GUIDELINE

Tyre safety for earth-moving machinery on Western Australian mining operations

MIAC

Government of **Western Australia**
Department of **Mines and Petroleum**
Resources Safety

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Contents

Guidelines

A guideline is an explanatory document that provides more information on the requirements of legislation, details good practice, and may explain means of compliance with standards prescribed in the legislation. The government, unions or employer groups may issue guidance material.

Compliance with guidelines is not mandatory but they could have legal standing if it were demonstrated that the guideline is the industry norm.

Who should use this guideline?

This guideline should be used by anyone engaged in mining operations in Western Australia who manages, operates or maintains a rubber-tyred heavy vehicle fleet.

Acknowledgement

This guideline was produced with the assistance of the Chamber of Minerals and Energy of Western Australia's Tyre Management Working Group and several tyre safety experts. Input was also received from industry and other Australian regulators during the public comment period.

Foreword

This guideline is issued by Resources Safety under the *Mines Safety and Inspection Act 1994*, and has been endorsed by the Mining Industry Advisory Committee.

The Act

The *Mines Safety and Inspection Act 1994* (the Act) sets objectives to promote and improve occupational safety and health standards within the minerals industry.

The Act sets out broad duties, and is supported by regulations, together with codes of practice and guidelines.

Regulations

The Mines Safety and Inspection Regulations 1995 (the regulations) provide more specific requirements for a range of activities. Like the Act, regulations are enforceable and breaches may result in prosecution, fines, or directions to cease operations and undertake remedial action.

Australian Standards

Compliance with Australian or international standards is not mandatory unless they are specifically cited in the Act or regulations.

Although specific versions of standards may apply under the regulations, references in this guideline are undated and it is good practice to consult the latest versions where applicable.

Application

Although aimed at off-the-road tyres (as defined in Australian Standard AS 4457) for earth-moving machinery, many of the principles may be extended to other rubber-tyred vehicles on mining operations, such as light vehicles and highway-type trucks.

1 Introduction

Working with off-the-road tyres for earth-moving machinery is potentially dangerous because of their large size and mass, magnitude of air or gas pressures, and presence of combustible materials. The uncontrolled release of stored energy can have serious, even fatal, consequences.

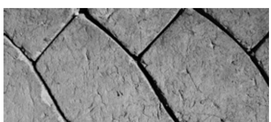
This guideline describes the common hazards when working with tyres, rims, wheels and assemblies on mining equipment. It provides guidance on safe systems of work in a mining environment, while allowing for flexibility in both process and documentation.

Operators should adopt a risk management approach to develop a documented tyre management plan that is current and specific to site, with appropriate controls to manage the risks. Four main elements should be considered:

- competent people — training, knowledge, experience, assessment, fitness-for-work
- safe systems of work — adequate procedures, information and instructions, record keeping
- fit-for-purpose equipment — safety-in-design, adequate capacity, well maintained
- a safe and controlled working environment — adequate workshop facilities and services.

The guideline is structured to describe the hazards and types of controls expected during the life cycle of an off-the-road tyre (and its rim or wheel assembly):

- tyre management plan and risk management (Chapter 2)
- nature of the hazards (Chapter 3)
- initial considerations and planning (Chapters 4 to 6)
- handling, fitting and maintaining tyres, rims and wheel assemblies on site (Chapters 7 to 9)
- fires, bursts and explosions in tyres in service (Chapter 10)
- other considerations (Chapters 11 to 13).



Appendices 1 and 2 provide information on applicable legislative provisions, standards and other guidance. Appendix 3 explains commonly used acronyms, while Appendix 4 overviews applicable high risk work licences. Appendix 5 contains examples of checklists to assist with record keeping.

Note: Unless otherwise specified, the terms "off-the-road" and "heavy" or "heavy vehicle" are implied when discussing tyres, rims and wheel assemblies in this guideline.

Note: In this guideline, the term "tyre assembly" refers to tyres, rims and wheel assemblies.

2 Tyre management plan and risk management

Tyre assemblies are safety-critical components that should be selected, operated and maintained correctly to reduce the risk of workers' exposure to associated hazards to as low as reasonably practicable.

A good tyre management plan clearly defines the selection, operation, maintenance and disposal (i.e. whole life cycle) of tyres, rims and wheel assemblies. The management of these items requires an integrated risk-based strategy from key departments on a mine, including management, production, maintenance, supply, occupational health and safety, and environment.

Taking a risk-based approach towards tyre management includes:

- identifying hazards
- examining information on tyre and rim failures (e.g. safety alerts)
- understanding the influence of the operational environment on tyre life and safetyassessing and selecting tyres, wheels or rims
- assessing and preparing storage and work areas
- selecting and implementing tyre-handling facilities, including plant, tools, equipment, and safe systems of work
- monitoring and implementing component inspection, maintenance and repair (e.g. non-destructive testing of wheel and rims)
- maintaining accurate record keeping
- understanding mechanisms of tyre fires and explosions
- providing appropriate emergency response capability
- ensuring people are competent for the tasks they are assigned.

The tyre management plan should provide those involved with tyres with an understanding of the mining operation's strategy for managing tyre assemblies and components, and their roles and responsibilities.

Appendix 5 contains sample checklists for the management of tyre assemblies that may assist with developing the management plan and record keeping.

Site-specific safe work procedures (SWPs) or safe work instruction (SWIs) should be developed by competent persons to support the tyre management plan. Changes to work conditions (e.g. inclement weather, new equipment) need to be addressed by work teams using a task-based risk assessment, such as a job safety analysis (JSA). If necessary, information from this process should be used to modify the SWP or SWI using the site's change management process.

Individual workers should also conduct appropriate personal risk assessments before commencing work.

3 Understanding the hazards

3.1 Potential scenarios

The hazards associated with tyres include:

- those related to handling and working with tyres, wheels and rims
- tyre fires, bursts and explosions when tyres are in service
- loss of control of vehicle due to tyre failure.

These hazards are dealt with separately in this guideline but care should be exercised to ensure that all scenarios are adequately risk assessed and managed within the operation's safety management system.

Major sources of risk when working with or using tyre assemblies include:

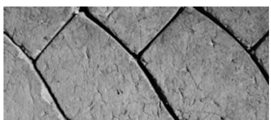
- sudden release of stored pressure energy — leading to projectiles (e.g. rim components, rocks) and percussive shock
- compressed air or other gases (e.g. nitrogen)
- noise
- handling heavy objects
- working with or operating heavy equipment
- heat and fire
- fuels and chemicals
- pyrolysis or diffusion — leading to explosions.

3.2 Compressed air

Compressed air poses a significant injury risk to workers, particularly to their eyes.

Appropriate personal protective equipment (PPE) should always be worn to protect workers from injury by high-velocity air jets, as well as particles of dust, metal, oil and other debris that can be mobilised by a high-velocity air stream.

Overalls and other PPE may protect the skin from light particles and debris. However, fabric does not offer protection



against high-velocity air at close range. Particles can be blown through overalls and skin to penetrate the body. Compressed air jets at close range can inject air into the body, causing swelling and pain. Air bubbles injected into the bloodstream can be carried to small blood vessels of the brain, lungs or heart, potentially causing a serious or even fatal embolism (blockage).

The stored potential energy contained in an inflated tyre, air receiver or other pressure vessel depends on the air volume and pressure, and may be substantial. Tyre blasts release significant energy. Overpressures caused by incorrect inflation, overheating, fire or a pyrolysis reaction will increase the risk.

Note: The force of a burst tyre may have enough energy to lift a small car eight metres into the air.

One way to reduce the risks to workers associated with inflation and deflation work is to use remotely controlled inflation systems. The use of properly designed tyre inflation cages, where available, and other barriers and restraining devices may also control some of the risks. Workers should be trained and instructed in the need to stand out of the line-of-fire during tyre inflation and during inspection of the tyre assembly during and following inflation.

3.3 Nitrogen

Nitrogen gas is virtually chemically inert, and at room temperature and atmospheric pressure has no taste, colour, odour or toxicity.

The correct use of nitrogen prevents pyrolysis. Inflating tyres with nitrogen reduces the potential for auto-ignition. When the oxygen concentration within a tyre is less than about 5.5 per cent by volume, it cannot auto-ignite because there is insufficient oxygen to support combustion. Some purging of tyres may be required to decrease the oxygen content to below this level.

The use of compressed nitrogen gas for inflating tyres may control the risks such as rim rust, aging of the inner tyre and poor sealing, leading to better inflation pressure stability and longer rim life.

Note: While nitrogen diffuses through rubber at only one-third the rate for air, most of the pressure loss in tyres can be attributed to leaky o-rings or valve hardware.

