costs are considered to be the same regardless.

Note: The per tyre costs equate to a cost of around 5 cents per bus km for a two axle bus, given the assumptions listed in Table 4.

As demonstrated in the simple analysis shown in Table 5, Cycle 1 or the new tyre life cycle has the highest cost per km for the tyre, whereas Cycle 2 and Cycle 3 have a reduced cost per km. This is based on two retreads per case and obviously if a tyre case cannot be successfully retreaded twice, then the lifecycle cost for that individual tyre would increase dramatically.

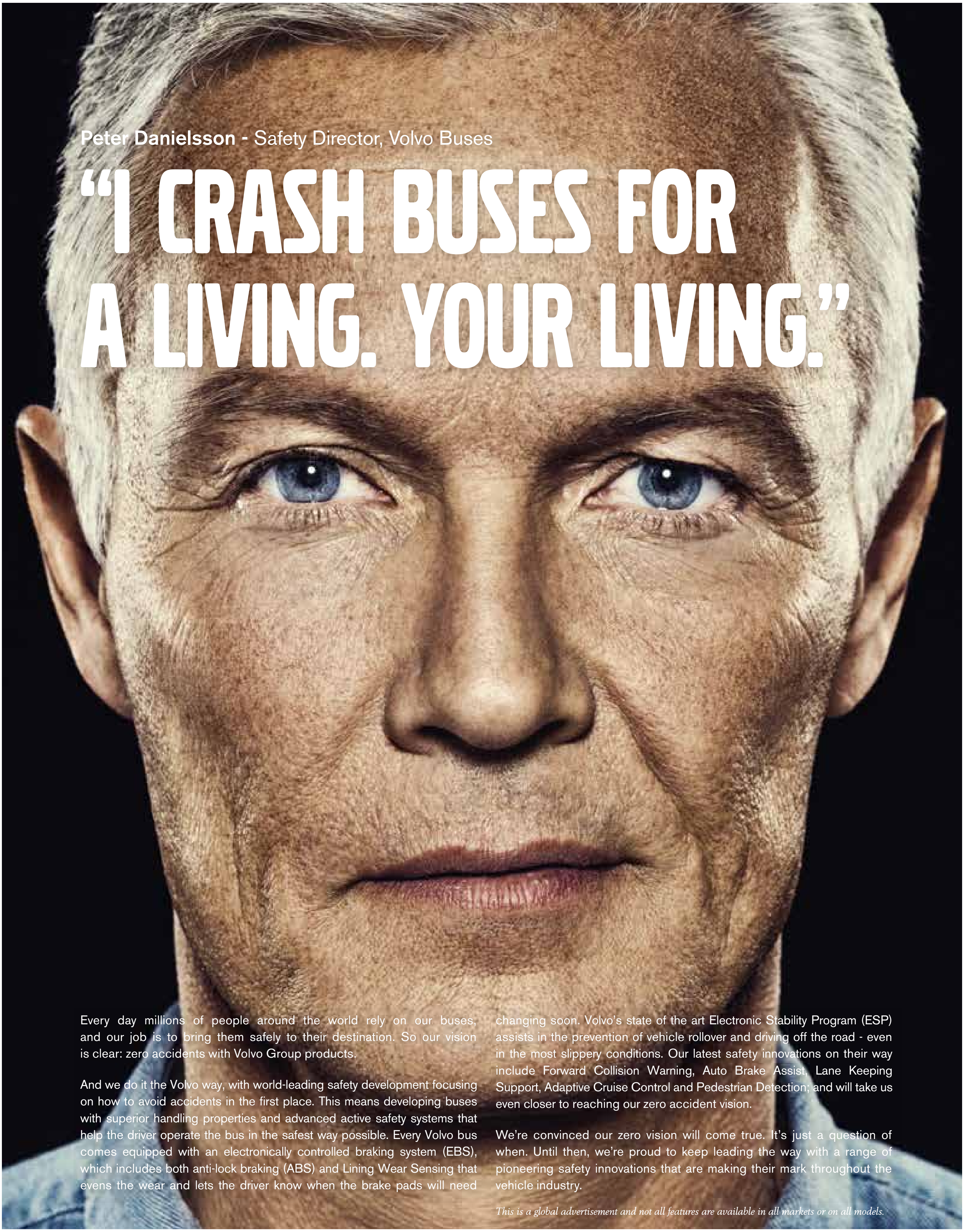
If an operator had a situation where their new tyres were continually failing the second retreading (Cycle 3), then additional new tyre stock would need to be purchased and the total tyre costs would increase.

A situation such as this may have a larger impact on fleet tyre costs than any significant variations in the new tyre price; a cheaper new tyre that has only limited retreadability may have a higher full life cost than a more expensive tyre that has a more reliable and durable casing.

**Table 5: Cycle Full Life Tyre Cost**

| Tyre Life Cycle Sequence | New Tyre Cost ($) | New tyre Rotation Cost ($) | New Tread Life (Km's) | Retread Cost ($) | Casing Repair ($) | Casing disposal Cost ($) | Retread Tread Life (Km's) | Cost per km tyre life Sequence (Cents per Km) |
|---|---|---|---|---|---|---|---|---|
| Cycle 1 New Tyre Life | 600 | 100 | 65,000 | | | | | 1.08 |
| Cycle 2 Retread Number 1 | | | | 250 | | | 45,000 | 0.56 |
| Cycle 3 Retread Number 2 | | | | 250 | 50 | 20 | 45,000 | 0.71 |

It is recommended that operators consider the full life tyre costs and possibly negotiate full life tyre supply arrangements or contracts with tyre suppliers.


Peter Danielsson - Safety Director, Volvo Buses
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Every day millions of people around the world rely on our buses, and our job is to bring them safely to their destination. So our vision is clear: zero accidents with Volvo Group products.
And we do it the Volvo way, with world-leading safety development focusing on how to avoid accidents in the first place. This means developing buses with superior handling properties and advanced active safety systems that help the driver operate the bus in the safest way possible. Every Volvo bus comes equipped with an electronically controlled braking system (EBS), which includes both anti-lock braking (ABS) and Lining Wear Sensing that evens the wear and lets the driver know when the brake pads will need changing soon. Volvo's state of the art Electronic Stability Program (ESP) assists in the prevention of vehicle rollover and driving off the road - even in the most slippery conditions. Our latest safety innovations on their way include Forward Collision Warning, Auto Brake Assist, Lane Keeping Support, Adaptive Cruise Control and Pedestrian Detection; and will take us even closer to reaching our zero accident vision.
We're convinced our zero vision will come true. It's just a question of when. Until then, we're proud to keep leading the way with a range of pioneering safety innovations that are making their mark throughout the vehicle industry.
This is a global advertisement and not all features are available in all markets or on all models.

## 5.2 Tyres – Buy or Lease

It is not unusual for transit bus operators in the United States to lease their tyres and tyre maintenance services.[34] These leasing agreements can include all aspects of tyre management from new tyre and retread supply through to pressure maintenance, on bus mounting and rotation and tyre casing disposal.[35]

Both leasing and buying have advantages and disadvantages. Regardless of the choice, it is crucial to first choose tyres and a tyre manufacturer that will provide the best overall support and also offer the most cost effective and reliable solution. The operator needs to determine the total cost of ownership and decide which option fits best to lower tyre costs whilst meeting their reliability expectations.

## The Buy Option

With complete control of the tyres fitted on its buses, buying tyres offers the greatest degree of freedom for the operator to develop and direct their own tyre management and maintenance program. The operator owns the tyres outright as soon as the invoice is paid, hence there are no restrictions on how the tyres are used and no requirements in terms of documentation, declaration of distances travelled or other administrative processes that can form part of a leasing arrangement.

Buying also alleviates any discomfort over feeling locked into a lease agreement. Purchasing offers the financial benefit of the company's ability to leverage its purchasing power when it comes time to buy tyres. Drawing from a positive cash flow may be the best option, since the unit price per tyre may be lower than that of leasing. With a well-maintained fleet buying can also significantly reduce the overall cost per km over the full life of the tyre.

## The Lease Option

There are several financial advantages to leasing tyres. The first relates to cash flow. Under a leasing arrangement, operators only pay for the accumulated kilometres on the tyres. Leasing requires no initial outlay or expenditure for the new tyre stock. This absence of upfront costs is often the most significant draw to leasing. Buses earn revenue as they operate and under a well negotiated lease, the operator pays for the tyres based on activity or distance operated. This makes the costs of tyres and tyre maintenance more predictable, while reducing the financial risk of potential fluctuations in tyre costs.