Using nitrogen gas can introduce additional hazards, including:

- new source of stored energy — nitrogen gas in pressurised containers introduces additional handling and storage hazards
- cryogenic hazard — liquid nitrogen is extremely cold and contact or breathing in associated cold vapours can lead to tissue damage

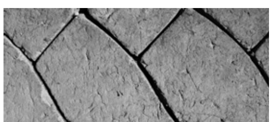
  Note: Nitrogen is only slightly (about 3 %) lighter than air at the same temperature and will therefore disperse slowly due to buoyancy alone. However, cold nitrogen gas can be denser than ambient air and will tend to settle at ground level and in low places, such as mechanics pits and floor sumps.

- nitrogen acting as an asphyxiant — venting of nitrogen into an enclosed or poorly ventilated workshop space (e.g. inflation chamber, sea container) can lead to an oxygen-deficient atmosphere and create an asphyxiation hazard.

Note: The minimum acceptable concentration of oxygen in a room's atmosphere is 18 per cent by volume under normal pressure (Safe Work Australia, 2012, Guidance on the Interpretation of Workplace Exposure Standards for Airborne Contaminants), but ideally it should be maintained above 19.5 per cent. If the nitrogen containment fails, large volumes of the gas can be released suddenly. Nitrogen is colourless and odourless so leaks are difficult to detect.

To avoid potential oxygen depletion, nitrogen should only be used in well ventilated areas. For enclosed facilities, the number of fresh air volume changes required per hour to achieve sufficient ventilation will depend on factors such as:

- the volume of ventilated space
- the quantity of available nitrogen
- whether oxygen levels are monitored
- whether ventilation is forced or based on natural air movement.



3.4 Noise

Noise-induced hearing loss resulting from injury to the inner ear can follow excessive or prolonged exposure to noise. In the workplace, activities that can raise noise levels include:

- the rapid release of compressed gases
- the operation of pneumatically powered air tools, such as impact wrenches
- heavy wheel parts and tools dropping onto concrete floors
- working close to diesel-powered mobile plant.

There is a regulatory requirement to manage noise exposure above specific action levels.

Engineering controls are preferred over a reliance on PPE to reduce workplace noise levels. Examples of engineering solutions include:

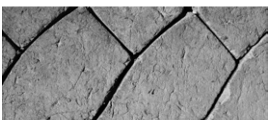
- providing suitable noise-attenuating enclosures for mobile plant and stationary powered equipment (e.g. forklifts, compressors)
- setting noise level criteria for the selection and purchasing of air tools and other equipment
- using special floor surfaces or mats to reduce the impact noise from hard floors.

Where it is not practicable to further reduce noise exposure, appropriate PPE must be provided and workers trained in its correct use. Tyre fitters may be at risk of injury if appropriate hearing protection is not worn.

Note: For further information on noise management, see the Department of Mines and Petroleum's guideline on the management of noise in Western Australian mining operations.

3.5 Handling of heavy objects

A tyre assembly fitted with a protector chain for a large front-end loader, for example, may weigh up to 15 tonnes and, as such, is too heavy to be manually handled. Purpose-designed tyre-handling machinery, assembly jigs, inspection stands and other specialised fit-for-purpose tools are required for moving



the tyre casings, wheels, rims and finished tyre assemblies of heavy mining vehicles.

The large dimensions and weights involved mean that, if finished tyre assemblies or components fall or slip out of their restraints during transport, storage, handling, assembly or fitment, they present potentially fatal crushing hazards for tyre fitters and vehicle operators.

Some low speed vehicles (e.g. tyre dozers, tractors, front-end loaders) use ballast (e.g. dry ballast, water solution) or other fill materials (e.g. inserts, foram fill). While water-ballasted tyres may weigh 20 to 30 per cent more than an air-filled tyre, dry-ballasted tyres are even heavier and can further increase the hazard of handling a heavy object. It is therefore imperative that reliable information on the mass of tyre assemblies, and whether the tyres are gas filled or ballasted, is available to competent persons to select suitably rated tyre-handling machinery. The weight of wheel assemblies should be clearly marked on or close to the assembly.

There are also potentially fatal crushing hazards associated with the support of earth-moving machinery when their tyre assemblies have been removed. The vehicle should be positioned on near-level ground before any attempt is made to remove wheel assemblies. Suitably rated jacking pads, jacking equipment and stands are required. The supporting surface (e.g. concrete or soil surfaces) should be assessed by a competent person to ensure it can support the point loads.

Load-supporting plant (e.g. jacks, axle stands, extension dollies) must be fit-for-purpose and designed by competent persons to established design standards (i.e. rated), and used by competent persons in accordance with the instructions of the original equipment manufacturers (OEMs) of the load-supporting plant and the vehicle.

Note: The use of packing in conjunction with a jack or stand should be limited to material that is fit for purpose (e.g. sufficient load capacity, will not deform under load, will not slide sideways, inherently stable).

3.6 Working with heavy equipment

Tyres are handled at various times using cranes, forklifts or mobile plant fitted with two- or three-arm hydraulic tyre-handling attachments. The tyres are very heavy so attempting to move them without fit-for-purpose equipment can result in serious injury, as well as possible damage to the tyre.

The operating instructions provided by the OEM should be followed to ensure additional hazards are not introduced by the tyre-handling machinery. General principles for tyre handling are covered in Chapter 7.

Poor handling of an unmounted tyre can cause irreparable damage, particularly to the bead. If the damage is undetected and the tyre is put into service, its subsequent failure can increase risks associated with the vehicle, such as loss of control of the vehicle, or sudden depressurisation near workers (e.g. in a workshop).

The interaction of heavy mobile equipment with each other and with workers requires risk assessment by competent persons and the implementation of appropriate risk controls.

Tyre-handling attachments

Various tyre-handling attachments are available for use with vehicle-mounted cranes (e.g. Hiabs), multipurpose machines (e.g. integrated tool carriers or ITCs) and large fork lifts. Such devices usually consist of hydraulically actuated gripper arms, commonly two or three arms, which grip the outside of the tyre to lift, move and manipulate it. The devices rely on achieving and maintaining sufficient grip to securely control the load. Significant hazards and risks may arise when:

- workers operate close to the machine or between the gripper arms (e.g. when removing or fitting wheel fasteners) — appropriate procedural and engineering controls are required to ensure workers are not crushed by the gripper arms or a falling tyre

- inflating the tyre while the gripper arms are gripping the tyre — this can lead to overloading of the hydraulic circuit, and hydraulic or structural failure, resulting in loss of grip of the gripper arms, with the potential for workers to be crushed, sprayed with hydraulic fluid or hit by debris.

Additional considerations for tyre-handling machines

For two-arm type manipulators, ensure that anti-fall back devices are fitted, in serviceable condition and locked in position before tyre-fitting workers enter the operating space or "footprint" of the manipulator arms.

To facilitate safer workplaces, never:

- operate under or near a suspended or elevated tyre assembly
- reduce the manipulator arms clamping force while a tyre assembly is suspended in the gripping pads
- use a tyre handler as a bead breaker unless it is specifically designed for this purpose
- inflate or deflate tyre assemblies while being gripped or supported by the clamp arms
- handle a tyre or tyre assembly unless the handler is rated for the load.

3.7 Heat and fire

External fires or heating of any part of a tyre assembly, wheel end or hub can compromise the integrity of the tyre, in extreme cases resulting in dangerous, rapid deflation (i.e. bursting) or explosion (due to pyrolysis or diffusion). Such events often start in another area of the vehicle, such as the engine, brakes or wheelmotor, and spread to the tyre. A tyre burst or explosion can spread fire to other tyres and areas of the vehicle. Tyre fires are difficult to extinguish, and also produce large volumes of toxic fumes.

An overheated tyre should be treated like a "ticking bomb". Trucks that have or are suspected to have overheated tyres should be parked-up in a safe place well away from other equipment and workers, and allowed to cool down slowly over at least 24 hours before any inspection or replacement of the tyre is attempted. The use of thermal imaging or remote tyre pressure monitoring (e.g. tyre pressure/temperature monitoring systems or TPMS) avoids the need for personnel to enter the danger zone of a suspected overheated tyre to conduct an initial assessment.

3.8 Fuels and chemicals

Rubber may react with some fuels, solvents and other hydrocarbon substances. Apart from potentially weakening the tyre, this can greatly increase the risk of the tyre catching fire if an ignition source is available. Other chemicals can introduce similar risks. For example, do not use a lubricant to assist with assembling tyres and rims unless it has been clearly identified by the manufacturer as being safe to use for its intended purpose and the flash point has been identified.