There are financial disadvantages to leasing. Firstly, as the manufacturer carries the capital cost of the supplied tyre stock, the final cost for each tyre may be higher than an outright purchase. However, the ability to "pay as you go" is often more attractive and helpful, despite the potential for a slightly higher overall per-tyre cost.

Another issue is that the operator does not own either the on-bus or off-bus tyre stock. Therefore it can be difficult to switch from a lease program back to purchasing without the significant upfront expense of purchasing the on and off-bus stock. Conversely there are also potential issues when entering into the lease as the operator owns their existing tyres and the value of this capital asset needs to be recognised at the start of the lease. Also the value of this asset needs to be maintained throughout the term of the respective lease arrangement (that is the lease provider needs to maintain the on and off-bus tyre stock to an agreed standard so that the capital value is retained).

Aside from the direct financial aspects, other areas to consider include reliability, service and maintenance. The leasing agreement may be strictly for the use of the tyres, or it can include partial or full service and maintenance. Opting for a third-party partner to control and maintain a bus fleet's tyres may improve an operator's situation, but conversely a contractor who performs poorly could generate both short and long term issues for an operator.

34 Osborne, M, Bus Ride Magazine, available from: http://busridemaintenance.com/2011/05/tire-program-options-come-down-to-two-choices, first viewed 19 September 2015

35 The Goodyear Tire And Rubber Company, Operations Committee July 15,2010 Contract No. Op31202523, "Bus Tyre Leasing & Maintenance Services", available from: http://media.metro.net/board/Items/2010/07_july/20100715OPItem8.pdf, first viewed 19 September 2015

# Section 6

# REDUCING THE FULL LIFE COST OF TYRES AND MAINTENANCE GUIDELINES

# 6 Factors that Effect Tread Wear which Effect Cost

The factors that effect tyre costs are many and varied, but the most obvious is tread life. The longer the tyre tread lasts, the way the tread wears and performs over its life, have a major effect on tyre cost. This Section reviews the vehicle specific factors that effect tread life and tyre maintenance practices and its effect on tread life and tyre costs.

## 6.1 Vehicle Alignment

Bus front and rear axle alignment has a major effect on tyre tread wear as well as the handling and safety of the bus or fleet of buses. A bus that is correctly set up and aligned will be much easier on its tyres than a bus that is incorrectly set up and/or out of alignment. This Advisory reviews the main areas of vehicle alignment including:

- front end toe
- camber
- caster
- rear Axle Alignment.

### Front End Toe

Front End Toe is in effect a measure of how straight the front steer tyres are pointing in relation to the bus and each other. If the tyres were perfectly straight, or the toe was zero, the distance between the two front tyres would be the same. In order for this to be the case, the transverse distance between the front of the left front tyre and front of the right front tyre would be the same as the transverse distance between the rear of the left front tyre and rear of the right front tyre, as viewed from the top of the bus.

> Toe-in exists when the transverse distance is less at the front of the tyres than at the rear of the tyres or the tyres are closer together at the front than at the rear, as shown in Figure 4.[36]

The purpose of toe-in is to relieve or counteract some of the force which pulls wheels outward as they roll along the road. Proper toe-in will ensure that the rotation direction and the direction of travel are as similar as possible at driving speed. Insufficient toe-in settings will result in steering instability.

Excessive toe-in results in feather wear in the direction shown by the arrows in Figure 4 and this type of wear is depicted in Figure 6.

> Toe-out exists when transverse distance is more at the front of the tyres than at the rear of the tyres or the tyres are further apart at the front than at the rear, as shown in Figure 5.

36 Figures 4 to 10 sourced from The Goodyear Tire and Rubber Company, "Radial Truck Tyre And Retread Service Manual 700-862-932-505 000000" 10/04, available from: https://www.goodyeartrucktires.com/pdf/resources/service-manual/retread_all_v.pdf, first viewed 19 September 2015

Excessive toe-out results in feather wear in the direction shown by the arrows or would be in the opposite direction than is given in Figure 5. Incorrect toe settings generally have the greatest effect on bus tyre wear and toe is the easiest adjustment to make on the front axle of a bus.

The typical range for toe for a bus ranges from 0 mm/m to 1.5 mm/m where the mm/m is a measure of how far the tyre would move sideways for each metre that it travels in the forward direction. For example, a front end toe measurement of 1.5mm/m, the tyre moves 1.5mm off line for every 1 metre of forward travel.

**Figure 4: Toe-In on a front steer axle.**

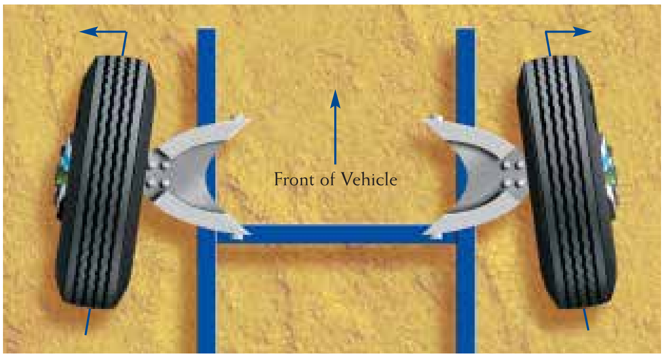



**Figure 5: Toe-Out on a front steer axle.**

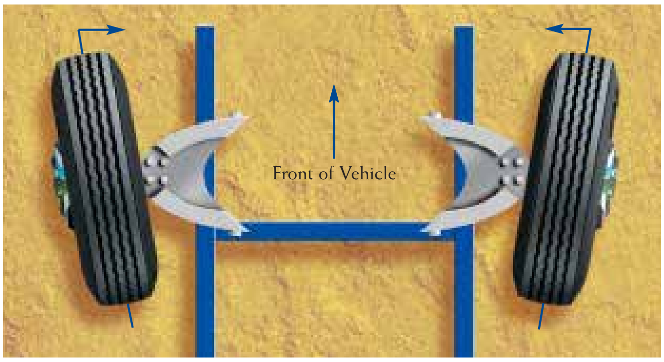
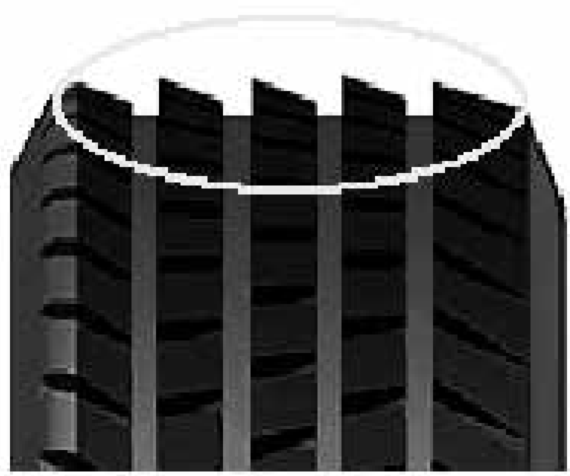



**Figure 6: Tyre Feather Wear for a Toe-in Situation**



## Camber

Camber is the tilt of the tyres as seen in a front view of the bus. Positive camber exists when the front tyres are closer together at the bottom (point of road contact) as shown in Figure 7. Negative camber exists when the tyres are closer together at the top, as shown in Figure 8.

In the past, manufacturers have set various limits for camber, some manufacturers set a small amount of positive camber on the left hand side to offset the downward slope of the road surface and zero for the right hand side as the right hand side tyre is normally travelling near the centre or crown of the road surface. Some manufacturers specify zero camber on both front wheels.

Typical camber settings for the steer axle are therefore:

- for the left-hand side +0.6° to +1.5° to help to overcome road camber effect
- for the right-hand side 0° to – 0.6°.Excessive Camber will cause one side of the tread to wear at an accelerated rate, as shown in Figure 10.

**Figure 7: Positive Camber**

**Figure 8: Negative Camber**

Figure 9: Camber Angles

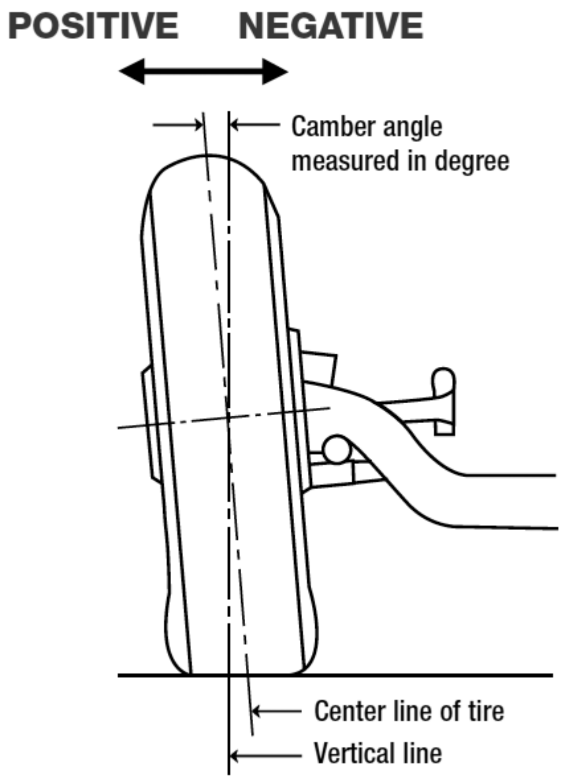



Figure 10: Tread Wear Due to Excessive Camber

## Caster

Caster is the condition where the king pin is inclined with the top of the pin angled rearward similar to the front forks of a bicycle. Caster angle is meant to compensate for the resistance which the tyre(s) encounters as a result of drag forces against the road. Caster angle should be the same, or nearly the same, for both wheels on a given axle or the result will be vibration and abnormal tyre wear. Note: Some manufacturers have slightly more caster on the left-hand side which induces a slight right hand turn to offset the effect of the road camber.

However, caster is not considered to have a major effect on tyre wear, but is important in the handling and driveability of the vehicle. Overall effects of caster can be summarised as follows:

Too little caster can cause:

- unstable steering
- constant corrections required
- wander and weave
- oversteer
- failure to return to straight ahead out of a turn.

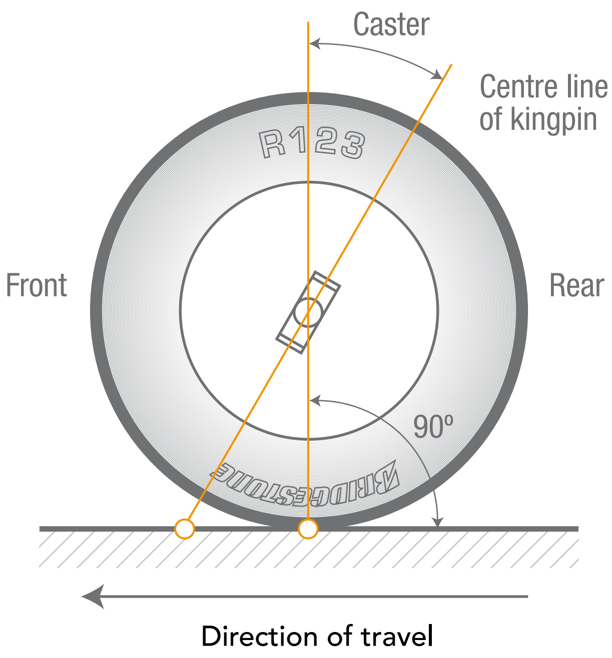
Too much caster causes:

- hard steering
- road shock.

Vehicle manufacturers normally recommend caster settings for their vehicles. Proper caster gives best handling in combination with the camber and king pin inclination designed into the axle.

Positive caster is provided by a backward (rotational) tilt of the top of the axle or backward inclination of the kingpin at the top as shown in a side view of the truck in Figure 11. The purpose of this is to provide a degree of self-centring for the steering plus it provides directional stability.

**Figure 11: Positive Caster on the Front Axle of a Bus**




Source: Bandag Tread Data Guide [37]

37 Bandag Manufacturing Pty Ltd, "Bandag Tread Data Guide", 10/2010, available from: http://www.bandag.com.au/lib/pdf/mf277.pdf, first viewed 19 September 2015

## Rear Axle Alignment

Drive axle alignment is very important for overall tyre wear.

To explain this, if we consider a tandem axle set up on a bus or truck and the effect that the rear axle alignment has and then consider this for a bus with a single rear axle.

Tandem drive axles that are not parallel to each other have a definite effect on steer-tyre wear.

Figure 12[38] shows a model of a tandem drive-axle with both drive axles in proper alignment. In this case, the driver steers the bus straight ahead and neither fast wear nor irregular wear would be expected as a result of the rear axles.

Figure 13 shows a model of a tandem drive-axle where neither drive axles are neither parallel to each other nor perpendicular to the chassis centreline. The drive-axle tyres are trying to force the vehicle to turn left and the driver must compensate by turning to the right. This will result in fast and irregular wear.

Figure 14 is an exaggerated view of a tandem drive-axle setup with drive axles parallel, but not perpendicular, to the chassis centreline. The eight driving tyres create a "thrust angle" to the left at the rear of the bus and to compensate, on a flat non-cambered road surface, the steering wheel would need to be turned slightly to the left.

However, on a typical road with a camber, or slope towards the left hand side gutter, having the rear axles set up in the same manner as shown in Figure 14 (or for a single rear axle, just having the one axle set to the left) in effect helps push the front axle of the bus up the slope or camber of the road. Some manufacturers recommend 1 to 2 mm/m to the left for the rear axles. This is done to reduce front axle tyre wear.

Figure 12: Aligned Rear Axles

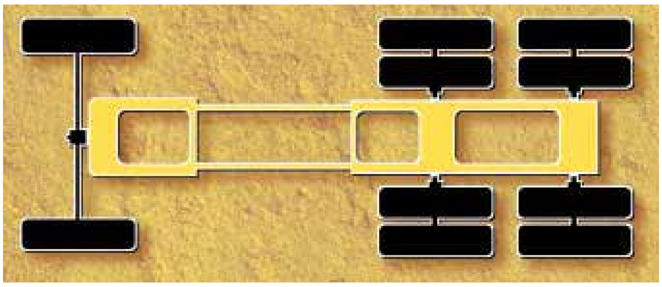


Figure 13: Incorrect Rear Axle Alignment

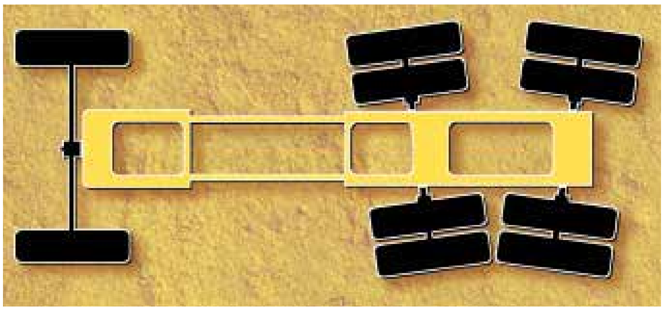
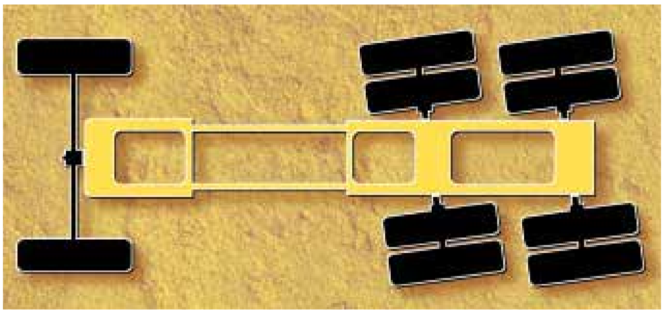


Figure 14: Exaggerated View of the Rear Axles Parallel but Turned to the Left



38 Figures 12 to 14 sourced from The Goodyear Tire and Rubber Company, "Radial Truck Tyre And Retread Service Manual 700-862-932-505 000000" 10/04, available from: https://www.goodyeartrucktires.com/pdf/resources/service-manual/retread_all_v.pdf, first viewed 19 September 2015

# 6.2 Tyre Pressure Maintenance

The single most critical maintenance activity in relation to bus tyres is pressure maintenance. The pressure within a tyre effects its load carrying capacity, its stability and handling characteristics, and its rolling resistance, all of these factors are key in its operational life.

The load carrying capability of a tyre is critically linked to the inflation pressure. Bus operators will generally select a particular "target pressure" for their fleet based on the unique load, operating, and environmental conditions in which they operate. These target pressures can and in most cases, should differ for the front and rear axle and also across bus tyre sizes.