3.9 Pyrolysis

Pyrolysis is the decomposition of carbonaceous material inside the tyre. Heating of the rubber (inner liner) releases gaseous volatile organic compounds into the air chamber of the tyre. Under certain temperature, pressure and concentration conditions, this volatile mix of air and fuel can become an explosive mixture and achieve auto-ignition. Rapid spontaneous combustion typically results in large catastrophic failures with destructive outcomes — the pressure typically exceeds 6.9 MPa (1,000 psi). Such events can propel debris hundreds of metres, and are potentially lethal to any workers in the vicinity, including persons in vehicles.

Sources of heating that could result in a pyrolysis explosion include:

- heating of stuck or “frozen” wheel fasteners
- welding or grinding of wheel components
- vehicle coming into contact with high voltage electrical conductors (e.g. overhead power lines)
- vehicle struck by lightning
- external fires (e.g. engine bay fires, hydraulic fires, electric fires, grass fires in parking area)

- overheating brakes (e.g. due to brake overuse, misuse or dragging)
- overheating of electric wheel motors
- gross under-inflation of tyres
- heat separation (i.e. separation of rubber layers in tyre leading to further heating from rubbing friction)
- overloading or over-speeding of the vehicle (e.g. exceeding its tonne kilometre per hour or TKPH load-speed rating).

The pyrolysis reaction cannot be detected and explosions can result spontaneously without warning or any obvious external visible signs that the tyre is progressing towards auto-ignition.

The risk of pyrolysis may be mitigated by:

- ensuring the air in the tyre does not reach auto-ignition temperature
- reducing the oxygen concentration in the tyre so there is insufficient oxygen to support combustion (e.g. use nitrogen for tyre inflation)
- using a suitable liquid tyre additive
- monitoring the vehicle's speed and load using on-board data acquisition and recording systems to help manage driver behaviour to stay within the TKPH rating
- using a TPMS to monitor tyre pressure and temperature in real-time to detect extreme air pressure or temperature anomalies.

3.10 Projectiles

Despite their size and mass, tyre, rim and wheel assembly components can be propelled long distances at great speed when tyres burst or explode. Not only do these projectiles represent a lethal hazard to workers, but they can also damage adjacent plant and structures, which could result in further hazards.

Multi-piece rims pose a greater risk than single-piece rims due to greater potential for a catastrophic disassembly and increase in the number and trajectories of potential projectiles.

Projectiles may be generated as a result of:

- poor maintenance and housekeeping
- incorrect assembly or fitment (e.g. mismatched, misfitted or missing components; incorrect seating of split rims or tyre beads)
- incorrect work procedures (e.g. starting to dismount a multi-piece rim assembly before the tyre is fully deflated; when removing a tyre assembly, loosening any fasteners before the tyre is fully deflated)
- the adjustment of an incorrectly or misfitted (e.g. installed backwards) lock ring without complete deflation
- re-use of damaged parts (e.g. out-of-round, deformed lock rings)
- use of non-original, or non-approved replacement parts
- rims that are cracked or fatigued.

The use of fit-for-purpose tyre inflation cages or equivalent containment devices may provide suitable protection during initial inflation after assembly. Tyre inflation cages are typically used for light vehicle and highway-type truck tyres. However, they are generally not practicable for earth-moving machinery because of their tyre size.

Controls to reduce the risk of projectiles include staying out of the potential line-of-fire by using:

- distance (e.g. long air hose with remote gauge and air valve, and large exclusion zone)
- suitably designed barriers or guards (e.g. blast-proof wall, earthen bund).

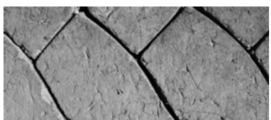
3.11 Foreign objects inside tyre

Foreign objects left inside the tyre can physically damage the casing liner or prevent proper seating of the bead and, in the event of a tyre burst, they can become lethal projectiles.

Scraps of wood left inside the tyre, when subsequently heated can result in a wood distillation reaction that releases methanol (wood alcohol) vapour into the tyre's air chamber. Under certain temperature, pressure and concentration conditions, this volatile mixture of air and fuel can become an explosive mixture and auto-ignite at a temperature much lower than that for a pyrolysis-related explosion.

Scraps of plastic and other materials can also release volatile organic compounds when heated.

Particles of foreign matter inside a tyre's cavity can also block the valve stem and could give someone servicing the tyre the impression that it is fully deflated when it is not.



4 Tyre and wheel or rim selection

4.1 General guidance

While tyres may appear similar across manufacturers, the quality and reliability can vary greatly. For this reason, tyre performance, TKPH rating and typical failure mode of a tyre should be considered, and a competent person should make the selection.

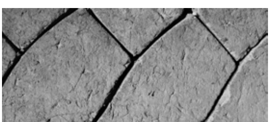
When a new tyre brand or construction type is introduced onto a site, detailed records should be maintained to build a site-based understanding of its projected life.

Tyre selection may also have a safety impact affecting the fitment or removal process, as changing the tyre assembly can introduce new hazards. A change management procedure incorporating risk management processes will assist in evaluating a new style of tyre, wheel or rim. It can help to reduce the consequences of premature or catastrophic tyre, wheel or rim failure. The following strategies are suggested when evaluating the performance of a new tyre assembly selection:

- position only proven brands on steering axles and position untested brands on rear axles until reliability is proven
- monitor tyre pressure retention, wear, damage and failure modes
- monitor tyre pressure and temperature and actual TKPH against the rating stated by the manufacturer.

4.2 Factors to consider when selecting tyres

Tyres are selected so that they are fit-for-purpose and have the best expected service life. Decisions regarding tyre selection should be based on the recommendations of competent persons in consultation with the tyre manufacturer and the OEM of the earth-moving machine on which the tyre will be used.



Although tyres are expected to operate under a variety of conditions, tyres should be selected to suit the worst conditions likely to be encountered. Factors affecting the life, reliability and serviceability of the tyre include:

- where the vehicle will be operated (e.g. type of surface, condition of surface, road gradient, road camber or profile, turn radii, quarry or underground, type and condition of dumping and loading areas, climate)
- how the vehicle will be operated (e.g. average and maximum speeds, maximum wheel load, average load, TKPH, weight distribution, length of cycles empty and laden, shift duration, number of cycles per shift)
- the type of machine (e.g. haul truck, make or model, OEM-recommended tyre size and rating).

It is most important to assess the site conditions so the optimum tyre design parameters (e.g. tyre construction, tread design, rubber compound, TKPH rating) are selected. Such site assessments are usually achieved by:

- surveying the site, investigating site maintenance records for tyres, inspecting failed tyres on site to look for common failure modes, interviewing tyre maintenance workers with experience of the site, and direct observation of traffic movement on site, or
- gathering data through monitoring and data logging technologies mounted on mobile plant — such technologies can monitor and record tyre pressure, temperature, TKPH, load, speed and other parameters, or
- a combination of the above, or
- a simulation of the proposed operations as used in mine planning.

Vehicles should not be operated beyond the limits of tyre load rating, speed and TKPH. Exceeding any of these parameters may create unsafe conditions such as overheating or physical damage. Optimising tyre selection and maximising the service of tyres can have significant consequences for safety by minimising the:

- number of tyre failures that contribute to loss-of-control incidents in the mining operation

- amount of unplanned breakdown work required in the field
- amount of tyre handling and changing work required, both planned and unplanned, that potentially exposes workers to hazards.

4.3 Factors to consider when selecting wheels or rims

Decisions concerning appropriate wheel or rim selection should be made by competent persons, based on proper analysis and understanding of the site conditions and requirements, as well as the practicable options available. Advice is required from the manufacturers as part of the decision-making process. For example, consider the position of a lock ring when selecting a rim, as the orientation of the ring will affect the risk of objects being projected into the work area if the ring fails.

A risk management approach should be used to sort the information gathered for the selection process. Selection will also affect the tooling and support equipment required on site to safely build and dissemble tyre assemblies.

4.4 Ongoing monitoring

Operating conditions should be closely monitored and recorded throughout the life of the mine. Conditions can change quickly, and often significantly, such that the original selection may need to be re-evaluated or operational adjustments made.

5 Tyre transportation and storage

5.1 Transportation

When loading, transporting and unloading tyres some precautions are required. These include:

- following the tyre manufacturer's instructions with regard to transport (e.g. new tyres have bead protector)
- using suitably rated mobile plant (e.g. forklift) with purpose-designed tynes, rubber-coated tyre cradle or tyre-handler attachment for loading and unloading
- lifting the tyre at its outer circumference, ensuring it is secured and cannot fall off (if using a forklift, do not insert tynes through the centre of the tyre)
- using the correct wide fibre slings or belts, not chains or ropes, if using a suitably rated and stable crane for lifting suspended loads
- ensuring workers do not stand under or near a suspended load
- ensuring the load is adequately secured for transportation to avoid damage from load displacement
- not using chains to secure a tyre during transportation to avoid internal damage that may not be evident during visual inspections.