If not properly inflated, the useful tyre life, as well as vehicle handling and safety, are compromised. Improper tyre inflation increases operating costs by reducing tyre life and lowering fuel economy (an underinflated tyre "flexes" and has higher rolling resistance). A 15 psi drop in bus tyre pressure will increase rolling resistance by 6% resulting in increased fuel usage.[39]

Tyres lose air pressure for a variety of reasons. Air can escape between the Bead and wheel, as well as through improperly tightened valves, torn rubber grommets, or valve cores that have been blocked open by dirt. Additionally, air molecules are small enough to diffuse through rubber (albeit very slowly), and an air pressure drop of up to 2psi per month is not uncommon.[40]

According to a report on Heavy Vehicle Efficiency[41] more than 80% of tyre problems are caused by under-inflation and could be eliminated through better tyre maintenance, especially proper tyre inflation. Under-inflation not only reduces the durability of tyres but also increases rolling resistance.

As shown in Figure 15, over inflated tyres make contact with the pavement in the centre portion of the tyre tread only, leading to braking and traction problems and accelerated wear on the centre tread area. This can occur on the rear dual tyres of a bus that is, for example, running most of its time in a semi-loaded condition and although the tyre pressures may be set for the maximum loaded condition, the tyres may be over inflated in relation to the actual average load being carried.

Under inflated tyres run on their edges; the two outer edges of the tyre tread face. Apart from reduced performace, overheating and potential overloading due to the lower pressures, under inflated tyres show accelterated wear on the outer tread edges.

Properly inflated tyres have full contact with the pavement and show even wear across the tread face.

Tyre inflation pressure should be checked on a regular basis and the fleet should have a structured tyre maintenance program. Tyres lose pressure for a variety of reasons such as:

- punctures and cuts
- loss of inflation through the tyre body, between the bead and wheel as well as through improperly tightened valves
- damaged rubber grommets
- valve cores that have been blocked open by dirt, or other debris.

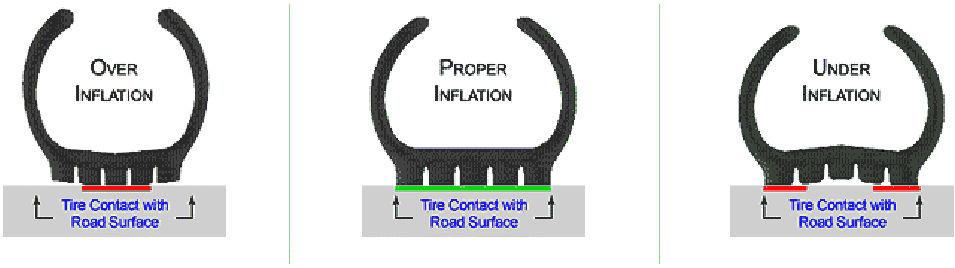
Most tyre companies recommend that tyres are checked with a calibrated pressure gauge for correct inflation pressure once a week in addition to the pre and post trip tyre checks by drivers. If this is not possible due to the fleet's operation, tyre checks should be scheduled as often as possible.

### *Example of a tyre operated under pressure*

This tyre shows excessive outer tyre wear. The outer tread is also scalloped which may indicate that the tyre was also out of balance or the bus had a lack of shock absorber control.

39 Winkler, C. B. and P. S. Fancher, Eds. (2000). Mechanics of Heavy Duty Truck Systems – Course Notes. Mechanics of Heavy Duty Truck Systems. Ann Arbor, University of Michigan.
40 Commercial Vehicle Safety Technologies: Applications For Tyre Pressure Monitoring And Management Booz Allen Hamilton Inc. United States Of America Paper Number 09-0134
41 Putz, M. (2003). "Air Apparent." Heavy Duty Trucking 83(1): 58-59.

**Figure 15: Typical tread Contact Patterns for Various Inflation States – Over, Under and Proper Inflation**




Source: The Ranger Station[42]

# What is the Correct Tyre Pressure

Determining what the correct tyre pressures are for a particular bus operation is not a simple process and operators will generally select a particular target pressure for their vehicles based on the unique loads, speeds and environmental conditions in which they operate. Typically the front tyres have a higher target pressure than the rear or drive tyres and the optimum target pressures are developed over time based mainly on tyre wear patterns.

The target pressure is also based on the following:

- the average and peak load being carried by a bus or coach, noting that the peak or maximum load may only occur for short periods of time each day for a route bus, whereas a coach may operate fully loaded for extended periods
- the maximum load being carried is critical as the ability of the tyre to carry load reduces as the tyre pressures reduce, see the example in Table 6. The target pressure needs to consider the load carrying capacity for the particular tyres being used
- operating speeds, typically the higher the speed the higher the target pressures need to be
- location of the tyre on the vehicle, typically steer tyres operate a higher pressure than drive tyres
- frequency of tyre pressure checks.

For example a two axle rigid route bus operating on 295/80R22.5 tyres may run a higher Target Pressure of 800 kPa (or 115 psi) on the front tyres. This higher pressure is used due to the weight, turning and braking loads being imposed on the front tyres, whereas the rear tyres may run at 650 kPa (or 95 psi). The lower target pressure on the rear tyres is used to better represent the actual loads being carried by the rear tyre set and hence to avoid uneven tyre wear, for example to avoid accelerated wear on the centre of the tyres.

**Table 6: Example of Load Carrying Capacity Compared to Target Pressure**[43]

| Tyre Size | Location* | | Tyre Loads in kg at Various Cold Inflation Pressures kPa (PSI) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 550 (80) | 600 (87) | 650 (95) | 700 (100) | 725 (105) | 750 (108) | 775 (112) | 800 (116) | 825 (120) |
| 295/80R22.5 | S | 2510 | 2690 | 2860 | 3040 | 3125 | 3220 | 3300 | 3350 | 3450 |
| 295/80R22.5 | D | 2280 | 2450 | 2600 | 2770 | 2840 | 2930 | 3000 | 3040 | 3150 |

* Note: Tyre in a Single (S) or Dual (D) Location

42 The Ranger Station, available from: http://www.therangerstation.com/Magazine/winter2011/tire/tire_diagram.GIF, first viewed 19 September 2015
43 The Tyre and Rim Association of Australia – Standards Manual – 2014, B-17

# 6.3 Tyre and Rim Mounting

There are potential safety issues in relation to mounting tyres to rims and then inflating tyres and when fitting wheel assemblies to buses. The following outlines the key safety related issues and also refers to operator alerts from Roads and Maritime Services (RMS) in New South Wales, Transport Safety Victoria, Workcover New South Wales and the Australian Tyre Industry Council Ltd.

## Fitting and Inflating Tyres

When fitting tyres to rims it is recommended that consideration be given to the wheel assembly as a "pressure vessel" and therefore has the potential for explosion with the consequent risk of serious injury if best practice procedures are not followed.

During tyre fitting the main hazards are as follows:[44]

- components of multi-piece wheels failing under pressure and being propelled away from the wheel assembly with considerable force
- tyre failure due to a hidden defect, incorrect fitting or unsatisfactory repair. In this case an explosion occurs with the possibility of injury by the air blast and/or the violent reactions of the whole assembly
- failure of the wheel under pressure resulting in the hazards outlined above.

The Australian Tyre Industry Council Ltd issued a safety bulletin and this has been reproduced in Appendix B. The bulletin provides advice on tyre inspection before mounting, inflation steps, use of safety cages and also highlights the issues associated with the split of multi-piece rims (noting that the use of multi-piece rims is no longer common in the bus industry, however if they are used and they fail during inflation, the results can be catastrophic).

The hazards associated with split rims are also highlighted on the WorkCover New South Wales web page.[45]

## Fitting Rims to Buses

When fitting wheel assemblies to buses, there is a real risk of the wheels dislodging from the axles if either the fitting process is not undertaken correctly or the wheel assemblies and nuts are not checked regularly.

Incidents of buses loosing wheels in both New South Wales[46] and Victoria,[47] are referred to in Appendix C containing two separate safety alerts that highlight the safety issues in relation to fitting wheel assemblies to buses.

The key issues being:

- operators must ensure that all wheel assemblies are fitted in accordance with the chassis manufacturer's instructions
- either visual indicators or products that arrest or inhibit slackening of wheel nuts be used
- drivers conduct visual checking of wheel nuts in pre-departure checks.