5.2 Housekeeping

Maintaining a high standard of housekeeping at the tyre service and storage area will help reduce the likelihood and severity of an unwanted event such as a fire. The area should be kept clean and free from combustible rubbish that could accumulate in such areas.

A risk assessment of the tyre service and storage area should be undertaken as part of the site's safety management system, and the necessary controls identified. Consider the following tyre storage and handling issues in the site's tyre management plan:

- tyre storage and laydown area plan
- traffic management
- access and security
- fire management and response
- cutting, grinding and other hot work
- no smoking policy.

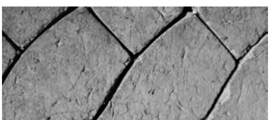
5.3 Storing tyres

Tyres should be stored in accordance with the manufacturer's instructions.

Within the storage yard, tyre stock is usually grouped or divided as follows:

- new tyres (not mounted) — often further subdivided by size, tread pattern, machine type, or other characteristics
- new tyres (mounted) – grouped by fitment
- partly worn (usually mounted) — often designated for use on rear wheels only
- repaired and re-manufactured (re-treaded) tyres
- demounted partly worn or fully worn tyres — inspected or waiting for inspection
- scrapped tyre assemblies awaiting disposal.

Such groupings should be clearly designated and marked in the field to avoid potential confusion, and described in the site's tyre management plan. This is particularly important where the visual appearance of the tyre assembly components may be similar.



Tyre storage areas

The design of the tyre storage and laydown areas, and the tyre management plan in general, should address:

- the tyre manufacturer's recommendations with regard to storage
- rotation of tyres in storage
- safe storage pressure for each type of wheel assembly (when tyres are to be stored ready mounted).

The layout of tyre storage areas should incorporate fire setbacks, removal of dry plant growth and combustible material, and the height of tyre stacks should be limited to assist emergency workers in the event of fire. Manufacturers generally recommend storing new or in-use tyres upright at a safe angle. End-of-life tyres may be stored in any safe arrangement.

Stored tyres may provide habitat for wildlife (e.g. snakes, spiders, bees) and caution should be exercised.

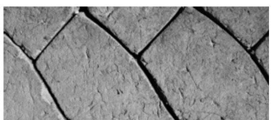
Tyre protection

In general, tyres need protection from water, oil, sunlight, ozone and heat sources to help maximise their life. New and partly worn tyres may be stored either:

- indoors, preferably in a cool, dark, dry place — usually for long term storage, or
- outdoors, preferably covered with a waterproof tarpaulin — usually short term.

Where tyres are stored outside, the maximum allowable storage period largely depends upon climatic conditions and manufacturer's specifications.

In general, tyres should not be stored on machines for prolonged periods. Where possible, the machine should be supported on stands to keep the weight off the tyres, or the machine moved periodically to prevent permanent distortion of the tyres. In long term storage, tyres should be deflated



to a nominal storage pressure as recommended by the manufacturer, to reduce the stress upon the tyre structure and facilitate handling.

The bead protector should be left in place until the new tyre is mounted.

Manufacturers typically recommend that new, unmounted tyres are stored upright at a safe angle rather than being laid on top of one another. This avoids permanent distortion of the casing and consequent difficulties when attempting to mount the tyre. However, the vertical storage of such large, heavy and potentially unstable objects requires appropriate risk controls. Suitable facilities are required to secure the tyres so that they do not roll away or fall over.

Where tyres are stacked vertically, ensure:

- they are securely stored on even ground, with adequate drainage, and no rough areas, rocks or debris that could damage the tyres
- the height of the stack is risk assessed for stability
- appropriate restraining devices are used.

Bund walls should be considered where there is the potential for tyres to roll away.

Cleanliness

Remove any debris (e.g. water, metal, wood and dust) and clean the inside of tyres before mounting.

Where storage yards are located near mine or processing plant facilities, tyres may be exposed to airborne pollutants (particularly hydrocarbons) or dust containing substances that can damage rubber compounds.

Where storage areas are subject to flooding or ponding, spilled hydrocarbons (e.g. fuels, lubricants) can concentrate on the surface of the water and damage tyres. Tyre storage areas should be well drained.

5.4 Fire prevention and suppression

Manual fire extinguishers, placed strategically around the tyre yard, may assist with rapid response to extinguish spot fires before they take hold. However, suppressing a fire that has taken hold in a storage area will be difficult. The prevention of and emergency response to fires should be addressed in the tyre management plan.

Potential sources of ignition and fuel need to be controlled within the tyre storage area. Electric motors, power switch boxes and cables, fuels and lubricants, hot work (e.g. metal welding, oxy-cutting) and other equipment and activities should be risk assessed as potential sources of ignition or fuel. Any tyres exposed to fuels, oils or lubricants should be thoroughly washed and assessed for damage by a competent person before being stored in the tyre yard.

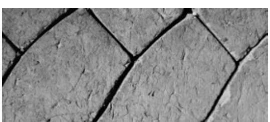
As well as reducing potential ignition sources, the use of equipment such as electrical welding units, battery chargers, power plants and transformers should be restricted near tyre storage areas to minimise exposure to ozone, which degrades tyre rubber compounds.

5.5 Storage of wheel and rim assemblies and components

Appropriate storage and management techniques help to maximise the life of components. Good practice includes:

- storage in a dry area to keep rim and wheel parts free from corrosion — rusted items should be properly refurbished before use
- storing rim components in a labelled racking system
- separate storage of damaged or suspect rims (e.g. awaiting crack testing), and damaged or improper rim parts, to avoid accidental reintroduction into service — if components are intended for disposal they should be cut apart
- careful handling of components to avoid scratching or distortion

- properly identifying parts and wheels by size, type and manufacturer, without mixing components from different brands (e.g. colour coding)
- establishing a coding system to assist in matching assembly components
- separating lock rings, bead seat bands and flanges, to allow for easy identification and matching of correct parts in the final assembly.



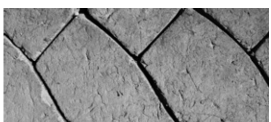
6 Work areas

6.1 General guidance

Areas and facilities for routine tyre service work need to be designed by competent persons to ensure their suitability. Matters to be considered include:

- rated and fit-for-purpose concrete jacking pads and jacking equipment and stands
- rated and fit-for-purpose plant for lifting and handling tyres, rims and wheels
- machines for mounting and demounting tyres
- rated and fit-for-purpose tyre and rim maintenance stands and jigs
- compressed air (or nitrogen) supply of appropriate quality and quantity for tooling and inflation (using separate air supplies and hoses)
- provisions and equipment for safe inflation and deflation of tyres (e.g. remote control inflation systems)
- storage for tools and small parts (e.g. valves, o-rings)
- access to vehicle wash-down facilities and general washing facility to clean rim components prior to fitment
- access to tyre storage and laydown yard
- shade and weather protection (for comfort and fatigue management)
- adequate general area lighting if operating at night, and adequate local lighting for the work areas (e.g. where fitment takes place).

Work areas should be located away from high traffic areas, offices and other populated areas. The number of personnel involved and in the vicinity of the work should be reduced to a minimum number essential to complete the work. All other personnel should be excluded from the area to minimise exposure.



The site-specific traffic management plan should include the segregation of heavy and light vehicles. Safe work procedures should be included in the tyre management plan for replacing wheel assemblies in areas other than designated tyre-handling facilities (e.g. on haul roads or in an open pit).

6.2 Signage and barricading

There should be signage and barricading to prevent inadvertent access by unauthorised personnel.

Appropriate signage and barricading will help control unwanted interaction between workers and mobile plant in tyre handling and storage areas. Signage should include a traffic map, “heavy vehicle and tyre handler in operation” hazard warning signs, and fire management diagrams.

Barricading should not allow unauthorised pedestrian or vehicular access. Chains or other hard barriers (e.g. fence, railing) are recommended for the tyre work areas.

6.3 Provision of compressed air

Sufficient quantities of clean and dry compressed air should be available for the inflation of tyres.

Compressed air delivered to a tyre should be free of foreign matter (e.g. metallic corrosion scale, water condensate, oil). Such contaminants can have an adverse effect on the tyre by reacting with the rubber compounds, metal rim and valve.

Inflation with dry compressed air will assist with pressure and temperature stability during operation.

The temperature of compressed air delivered to a tyre should be as close to ambient as possible.

When using pressurised hosing, ensure:

- appropriate hose fittings with matching clamps are used
- all hose ends are either
  - locked to prevent separation, or
  - fitted with self-sealing joiners to prevent the uncontrolled escape of compressed air

- high-volume pressure hoses are confirmed as depressurised before separation.

Hoses should be kink resistant. The use of stop-flow valves will also reduce the risk of hose failure. Air control valves for inflation should be remote and of a failsafe type (e.g. incorporating a pressure-limited device).

Pressure gauges should be calibrated to ensure readings on deflation pressures are accurate, and the gauge should return to zero when not in use.

Air bottles or gas cylinders should never be used to fill a tyre unless the filling system is fitted with an automatic means to prevent the tyre being over inflated.

Critical actions during tyre inflation

- Never leave tyres unattended during inflation.
- Check tyre pressures remotely and away from the line-of-fire.
- Ensure the pressure gauge is visible to the checker.
- Ensure the correct tyre inflation information is used.
- Never try to reseat the rim-to-tyre connection or any part of a multi-piece rim during the inflation process.

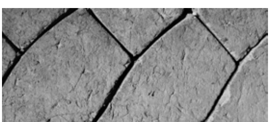
6.4 Use of nitrogen

To differentiate nitrogen-filled tyres, permanently mark the tyres using a method acceptable to the tyre manufacturer or use a different fitting, and ensure accurate record-keeping.

6.5 Tooling

All tooling should be sized and selected by technically competent persons to be fit-for-purpose. Site procedures should require workers to confirm the serviceability of all tooling to be used before commencing a task. Tools suspected to be defective, modified or malfunctioning should be fitted with out-of-service tags and removed from use until repaired, assessed or replaced.

Pressure gauges, torque wrenches and other critical measuring tools should be calibrated against the site standard at regular intervals by a competent person. Ensure calibration records are maintained.



7 Tyre handling on site

7.1 General guidance

A damaged bead can lead to failure at any time either during or after inflation. Following the tyre manufacturer's instructions should eliminate the risk of bead damage and problems that may result. Precautions include:

- using fit-for-purpose tyre-handling equipment
- using flat straps for lifting — never steel slings, chains or ropes
- lifting tyres from underneath — never on the bead
- lifting tyres under the tread when a forklift truck is used — never on the beads
- leaving the bead protector in place until the tyre is about to be fitted
- retaining the bead protectors supplied with tubeless tyres for refitting when a tyre is temporarily removed for repair or re-treading.

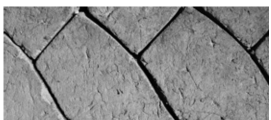
7.2 Tyre-handling machinery

A variety of tyre-handling attachments is commercially available for use with forklifts, hydraulic vehicle-mounted cranes and tyre handlers, loaders, ITCs and other multipurpose machines.

Responsible persons should ensure the machines used are:

- fit-for-purpose
- safe to use
- adequately inspected and maintained, with appropriate records being kept

and operators are adequately trained and assessed as competent to operate the particular type of machine and tyre-handling attachment.



Robotic and remotely operated tyre- and wheel-handling equipment is becoming commercially available and responsible persons should consider this technology during the risk assessment.

Lifting with a crane

When lifting and moving tyres as a freely suspended load using a crane:

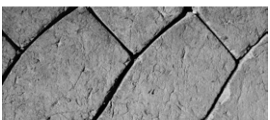
- ensure the rated capacity of the crane is appropriate for the weight of the tyre being lifted or moved
- ensure a mobile crane and its suspended load remain stable whether the crane is stationary or tramming
- maintain an exclusion zone around the work area
- never work beneath a suspended tyre
- stay clear of any slings being used
- do not use chains to lift or suspend a tyre
- to avoid damaging the bead, do not allow rope slings to rub against the bead area of the tyre.

If a tyre must be lifted using a crane, use a wide fibre sling or belt to prevent damaging the bead.

Lifting with a forklift

When lifting and moving a tyre with a forklift:

- ensure the rated capacity of the forklift is appropriate for the weight with the mass of the tyre being lifted or moved
- consider the stability limits of the forklift and the ground conditions where it will be travelling with the load
- secure the tyre with suitably rated tie-down straps, as a minimum
- consider using a specifically designed rubber-coated cradle or slipper extensions on fork tynes to provide adequate support when lifting or transporting the tyre
- always lift the tyre at its outside circumference — never insert the fork arms through the centre of the tyre as this can damage the bead, resulting in premature failure when the tyre is inflated



- if the load obstructs the forklift driver's view, operate the forklift in reverse, enlist a spotter to assist with manoeuvring, or do both — equipping the fork lift with reversing cameras or other proximity detection aids may be used as part of the safe system of work.

Clamp-type tyre manipulators

When using clamp-type tyre manipulators:

- match tyre-handling attachments to multipurpose mobile plant
  - the combination of plant has been assessed by suitably competent persons and deemed safe to use, or
  - responsible persons should ensure that tyre-handling attachments are only used with machinery that is accepted by the OEMs of the earth-moving machine and attachment
- verify the competency of the operator of the tyre-handling attachments
  - use the national unit of competency *AURKTJ006 Use of earthmoving and off-the-road tyre handlers* for competency assessment
  - responsible persons need to address this in the risk management strategy
- consider safety factors in design between manufacturers
  - there is no Australian or international standard for tyre-handling attachments
  - responsible persons need to ensure the machines used are fit-for-purpose.
- inspect the machinery and assess the job risks before commencing work
  - account for prevailing weather conditions
- park-up and isolate the machine on a suitable stable surface, and at a safe distance from other activities
- based on a risk assessment, create a clearance zone that is large enough to encompass the direct work area and travel path of the tyre handler while removing or fitting a tyre

- operate the tyre handler within its rated capacity and according to the OEM's instructions
  - a copy of the OEM's operator manual, maintenance manual and log book should be available to the operator
- deflate tyres to the nominal handling pressure recommended by the site procedure for the task being undertaken or storage
- ensure gripping pads have full contact with tyre treads before lifting
- if using a two-arm tyre handler to move tyres, travel at a safe speed with the tyre low to the ground and in the horizontal position, with the arms of the tyre handler tilted back
- rotate the tyre into the vertical position only when necessary.

8 Tyre mounting and demounting

8.1 General guidance

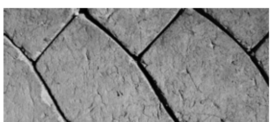
There are two ways to mount or demount tyres:

- horizontal mounting or demounting when the wheel or rim has already been removed from the vehicle.
- vertical mounting or demounting when the wheel or rim is still on the vehicle after the vehicle has been isolated, stabilised (e.g. chocked) and jacked.

8.2 Preparing tyres for mounting

When preparing tyres for mounting, considerations include:

- selecting the appropriate components for assembly or mounting
- using a suitably rated mounting stand, if horizontal mounting is used
- checking or replacing valve components
- ensuring no deformities or anomalies are identified on the tyre
- lubricating the tyre beads, rim components and o-ring with an approved lubricant
- removing foreign material from inside the tyre air chamber
- fitting the tyre to the wheel or rim, and the components required (e.g. o-ring, lock ring)
- the inflating procedures and facilities for remote inflation
- potential lines of fire and the use of barriers
- establish an exclusion zone around the work area.



8.3 Demounting a tyre

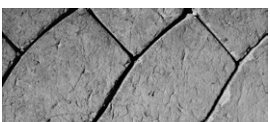
When stripping a tyre from the assembly, considerations include:

- completely deflating the tyre and removing the valve where appropriate or placing it in the open position before attempting to disassemble the tyre assembly
- deflating both tyres on a dual tyre assembly to a safe pressure (as determined by the site risk assessment) before demounting the outer tyre
- how the lock ring and o-ring will be removed (e.g. use a lock ring catcher to minimise the risk of injury from a falling lock ring)
- the hazards involved in breaking the tyre bead (e.g. use a safety restraint, barricading or guarding to prevent injury from unexpected ejection of bead-breaking tools)
- the mechanism for removing the tyre from the assembly
- how to remove the tyre bead seat-band and flange from tyre
- the mechanism for moving the tyre to a designated area for inspection before reuse, reconditioning or scrapping.

8.4 Checking the assembly

A competent person should check assemblies and components before they are used or stored. Other considerations include:

- ensuring the period of use coincides with the crack test schedule (as set by site requirements, which should reference AS 4457)
- examining cracked or fazed paint, and other defects or signs of abnormal wear
- examining components (e.g. nave or wheel disc, fastener holes, seating taper, rim, bead set band, flange, locking ring) for defects and ongoing serviceability — used o-rings should be cut to prevent re-use
- verifying the compatibility of wheel and rim components
- examining the seating of components after they have been assembled to identify any inconsistencies or flaws



- recording the unique wheel, rim or component identifier and recording its service life in the appropriate maintenance record (see Section 12.2 for further information).

8.5 Removal or fitting of tyre assemblies

Before commencing any repair work, check that the tyre is deflated and, where possible, noise-muffling devices (deflators) are used.