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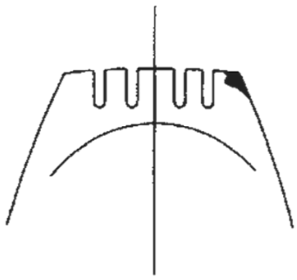
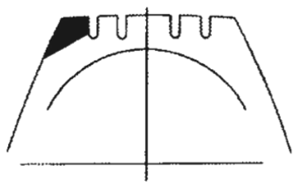
44 Australian Tyre Industry Council Ltd, Advisory Bulletin 3, Correct Procedures for the Safe fitting and inflation of Truck Tyres, 12 September 2014

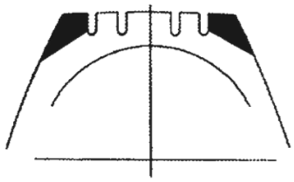
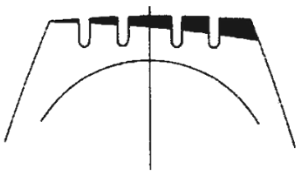
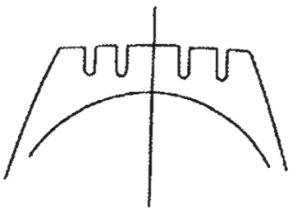
45 For hazards associated with split rims, visit the WorkCover NSW web page: http://www.workcover.nsw.gov.au/health-and-safety/safety-topics-a-z/split-rim-wheels

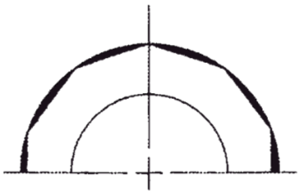
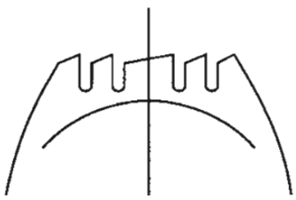
46 OTSI reports Investigation-Report-Hunter-Valley-Buses-Wheel-Off and 141022_STA_Macquarie Park_Wheel off_final_150526

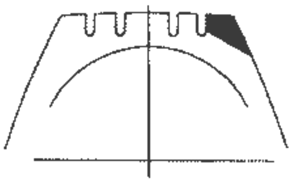
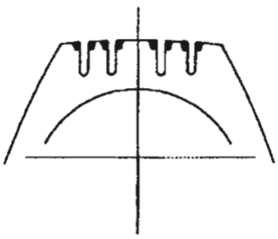
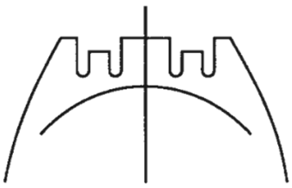
47 Transport Safety Victoria, SA. No. 2013 – 01, Notice To Bus Operators Transport Safety Victoria "Risk-of-wheels-dislodging-from-axles", 11 April 2013

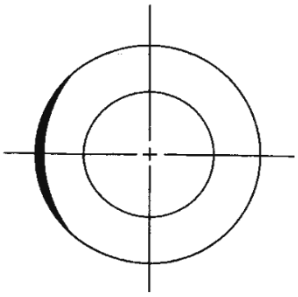
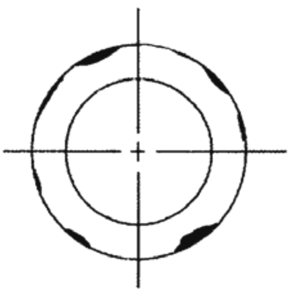
# 6.4 Troubleshooting Tyre Maintenance Guide

| Irregular Wear Condition/Description | Identifying Root Causes | Actions to Correct |
|---|---|---|
| **Shoulder Step/ Chamfer Wear**  | Typical radial tyre wear in slow-wearing applications. | Leave tyre in service unless wear becomes more pronounced.<br>Tyre rotation (side to side).<br>Rotate to the drive axle, if feasible.<br>Flip the tyre on the wheel rim. |
| | Tread design or service application. | Verify tyre selected matches the usage it will normally encounter (e.g., regional or city bus tyre). |
| **Full Shoulder Wear**  | Side scrub caused by improper toe condition. | Verify total vehicle alignment, including rear axle if necessary.<br>Depending on severity of the wear,rotate to another position or remove for retreading. |
| | Damaged and/or improperly maintained steering/suspension components. | Inspect steering and suspension components for worn or damaged parts; replace as necessary.<br>Ensure all steering and suspension component fasteners are torqued to the value specified by the vehicle manufacturer.<br>Verify air suspension ride height is correct.<br>Ensure proper vehicle preventive maintenance. |
| | Improperly seated tyre beads. | If bead appears to be improperly seated and irregular wear is minimal, deflate tyre, rotate tyre 180 degrees on rim, re-lubricate and re-inflate tyre. Re-check for correct bead seating<br>If wear is excessive rotate to drive axle (if possible) or remove for retread.<br>Diagnose and review tyre/wheel installation procedures. |

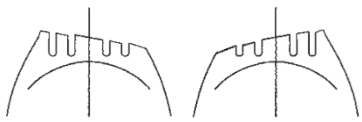
| Irregular Wear Condition/Description | Identifying Root Causes | Actions to Correct |
|---|---|---|
| **Rapid Shoulder Wear - Both Shoulders**  | Over inflation. | Verify proper inflation pressure for load carried. |
| | Incorrect rim width. | Verify proper rim width with tyre manufacturer.<br><br>If wear is excessive, rotate to trailer position depending on severity of wear.<br><br>If necessary, remove for retreading. |
| **One-Sided Wear**  | Improper alignment. | Verify total vehicle alignment.<br><br>Determine wheel end camber angle. Incorrect camber can cause smooth wear extending from the shoulder towards the centre of the tread. Correction of steer axle camber on solid axles is not recommended by most axle manufacturers but independent front suspensions may be adjustable. Consult the axle manufacturer for guidance if excessive positive or negative camber is found to be causing tyre wear. |
| | Worn kingpins or improper bearing adjustment. | Inspect kingpin for excessive play and verify wheel bearings are adjusted properly; replace as necessary. |
| | Excessive axle loads. | Verify proper inflation pressure for load carried. |
| **Overall Fast Wear**  | Severe Service Conditions, frequency and severity of turning, abrasive road surfaces in combination with vehicle configuration. | Review operational environment to which the tyre is exposed.<br><br>Review fleet vehicle specifications for service application. |
| | Tyre misapplication. | Verify tyre selected matches the usage it will normally encounter. |
| | Aggressive driving habits. | Evaluate driver habits and incorporate appropriate training. |

| Irregular Wear Condition/Description | Identifying Root Causes | Actions to Correct |
|---|---|---|
| **Cupping/Scallop (Shoulder Wavy) Wear**  | Assembly out of balance. | Inspect for proper bead seating of the tyre on the rim.<br><br>If wear is minimal, deflate tyre, rotate tyre 180 degrees on rim, re-lubricate and re-inflate tyre. Check for improved balance.<br><br>If wear is excessive rotate to drive axle (if possible) or remove for re- tread.<br><br>Diagnose and review mounting practices to prevent future occurrences. |
| | Non concentric mounting, assembly non-uniformity or assembly out of round. | Inspect for proper bead seating of the tyre on the rim.<br><br>If bead appears to be improperly seated and irregular wear is minimal, deflate tyre, rotate tyre 180 degrees on rim, re-lubricate and re-inflate tyre. Re-check for correct bead seating.<br><br>If wear is excessive rotate to drive axle (if possible) or remove for retread.<br><br>Diagnose and review tyre/wheel installation procedures. |
| | Lack of shock absorber control. | Inspect for damaged or worn shock including upper and lower bushings; replace as necessary. |
| | Under inflation. | Verify proper inflation pressure for load carried. |
| **Feather Wear**  | Excessive side force scrubbing as a result of conditions of misalignment; primarily excessive toe and drive axle misalignment. | Verify total vehicle alignment. |
| | Worn, damaged or missing suspension components. | Inspect steering and suspension components for worn or damaged parts; replace as necessary.<br><br>Ensure all steering and suspension component fasteners are torqued to the value specified by the vehicle manufacturer. |

| Irregular Wear Condition/Description | Identifying Root Causes | Actions to Correct |
|---|---|---|
| **Feather Wear cont.** | Bent tie rod or other chassis misalignment. | Review vehicle maintenance records for history of major accidents and body or frame repairs or corrections. |
| | Dry fifth wheel. | Review preventive maintenance procedures to include appropriate fifth wheel greasing frequency. |
| **Scrub/Thrust-Induced Full Shoulder Wear**  | Drive axle misalignment. | Verify total vehicle alignment. Depending on severity of the wear, rotate to another position or remove for retreading. |
| **Erosion/River Wear**  | Slow rate of radial tyre wear on free rolling axle in a line haul operations with light loads and infrequent turning. | Tyres with erosion/river wear should be left in service and not be of a concern. These slow wear rates lead to a small amount of erosion of the edge of the tread rib which is accepted as normal for today's radial tyre. |
| | Individual tyre design and construction. | Select a steer tyre which has been de-signed for the vehicle type and conditions it will regularly see. |
| **Rib Depression/Punch Wear**  | Low inflation pressure. | Verify proper inflation pressure for load carried. Ensure routine inflation pressure maintenance is part of preventive maintenance program. |
| | High speed and light loads. | Rotate, or if necessary remove for retreading. |
| | Improper bead seating. | Inspect for proper bead seating of the tyre on the rim. |
| | Assembly out of balance. | Verify proper tyre balance of the worn tyre and ensure tyre balance procedures are followed. |
| | Improper bearing adjustment. | Verify wheel bearings are adjusted properly. |
| | Lack of shock absorber control. | Inspect for damaged or worn shock; replace as necessary. |