When removing or fitting a tyre assembly, considerations include:

- selecting a suitable site free of unnecessary hazards
- isolating and stablising (e.g. chocking) the vehicle
- ensuring jacks, stands, the jacking pad, tyre handlers and other equipment have sufficient rated capacity, are fit for purpose and are in serviceable condition
- verifying the jacking points and stand points on the vehicle using the OEM's instructions before raising
- using a jack to raise and lower the load, and a safety stand (or stands) to support the load while the tyre is being changed — never use wooden blocks or steel plates to increase the reach of a jack unless provided by the jack's manufacturer
- deflating the tyre to a safe handling pressure before working on any assembly fasteners
- keeping track of components.

Note: A vehicle on a jack is a suspended load until supported by a safety stand or the jack is locked in place. Workers should never be allowed to work under a suspended load.

9 Tyre and wheel assembly maintenance and repair

9.1 General guidance

Substantial information on tyre and wheel assembly maintenance and repair is provided in Australian Standards AS 4457.1 and AS 4457.2, and this chapter is intended to complement that guidance.

9.2 Operational data

Tyres may exhibit many conditions and, before any repair work is attempted, a tyre should be assessed by a competent person to determine serviceability and whether a repair is feasible. The tyre's operational and maintenance history should be scrutinised as part of any inspection.

The serviceability of a tyre is determined through visual inspection of all external surfaces and surfaces within the air chamber. Any cuts, separations, bubbles, deformations or burn marks should be assessed. As a tyre's tread wears, the main rubber compound is eroded. At a low tread depth, a softer compound may be exposed that wears, cuts and chips at a faster rate than the main tread rubber.

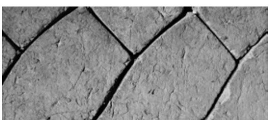
Before repairing a tyre, take into account:

- location and extent of physical damage (e.g. cuts)
- integrity of the casing liner and bead
- potential remaining life (e.g. expected tread life).

Consider scrapping tyres that may have unseen damage, such as those with:

- a history of under-inflation (e.g. run flat)
- burn or scorch marks.

Note: Tyre repair is a specialised field and assessment should only be undertaken by the tyre manufacturer or competent repair specialists (refer to AS 4457.2).



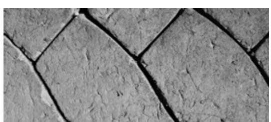
9.3 Factors affecting tyre life

Factors that adversely affect tyre life include:

- tyre selection
  - quality of manufacture
  - construction (radial or bias ply)
  - tread pattern and depth
  - tread compound
  - star or ply rating
- operating conditions
  - design, construction and maintenance of roadways, and loading and dumping areas
  - mine design parameters (e.g. downhill loaded hauling increases workload on front tyres; tight turning radii produces asymmetric wear)
  - competency of operators (e.g. driving style)
  - work practices (e.g. exceeding the TKPH rating by overloading or over working leading to increased running temperatures)
- tyre incidents
  - deflation events
- maintenance
  - tyre inflation pressure setting and control
  - matching tolerance (e.g. haul truck dual tyres)
  - wheel alignment and suspension
  - management of abnormal tyre wear (e.g. asymmetrical, heel-toe wear)
  - tyre fitment and rotation management.

Maintaining the correct tyre pressure is essential to maximising a tyre's service life and reducing the risk of premature failure. Operating with tyres that are grossly over or under inflated may not only damage the tyres, but also expose workers to additional risks.

The history and wear of the tyre also influences the success of any tyre repair that is attempted.



9.4 Monitoring tyre pressure

The appropriate tyre inflation pressure settings (i.e. cold and maximum hot inflation pressures) should be determined in conjunction with the tyre manufacture for each application on site, and will depend on the tyre specifications, vehicle type and operating parameters.

Low inflation pressures can damage a tyre in a number of ways, including:

- heat separation caused by over work
- irregular wear of the tread caused by excessive tread movement
- separation caused by excessive sidewall distortion
- friction and chafing caused by distortion of the bead area or slipping of the bead
- separation of plies due to high stress between plies.

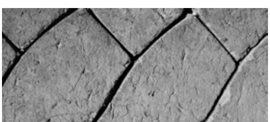
Such damage can cause the tyre to burst suddenly and violently.

High inflation makes the tyre more rigid and less able to absorb impacts, and breaks and cuts are more likely when driving over hard and sharp objects. Over inflation also increases the risk of a tyre burst, particularly for already damaged or weakened tyres.

The tyre management plan should include the cold and maximum hot inflation pressure information for each tyre on site.

While Australian Standard AS 4477.2 does not require any minimum inspection interval for tyre pressure monitoring, it does state that inspections should be undertaken periodically according to the manufacturer's recommendations. Each site should determine an appropriate frequency of checking based on a risk assessment, including consultation with the manufacturer. All tyre pressure data should be recorded.

When a TPMS is installed and functioning correctly, the requirement for periodic manual inspection of tyre pressure, as well as checking for faults, is reduced. However, the maintenance program should include regular checking of each



wheel position to enable external visual inspection of the tyre, rim and fasteners.

Correct tyre pressures should be achieved using high-quality tyre inflation equipment, including pressure gauges that are periodically checked against a master gauge, which itself is periodically re-calibrated. Pressures should be systematically recorded so that leaking or damaged tyres can be identified and changed before they fail catastrophically.

The practice of “tyre tapping” is an inadequate and inappropriate method of pressure monitoring, and is not regarded as part of a safe system of work.

9.5 Tyre matching, alignment and rotation

Other maintenance aspects to maximise tyre performance and combat abnormal wear include:

- matching of tyres (by circumference or tread depth) in rear dual assemblies
- proper setting (and adjustment as required) of front tyre wheel alignment and suspension struts (front and rear)
- rotation of tyres, as necessary, to compensate for abnormal wear characteristics such as asymmetrical or heel/toe wear, and from front to rear for safety considerations.

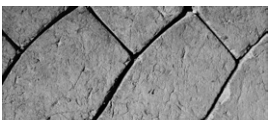
These should be implemented as part of the tyre management plan.

Asymmetrical wear (the faster wearing of one shoulder of a tyre compared with the other shoulder) is mainly associated with cornering of haul trucks and becomes more of an issue as truck size increases.

9.6 Maintenance of wheel and rim assemblies

Substantial information on wheel and rim assembly maintenance and repair is provided in Australian Standard AS 4457.1.

To control the hazards arising from fatigued and cracked rims it is recommended that a non-destructive testing (NDT) regime be included as part of the tyre management plan.



10 Fires and explosions in tyres in service

10.1 General guidance

Tyre fires and explosions on earth-moving machinery can have serious consequences. The risk management and planning process needs to address the potential for such scenarios, with appropriate controls and emergency response included in the tyre management plan.

Site-based procedures should cover the use of emergency services personnel. In the event of a tyre fire, only those workers who have received specific training on the use of appropriate fire-fighting equipment should attempt to suppress or extinguish the fire. All other workers need to evacuate immediately to a safe distance, which should be specified in the tyre management plan or site emergency response plan.

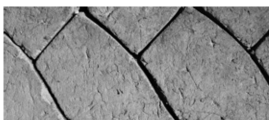
Access or egress points in the tyre storage and maintenance areas should be kept clear and clearways maintained to allow for unobstructed evacuation and emergency services access.

10.2 Tyre fires

The mechanisms of tyre fires and tyre explosions are quite different. Tyre fires are external to the tyre cavity and can be seen and smelt.

Tyre fires involve the tyre rubber catching fire (combusting) directly. This is usually initiated by:

- fire in the engine, wheel motor or brake that spreads to the tyre
- fire external to the vehicle (e.g. brush fire, ground shale fire) that spreads to the tyre
- friction from rubber on rubber contact that can happen when a tyre deflates or separates during operation
- friction from rubber on steel contact (e.g. a wheel or rim spinning inside a flat tyre)
- heat generated by an explosion.



Causes

The primary cause of a tyre fire is the application of heat to the tyre or the development of heat within the tyre structure for various reasons, including:

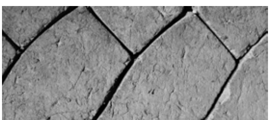
- brake problems or misuse (e.g. over use)
- wheel motor problems (e.g. overheating)
- gross under-inflation or run-flat
- grossly exceeding tyre workload (TKPH) capacity through excessive speed or load
- oil or fuel igniting after coming into contact with hot surface.

Lightning strikes or contact with power lines will most likely result in a tyre explosion, which could contribute to secondary fires at other wheel positions.

Prevention of tyre fires

To minimise the risk of tyre fires, consider:

- minimising the potential sources of ignition and fuel load in tyre yards
- modifying vehicle hydraulic systems with fire-resistant hydraulic fluids
- ensuring
  - adequate procedures, facilities, tools and systems of work are available
  - recommended tyre pressure is maintained (e.g. use a TPMS that incorporates tyre temperature monitoring and alarms)
  - where practicable, overhead power lines do not cross haul roads but, where they do, there is adequate clearance, warning signs and warning systems (e.g. "tray up" alarm, proximity sensing equipment, non-contact electric field sensing equipment).
- providing
  - on-board fire-extinguishing systems, such as automatic aqueous film-forming foam (AFFF), supplemented with suitable and adequate manual extinguishers



  - lightning notifications to reduce the potential exposure of vehicles to strikes
- addressing driver behaviour and competency (e.g. speeding, misuse of brakes)
- developing preventative maintenance strategies for vehicle brakes and wheel motors
- ensuring maintenance workers are trained and assessed as competent for their duties.

When dangerous goods such as solvents, cements, buffers and glues are used in tyre work areas, ensure:

- forced-air ventilation techniques are used to minimise the potential for volatiles to accumulate
- containers are sealed after use
- such products are properly labelled and securely stored in approved facilities.

10.3 Tyre explosions

Two distinct mechanisms produce the gases implicated in tyre explosions:

- pyrolysis — where the tyre's inner liner undergoes a chemical change giving off volatile organic hydrocarbon vapours (see Section 2.9)
- diffusion — where an organic compound (e.g. wood) left inside a tyre gives off methanol vapour.

The auto-ignition temperature of a diffusion explosion is typically less than 100°C, which is much lower than that associated with pyrolysis (typically > 400°C).

Causes

Scenarios that help create an environment where tyre explosions are more likely include:

- welding or oxyacetylene heating of wheel or rim components (especially frozen wheel fasteners) to which a tyre is mounted, irrespective of whether the tyre is inflated or deflated
- contact with high voltage power line

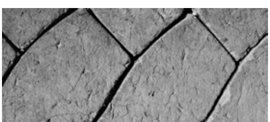
- lightning strike
- poor fitting practices where debris (especially wood) is left inside the tyre
- using petroleum-based lubricants
- grossly exceeding tyre workload (TKPH) capacity through excessive speed or load.

It is recommended that any tyre exposed to a high voltage current or lightning strike be scrapped and rendered unusable because not all damage will be visible.

Prevention of tyre explosions

To minimise the risk of tyre explosions, consider:

- replacing compressed air with nitrogen gas for inflation, provided the correct nitrogen inflation procedure is used so that the tyre is sufficiently purged of air
- ensuring overhead power lines crossing haul roads have adequate clearance and warning signs
- providing lightning notifications to reduce the potential exposure of vehicles to strikes
- avoiding the use of petroleum-based products on or near tyres
- operating tyres within the manufacturer’s specifications.



11 Tyre disposal and end-of-life considerations

When disposing of tyres, ensure any tenement conditions or environmental management requirements are met.

If tyres are buried in waste dumps, the location, size and type of tyre, and disposal pattern should be recorded.

Tyres awaiting disposal should be stored so they do not create a fire or other form of hazard.

Tyres deemed to be at their end-of-life should be rendered unserviceable to prevent further use.

Tyres that are on-sold for re-use should be accompanied by a fully documented service history or, where this does not exist, a condition report.

It is recommended that the principles of the national Tyre Stewardship Scheme are followed, as outlined in Tyre Stewardship Australia's *Tyre Product Stewardship Scheme – Guidelines*. The Scheme aims to reduce the environmental and health and safety hazards associated with tyre disposal. Participation is voluntary.

Recycling of tyres should be addressed according to the mining operation's environmental policy.

12 Record keeping

12.1 General guidance

In any tyre management program, data records provide a history of the life of tyres, rims and wheels, allowing a comparison of performance by manufacturer or specification. The records also provide the foundation for improving management and work methods and tools.

Australian Standards AS 4457.1 and AS 4457.2 provide guidance on record keeping for tyres, rims and wheels. These standards represent good industry practice and they should be followed as a minimum requirement of any site risk management system and tyre management plan.

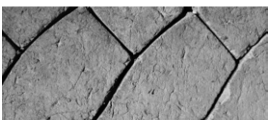
Performance records may also reveal problem areas that contribute to future failures. Thorough and accurate records provide information about service requirements. This knowledge can be used as a training tool for tyre service personnel.

Major tyre assembly components should be individually identified and tracked through their unique serial numbers. This allows purchasing data, inspection records, history, performance, operating and repair records to be traceable to the individual components. Ideally, the record system should assist in managing and tracking the entire life cycle of the major components.

Proprietary software packages, computer-based systems and specialist industry service providers may be used to help design and implement record-keeping systems and provide training. Commercially available vehicle-mounted, real-time data acquisition and recording systems can be integrated with such record-keeping systems.

Decisions on the most appropriate systems for gathering data and maintaining records should take into account:

- the organisational need for continuous learning
- how such information can improve management decision-making



- the benefits of such information to investigations of unexplained failures
- costs versus benefits in creating and maintaining records (e.g. maximising operating life and serviceability, helping to reduce unexpected failures and tyre change-outs)
- legal, regulatory and operational needs for records (e.g. contribution to safe systems of work, meeting duty of care obligations)
- accuracy and traceability of records
- secure storage of data
- accessibility of data and reports
- retention period for records.

12.2 Wheel and rim identification

Site records assist repairers in assessing the serviceability of major components and determining appropriate repairs. Detailed information should also be available for each wheel or rim sent for repair, with repair reports filed in the record system. The wheel and rim register should include:

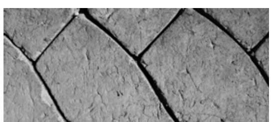
- design information
- historical operating-life data
- maintenance, inspection (including NDT reports) and repair records

against each uniquely numbered wheel or rim to enable tracking and identification.

12.3 Assessing wheel and rim integrity

Industry practice suggests several methods can be used to assess wheel and rim integrity. These include:

- logging the number of hours or kilometres, or both, experienced by a wheel or rim
- monitoring operating conditions, including payloads, haul road profiles and maintenance.



The site risk assessment should define the controls to be included in the tyre management plan. Matters to consider include:

- what constitutes a worn-out component
- the frequency of non-destructive testing (NDT)
- operating techniques employed during operation, including speed, load and cornering speed
- the integrity of components (e.g. lock rings, bead seat bands, flanges, valves, fasteners)
- only using compatible components matched in a rim or wheel assembly.

Only competent persons should undertake inspections and repairs.

Adequate records of all inspection and repair events should be:

- maintained in accordance with AS 4457.1, as a minimum
- traceable to the individual serial number displayed on the wheel or rim base.

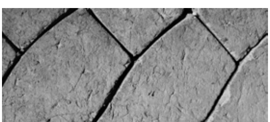
Records should detail the nature of the repair, the repair organisation, date of repair and NDT reports.

Areas of wheels or rims that typically need to be examined include:

- lock ring and o-ring grooves
- the gutter section, which is subject to high stress that can lead to cracking
- welds joining the base components as well as the nave plate.

Always remove the tyre from the wheel or rim before attempting a repair. A heat source applied to a wheel or rim or any of its fasteners (even if the tyre is deflated) creates the potential for a tyre explosion.

For further guidance, see AS 4457.1.



12.4 Inspection periods for wheels and rims

The inspection and testing period should be determined through site risk assessments and manufacturer's advice as required by AS 4457.1. This standard provides guidance on the repair of wheel and rim components as well as the workers authorised to perform those duties. For further direction, see International Standard ISO 4250-3:12.

13 Emergency response

13.1 General guidance

The Principal Employer or Registered Manager is required to prepare a plan for dealing with emergencies at the mine, including fire fighting and the deployment and use of mines rescue teams. Emergency response plans should:

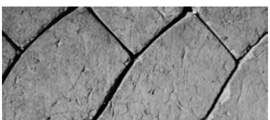
- identify the hazards that might cause an emergency
- assess the risk of an emergency
- include means for dealing with such emergencies.

For Western Australian mines that operate earth-moving machinery, emergency preparation should consider the response to tyre fires and potentially hot tyres and potential tyre explosion events.

13.2 Emergency response plan

Any emergency response plan specific to tyre fires should consider:

- when and how the emergency response can be performed, including the safe evacuation of the operator from the vehicle
- the workers responsible and order of command
- emergency warning systems
- relocation of non-affected tyres to a nominated secure area
- the need for sufficient supplies of water, foam or other approved fire-fighting concentrates
- fire-fighting equipment requirements — hand-held fire extinguishers are generally ineffective once a tyre fire has taken hold
- training and rehearsing for emergency events
- minimum safe approach distances and the approach directions for overheated or ignited tyres.