| Irregular Wear Condition/Description | Identifying Root Causes | Actions to Correct |
|---|---|---|
| **Out-of-Round Wear**<br> | Excessive radial run out. | Diagnose tyre mounting visually and with metal ruler for mounting concentricity; measure total tyre/wheel run out with dial indicator.<br><br>If tyre is not seated properly on the rim, and out of round wear is minimal, rotate tyre 180 degrees on rim, re-lubricate and re-inflate tyre. Check for improved bead seating and lower overall assembly run out.<br><br>If vibration or ride disturbance is an issue, eliminate other possible conditions such as alignment, fifth wheel placement, excessive component tolerances such as wheel/rim run out, inflation pressure and wheel damage.<br><br>Verify re-seated tyre has improved ride complaint.<br><br>If wear is excessive, rotate to drive axle or remove for retreading. |
| | Non-uniformity of rotating assembly. | Inspect for proper bead seating of the tyre on the rim.<br><br>Inspect and verify hub and stud circle for damage or non-uniformity.<br><br>Inspect for improper seating of the brake drum and or disk on the hub.<br><br>Inspect for broken, distorted or non- uniform brake drums.<br><br>Rotate, or if necessary remove for retreading. |
| **Spot Wear**<br> | Lack of shock absorber control. | Inspect for damaged or worn shock; replace as necessary. |
| | Improper bead seating. | Inspect for proper bead seating of the tyre on the rim. |
| | Loose wheel bearing. | Verify wheel bearings are adjusted properly. |
| | Assembly out of balance. | Verify proper balance of the worn tyre and ensure tyre balance procedures are followed for all other tyres. |



| Irregular Wear Condition/Description | Identifying Root Causes | Actions to Correct |
|---|---|---|
| **Spot Wear cont.** | Improper Inflation Pressure. | Verify proper inflation pressure for load carried.<br><br>Ensure routine inflation pressure maintenance is part of preventive maintenance program. |
| | Aggravated by high speed and light loads. | Review vehicle routing to minimize very light load mileage, if possible.<br><br>Verify proper inflation pressure for load carried. |
| **Toe-in Wear**<br><br>**Left** **Right** | Improper alignment specifically excess toe-in. | Verify total vehicle alignment.<br><br>Depending on severity of the wear, rotate to another position or remove for retreading. |
| **Toe-Out Wear**<br><br>**Left** **Right** | Improper alignment – specifically toe out. | Verify total vehicle alignment.<br><br>Depending on severity of the wear, rotate to another position or remove for retreading. |
| | Aggravated by improperwheel bearing adjustment and/or worn steering components. | Verify wheel bearings are adjusted properly.<br><br>Inspect steering components for worn or damaged parts; replace as necessary.<br><br>Verify correct steering arm angle for vehicle wheelbase if vehicle has undergone extensive steering or chassis rework. |
| | Improper selection of steering arms to matchvehiclewheel-base. | ReviewOEspecificationsforpropersteering arm selection. |

# 6.5 Waste Regulations for Tyres

## Managing waste tyres

Tyres that are used, rejected or unwanted are classified as waste tyres and need to be managed responsibly. This includes shredded tyres or tyre pieces. Tyres that are retreaded, or intended to be used for retreading or recycling must also be managed as waste tyres.

## Environmental

Illegal dumping of tyres is unsightly. It contributes to the destruction of native bushland and community open spaces.

Check where your waste is going, keep information about who transported your waste. Retain records about where your waste is disposed or processed (such as dockets or receipts from the waste facility).

Each State has its own legislation and requirements for tyre disposal, operators should check what the requirements are within their respective State, for example:

> In New South Wales under the Protection of the Environment Operations Act 1997 (POEO Act) to accept waste tyres for storage, processing or disposal, the company needs to be fully registered. The register is available at www.epa.nsw.gov.au/publicregister.

> In Western Australia, the storage, handling, transportation and disposal of used tyres are specifically controlled under the following Western Australian legislation:

- Environmental Protection Regulations 1987 (Part 6, Schedule 1 and Schedule 5) – storage, handling, transportation and disposal
- Environmental Protection (Controlled Waste) Regulations 2004 – transport
- Both the Environmental Protection Act 1986 and the Waste Avoidance and Resource Recovery Act 2007 have provisions that can be relevant to the control of used tyre waste. http://www.der.wa.gov.au/our-work/controlled-waste/137-fact-sheets

## Keep written records

The common theme across all States is that accurate written records need to be kept to prove that your waste tyres were taken to a lawful place. As a minimum, for tyre disposal, operators should record and retain the following information:

- Details of the organisation that transported your waste tyres including:
  a. Company name
  b. ABN
  c. Vehicle registration
  d. Driver details
- Date and time of transport
- Quantity of tyres
- The facility where your waste tyres are disposed or processed:
  a. Name of the waste facility
  b. Address of the waste facility
  c. ABN
  d. Contact person (name and phone number)
  e. Environment protection licence number (if required)
  f. Details about the development consent (if required)

Keep written statements from your waste transporter and the waste facility (such as a letter identifying where your waste tyres are disposed or processed).

# Annexures

# Appendix A Load Index Chart

| Load index | Kg | Load index | Kg | Load index | Kg | Load index | Kg | Load index | Kg |
|---|---|---|---|---|---|---|---|---|---|
| 51 | 195 | 87 | 545 | 123 | 1550 | 159 | 4375 | 195 | 12150 |
| 52 | 200 | 88 | 560 | 124 | 1600 | 160 | 4500 | 196 | 12500 |
| 53 | 206 | 89 | 580 | 125 | 1650 | 161 | 4625 | 197 | 12850 |
| 54 | 212 | 90 | 600 | 126 | 1700 | 162 | 4750 | 198 | 13200 |
| 55 | 218 | 91 | 615 | 127 | 1750 | 163 | 4875 | 199 | 13600 |
| 56 | 224 | 92 | 630 | 128 | 1800 | 164 | 5000 | 200 | 14000 |
| 57 | 230 | 93 | 650 | 129 | 1850 | 165 | 5150 | 201 | 14500 |
| 58 | 236 | 94 | 670 | 130 | 1900 | 166 | 5300 | 202 | 15000 |
| 59 | 243 | 95 | 690 | 131 | 1950 | 167 | 5450 | 203 | 15500 |
| 60 | 250 | 96 | 710 | 132 | 200 | 168 | 5600 | 204 | 16000 |
| 61 | 257 | 97 | 730 | 133 | 2060 | 169 | 5800 | 205 | 16500 |
| 62 | 265 | 98 | 750 | 134 | 2120 | 173 | 6000 | 206 | 17000 |
| 63 | 272 | 99 | 775 | 135 | 2180 | 171 | 6150 | 207 | 17500 |
| 64 | 280 | 100 | 800 | 136 | 2240 | 172 | 6300 | 208 | 18000 |
| 65 | 290 | 101 | 825 | 137 | 2300 | 173 | 6500 | 209 | 18500 |
| 66 | 300 | 102 | 850 | 138 | 2360 | 174 | 6700 | 210 | 19000 |
| 67 | 307 | 103 | 875 | 139 | 2430 | 175 | 6900 | 211 | 19500 |
| 68 | 315 | 104 | 900 | 140 | 2500 | 176 | 7100 | 212 | 20000 |
| 69 | 325 | 105 | 925 | 141 | 2575 | 177 | 7300 | 213 | 20600 |
| 70 | 335 | 106 | 950 | 142 | 2650 | 178 | 7500 | 214 | 21200 |
| 71 | 345 | 107 | 975 | 143 | 5725 | 179 | 7750 | 215 | 21800 |
| 72 | 355 | 108 | 1000 | 144 | 2800 | 180 | 8000 | 216 | 22400 |
| 73 | 365 | 109 | 1030 | 145 | 2900 | 181 | 8250 | 217 | 23000 |
| 74 | 375 | 110 | 1060 | 146 | 3000 | 182 | 8500 | 218 | 23600 |
| 75 | 387 | 111 | 1090 | 147 | 3075 | 183 | 8750 | 219 | 24300 |
| 76 | 400 | 112 | 1120 | 148 | 3150 | 184 | 9000 | 220 | 25000 |
| 77 | 412 | 113 | 1150 | 149 | 3250 | 185 | 9250 | 221 | 25750 |
| 78 | 425 | 114 | 1180 | 150 | 3350 | 186 | 9500 | 222 | 26500 |
| 79 | 437 | 115 | 1215 | 151 | 3450 | 187 | 9750 | 223 | 27250 |
| 80 | 450 | 116 | 1250 | 152 | 3550 | 188 | 10000 | 224 | 28000 |
| 81 | 462 | 117 | 1285 | 153 | 3650 | 189 | 10300 | 225 | 29000 |
| 82 | 475 | 118 | 1320 | 154 | 3750 | 190 | 10600 | 226 | 30000 |
| 83 | 487 | 119 | 1360 | 155 | 3875 | 191 | 10900 | 227 | 30750 |
| 84 | 500 | 120 | 1400 | 156 | 4000 | 192 | 11200 | 228 | 31500 |
| 85 | 515 | 121 | 1450 | 157 | 4125 | 193 | 11500 | 229 | 32500 |
| 86 | 530 | 122 | 1500 | 158 | 4250 | 194 | 11800 | 230 | 33500 |

Source: United Nations, Agreement, Regulation No. 109[48]

48 United Nations, Agreement, Regulation No. 109, Rev.2/Add.108/Rev.1 (June 2010), "Uniform Provisions Concerning The Approval For The Production Of Retreaded Pneumatic Tyres For Commercial Vehicles And Their Trailers", Annex 4

# Appendix B – Correct Procedures for the Safe fitting and inflation of Truck Tyres[49]

ATIC
AUSTRALIAN TYRE INDUSTRY COUNCIL LTD

**ADVISORY BULLETIN**

| NUMBER | ISSUED | VERSION | PAGE |
|---|---|---|---|
| 3 | 12/09/14 | 1.0 | 1 OF 3 |

## Correct Procedures for the Safe fitting and inflation of Truck Tyres

### The purpose of this bulletin is to remind you of the importance of good safety procedures during tyre fitting.

A tyre and wheel assembly must be considered as a "pressure vessel" and as such has the potential for explosion with consequent risk of serious injury if best practice procedures are not followed.

During tyre fitting the main hazards are as follows:

1. Components of multi-piece wheels failing under pressure and being propelled away from the wheel assembly with considerable force.
2. Tyre failure due to a hidden defect, incorrect fitting or unsatisfactory repair. In this case an explosion occurs with the possibility of injury by the air blast and/or the violent reactions of the whole assembly.
3. Failure of the wheel under pressure resulting in the hazards outlined above.

In all cases the air will escape in an area that resembles a cone based at the wheel assembly. It is essential that any person involved with the assembly is kept out of this area.

Of these main hazards the first is most widely appreciated and use of safety devices guards against danger. The greatest single cause of injuries sustained in tyre fitting is the second hazard listed above and the worst injuries result when the failure of the tyre occurs on the side of the tyre nearest the floor or wall resulting in the wheel assembly being propelled in an upward or sideways direction.

### Approaches to guard against hazards

#### 1 Multi-piece wheels

Whilst improved design particularly of locking rings has lessened the dangers it is still necessary to check the following.

a) that correct matching components are being used.

b) That rim nave flanges and locking rings are clean and free from rust, burrs or distortion. Particular attention must be made to ensure that the locking ring and channel into which it is secured are scrupulously clean. Repainting with protective paint should be considered but ensure that there is only a thin coat on surfaces mating with other wheels or brake drums.

#### 2 Single piece wheels

A full inspection of the complete wheel needs to be carried out, looking for any signs of cracks or excessive corrosion. Any cracked wheels should be discarded and no attempt made to be repair by welding. Such a weld will inevitably fail under the stresses imposed on the wheel in service. Alloy rim flanges in particular should be checked for wear as a worn flange might not adequately retain the bead under inflation. Rim manufacturers can supply a simple gauge to be used for this purpose.

#### 3 Tyre examination

This is a subject within itself and to be thorough a great deal of training and experience has to be called upon. The list below of items to check is by no means exhaustive, but is suggested as the basis to a common sense approach.

**This Bulletin should be considered as being of a general advisory nature only. In case of conflict with existing recommendations issued by a vehicle manufacturer, these latter recommendations should apply.**

49 Australian Tyre Industry Council Ltd, Advisory Bulletin 3, "Correct Procedures for the Safe fitting and inflation of Truck Tyres", 12 September 2014

## ADVISORY BULLETIN



**Tyres**

Cuts in tread and/or sidewall?
Damage or distortion in the bead?
Sidewall bulges or distortion?
Penetration by foreign object (nail etc.)
Casing creasing?
Oil and fuel contamination?
Condition of repairs?
Is the tyre clean inside & completely free from contaminants?

**Tubes**

Is it the correct size & type?
Creases?
Old tubes thinning in some areas?
Condition of repairs?
Rust, grit, foreign matter on tube?

**Flaps**

Is it the correct size?
Oil contamination?
Rust & foreign matter?
Creases and/or edges distorted?
It is good general advice that a new tyre deserves a new tube and flap

It is good general advice that a new tyre deserves a new tube and flap. As with wheels, all the above components require the utmost cleanliness.
After looking at the hazards and checks to be made during fitting we now need to consider the same for inflation.
The general practice is to use upright safety cages in a workshop and a portable safety cage for site or roadside service.
Both types are effective in restraining locking rings and flanges provided the device is of suitable strength and design.

The amount of protection afforded from the results of a tyre burst is less than satisfactory. In the case of an upright safety cage the blast from a burst in the sidewall away from the wall has been known to injure persons standing up to 3 metres away in the path of the shock wave. A burst on the side wall of the tyre adjacent to the wall has been known to tear the cage from its fastenings. While a portable safety cage where the assembly is generally in a horizontal plane a burst in the lower sidewall of the tyre will throw the assembly violently upwards. Portable safety cages should therefore only be considered as effective protection against flying components and not a restraint in the event of a tyre burst, particularly if the burst occurs in the lower sidewall.

**This Bulletin should be considered as being of a general advisory nature only. In case of conflict with existing recommendations issued by a vehicle manufacturer, these latter recommendations should apply.**

## ADVISORY BULLETIN

**ADVICE ON INFLATING A TYRE**

Inflate to 15 to 20 psi and ensure that the moving parts of a multi piece assembly are correctly positioned by tapping the components lightly with a hammer. In all cases check that the distance between the fitting line above the bead and the top edge of the flange is equal for the full circumference of the tyre. If there is any doubt at all deflate the tyre and refit. DO NOT increase the pressure in the hope that anything not quite right will correct itself. Having reach 15-20 psi satisfactorily place the assembly in the inflation cage whilst inflating to the final pressure.

**Whatever type of restraining system is used the priority is to keep the operative and any other person in the vicinity away from the area where the blast may occur.**

**Do Not** lean over the assembly during inflation.
**Do Not** sit or stand near the assembly.
**Do** use a clip on chuck at the end of the airline and fit & use a press button hand control that is at least 3 metres from the chuck valve.

This should ensure that the operator is clear from any blast that may occur.

We must all endeavour to promote this advice anywhere that truck tyres are fitted as it is the duty of everyone to ensure the health and safety of everyone in the industry..

# Appendix C – Wheel Assembly Fitting Safety Bulletins from RMS[50] and Transport Safety Victoria[51]

NSW GOVERNMENT | Transport Roads & Maritime Services

## Information Alert 6/14

28 August 2014

Dear Operator

**SECURITY OF WHEELS ON BUSES**

**ISSUE:**

The Office of Transport Safety Investigation (OTSI) released technical inspection findings relating to a wheel being detached from a bus on 14 January 2014. The report referred to the examination of the circumstances of the incident which highlighted preventative measures of regular checking of wheel nut security.

There have been previous alerts to operators involving wheels detaching from buses. Roads and Maritime Services is concerned that some operators may not have the appropriate system in place to ensure wheel nuts on buses are tensioned correctly. It is imperative that drivers are educated in regards to the pre-departure and end of shift procedures adopted by operators, which includes the visual checking of wheel nuts.

It is recommended that operators become familiar with the OTSI investigation regarding the security of wheels on buses and the report that can be accessed via the internet at http://www.otsi.nsw.gov.au/bus/investigations.php

**NOTICE:**

OTSI has identified preventive measures to assist in the security of wheels on buses which may be of use to operators. OTSI advised that regular checking of wheel nut security in its most basic form involves the checking of nut tightness on a regular basis. All wheels should be tightened in accordance with the manufacturers' standards and instructions. When possible the checks should be performed with a torque wrench, without first slackening the wheel nuts. If a torque wrench is not available, as is often the case away from a workshop, frequent visual checks should be performed until one is available. Pre-trip visual checks of wheel nuts and studs by drivers should be routine. There are aftermarket products available that are intended to aid in the prevention of wheel loss. These fall into three basic groups:

1. Products which give a visual indication of nut movement.
2. Products that arrest slackening of wheel nuts.
3. Products that lock the wheel nuts so that they cannot move.

There is also at least one product that combines the characteristics of categories 1 and 2 above.

Roads and Maritime Services - Safety & Compliance, Accreditation

For further information contact: Scott Watson or Peter Parkes, Bus Safety Officers, Accreditation on 8849 2628

50 Information Alert 6/14 28 August 2014, SECURITY OF WHEELS ON BUSES, RMS NSW

51 Transport Safety Victoria, SA. No. 2013 – 01, Notice To Bus Operators Transport Safety Victoria "Risk-of-wheels-dislodging-from-axles", 11 April 2013

**REQUIRED ACTION:**
Bus Operators are to:

- ensure that mechanics or suitably trained persons are aware of and comply with Manufacturer's Standards and instructions when tightening wheel nuts; and

- ensure that all drivers include the visual checking of wheel nuts in pre-departure checks and end of shift checks.

Bus Operators are reminded that failure to maintain buses in accordance with the manufacturer's maintenance standards is classified as a *Safety Critical Deficiency.*

**Joanne Treacy**
**General Manager**
**Accreditation**

Roads and Maritime Services - Safety & Compliance, Accreditation

For further information contact: Scott Watson or Peter Parkes, Bus Safety Officers, Accreditation on 8849 2628

SA. No. 2013 - 01

# Safety Alert

TRANSPORT SAFETY VICTORIA

PO Box 2797, Melbourne, Vic, 3001
T 1800 223 022
E information@transportsafety.vic.gov.au
**Bus & Rail** F 03 9655 8929
**Maritime** F 03 9655 6611

## NOTICE TO BUS OPERATORS

Safety alerts are published by Transport Safety Victoria (TSV) under section 197 of the *Transport Integration Act 2010* (Vic) to promote the safe operation of transport services. Safety alerts are intended to provide information only and must be read in connection with obligations under relevant legislation.

### Subject

**Risk of wheels dislodging from axles.**

### Issue

In the past seven months TSV has received three bus incident notifications relating to dislodged wheels. Bus operators have reported that while their bus was in operation the dual wheels have completely dislodged from the left hand side of the drive axle.

In all instances the driver was not aware of any problem until a vibration was felt, followed shortly after by a thumping sound as the dislodged wheels struck the under body of the bus.

TSV has investigated each incident. However, it has not been possible to conclusively identify the cause.

TSV recommends that bus operators review their pre-trip inspection process and consider the use of engineering controls to reduce the risk of wheel nuts loosening.

The following wheel nut management systems may be of assistance:

- wheel nut indicators - provide a visual indication for a wheel nut that has loosened,
- wheel nut link retainers - link wheel nuts together reducing the risk of a wheel nut loosening.

For further information about this matter, and/or bus legislative requirements in Victoria, please contact Andrew Chlebica, Manager Compliance and Information, on (03) 9655 6873.

**THIS ADVICE IS EFFECTIVE IMMEDIATELY**

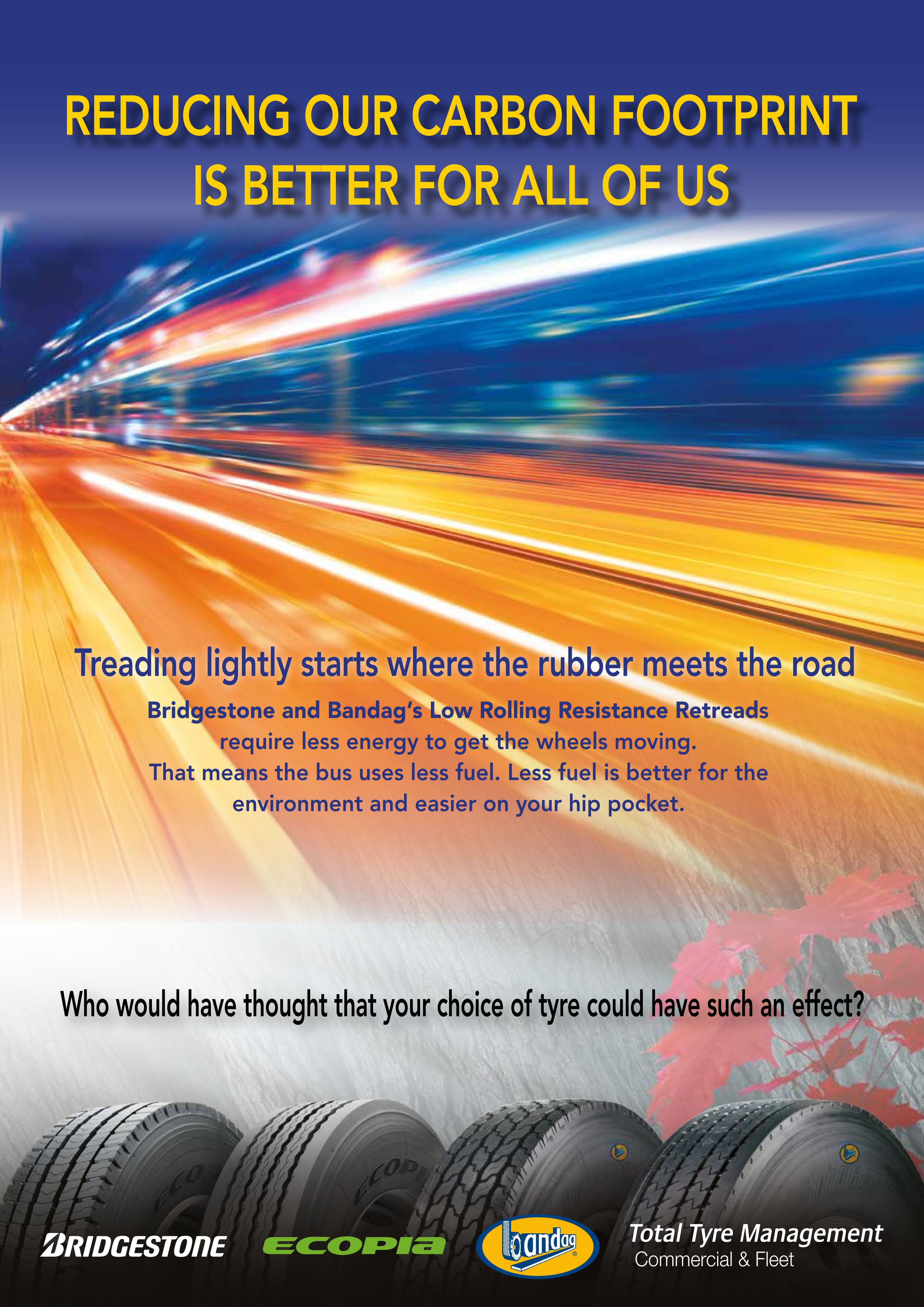
Approved:

**STEPEN TURNER**
Director, Bus Safety

Date: 11 April 2013

www.transportsafety.vic.gov.au

State Government Victoria


REDUCING OUR CARBON FOOTPRINT
IS BETTER FOR ALL OF US
Treading lightly starts where the rubber meets the road
Bridgestone and Bandag's Low Rolling Resistance Retreads
require less energy to get the wheels moving.
That means the bus uses less fuel. Less fuel is better for the
environment and easier on your hip pocket.
Who would have thought that your choice of tyre could have such an effect?
BRIDGESTONE
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bandag
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BUS INDUSTRY CONFEDERATION
PO Box 6171, KINGSTON ACT 2604

**Tel:** +61 2 6247 5990
**Fax:** +61 2 6273 1035

**Email:** enquiries@bic.asn.au
**Web:** www.ozebus.com.au

## Bus Australia Network

Industry Partner