Note: When tyres have ignited or are suspected of overheating, the vehicle should be isolated for at least 24 hours. The exclusion zone should be defined in the emergency response plan.

Underground tyre fires

Information to assist in emergency planning for tyre fires in underground mines is available in the Department of Mines and Petroleum's guidelines for:

- prevention of fires in underground mines
- refuge chambers in underground mines.

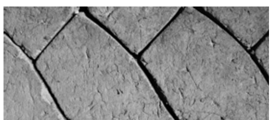
Appendix 1 – Legislative provisions

The parts of the *Mines Safety and Inspection Act 1994* and Mines Safety and Inspection Regulations 1995 that are directly applicable to this guideline are listed below.

Mines Safety and Inspection Regulations 1995

Part 4	**General safety**
r. 4.13	Induction and training of employees
Part 6	**Safety in using certain types of plant in mines**
r. 6.17	Employer to identify hazards associated with plant and to assess risks
r. 6.18	Employer to reduce risks identified
r. 6.21	Employer to prevent unsafe use of plant
r. 6.22	Employer's duties when plant is damaged or repaired
r. 6.23	Employer's duties when design of plant is altered
r. 6.25	Employer's duties to keep records
r. 6.26	Plant under pressure
r. 6.27(2)	Plant with moving parts
Part 7	**Occupational health**
r. 7.3	Action level for noise

Note: The only authorised versions of the Act and regulations are those available from the State Law Publisher (www. slp.wa.gov.au), the official publisher of Western Australian legislation and statutory information.



Appendix 2 – Selected standards and guidance

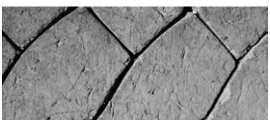
Examples of Australian and International Standards and other guidance that may be useful are listed below. Applicable safety alerts may be obtained from State regulators.

Note: This list is not exhaustive but gives an indication of the many aspects to be considered.

Standards Australia

www.standards.org.au

AS/NZS 2230	*New pneumatic tyres for light trucks and truck/buses*
AS/NZS 2538	*Vehicle support stands*
AS/NZS 2693	*Vehicle jacks*
AS/NZS 3788	*Pressure equipment – In-service inspection*
AS 4343	*Pressure equipment – Hazard levels*
AS 4457.1	*Earth-moving machinery – Off-the-road wheels, rims and tyres – Maintenance and repair – Wheel assemblies and rim assemblies*
AS 4457.2	*Earth-moving machinery – Off-the-road wheels, rims and tyres – Maintenance and repair – Tyres*
AS/NZS 4477.2	*Information technology – Telecommunications and information exchange between systems – Private integrated services network – Specification, functional model and information flows – Identification supplementary services*



International Organization for Standardization

www.iso.org

ISO 4250-1	*Earth-mover tyres and rims – Part 1: Tyre designation and dimensions*
ISO 4250-2	*Earth-mover tyres and rims – Part 2: Loads and inflation pressures*
ISO 4250-3	*Earth-mover tyres and rims – Part 3: Rims*
ISO 31000	*Risk management – Principles and guidelines*

Other standards

Australian Design Rules ADR 42/04, Section 25: *Tyre and rim selection*, www.comlaw.gov.au/Series/F2005L03996

Road Transport Competency Standards TLIB2004A, *Carry out vehicle inspection*, www.training.gov.au/Training/Details/TLIB2004A

Resources Safety, Department of Mines and Petroleum

www.dmp.wa.gov.au/ResourcesSafety

Department of Mines And Petroleum, 2013, *Prevention of fires in underground mines — guideline*, Resources Safety Division, Department of Mines and Petroleum, Western Australia, 42 pp.

Department of Mines And Petroleum, 2013, *Refuge chambers in underground mines — guideline*, Resources Safety Division, Department of Mines and Petroleum, Western Australia, 43 pp.

Compressed Air Association of Australasia

www.compressedair.net.au

Air compressors in the workplace and home

The Maintenance Council (TMC)
www.trucking.org/Technology_Council.aspx

Radial tyre condition analysis guide – A Comprehensive review of tread wear and tire conditions

Queensland Courts, Office of the State Coroner
www.courts.qld.gov.au

Findings of Inquest: Inquest into the death of Wayne MacDonald File no(s): 2010/4299, 9 September 2014

Queensland Government, Department of Employment, Economic Development and Innovation
mines.industry.qld.gov.au

Earthmover tyre and rim safety, Safety Alert No. 1, 28 March 2011

The Tyre and Rim Association of Australia
www.tyreandrim.org.au

Tyre and Rim Standards Manual, 2014

TYREgate
www.mirmgate.com.au/index.php?gate=tyregate

Tyre Stewardship Australia
www.tyrestewardship.org.au

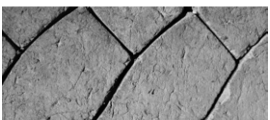
Tyre Product Stewardship Scheme – Guidelines

TyreSafe UK
www.tyresafe.org

Truck tyre Safety

WorkSafe Victoria
www.worksafe.vic.gov.au

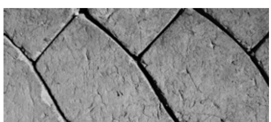
Working safely with air receivers – a handbook for workplaces



Appendix 3 – Common terms and acronyms

Common terms

Bead	Part of the tyre that secures it to the rim
Burst	Instantaneous release of stored energy within a tyre's air chamber
Casing	Structure and components of a radial ply tyre
Lock ring	Part of a wheel or rim which retains the components when a tyre is mounted to the wheel/rim base
Off-the-road (OTR) tyre	A tyre that has a rim diameter of 24 inches or larger, as defined in AS 4457
Rim	The part of the tyre assembly that uses a taper seat arrangement to afix to the wheel motor or hub of an earth-moving machine
Rim base	Part of the assembly on which the tyre is mounted and supported
Rim assembly	Assembly of components comprising the rim, including rim base, flanges, bead seat band and lock ring — but without a tyre
Tyre assembly	A tyre mounted to a wheel or rim assembly
Tyre explosion	Auto-ignition of an explosive gas mixture within a tyre's air chamber resulting in a large over pressure leading to catastrophic tyre failure and rapid release of hazardous energy
Tyre pyrolysis	Thermochemical decomposition of the tyre's inner liner producing gases that may form an explosive mixture within the tyre's air chamber
Wheel	Rotating load-carrying member between the tyre and axle, usually consisting of rim base and wheel disc, hub or nave plate
Wheel assembly	Comprises a rim base, flanges, bead seat band, lock ring and wheel disc or nave plate welded to the rim base



Acronyms

TKPH

The load speed rating of a tyre, which helps determine the tyre's suitability for an operation, is measured as tonne kilometre per hour (TKPH).

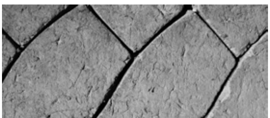
As tyres flex during rotation, heat builds up within the tyre. The rate of heat build-up depends on the load on the tyre, average haul speed, ambient temperature and distances travelled. Based on the tyre's ability to withstand the heat generated while it is working, the manufacturer assigns a TKPH rating that sets a limit on how hard the tyre may work before there is likely to be a detrimental effect on the tyre's life.

A tyre's TKPH rating depends on its design. The rating varies according to the its size and type, and is a function of load and the number of kilometres covered each hour assuming an ambient temperature of 38°C (100°F).

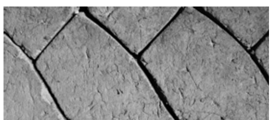
The operating TKPH is a measure of the amount of work the tyre has actually done while in service. Over a shift, it is calculated by multiplying the MTL during the shift by the AWSS.

The TKPH rating is based on an ambient temperature of 38°C so the calculated operational TKPH may need to be adjusted if the ambient conditions during the shift are significantly different. For each type of tyre, tyre manufacturers can provide data for the revising the coefficient and the formula to be used for different ambient temperatures.

Note: The average work-shift speed (AWSS) is the total distance travelled during the shift divided by the shift duration to obtain an average speed. The mean tyre load (MTL) is the tyre load when the vehicle is empty plus the tyre load when the vehicle is loaded divided by two to obtain the average tyre load.



TPMS	Tyre pressure monitoring systems (TPMSs), also sometimes referred to as tyre monitoring systems (TMSs)consist of pressure and temperature sensors fitted to the tyre that communicate wirelessly with a data collection device in the operator’s cab. The operator can view the temperature and pressure of each tyre on a display in real-time while data is continuously logged for download, record keeping and analysis. Such systems may also incorporate alarms or alerts to warn the driver when pressure and temperature deviate from the operational range. Remote monitoring and recording may also be available.



Appendix 4 – High risk work licensing

Under the regulations, tyre-handling machinery that uses clamp-type tyre manipulators does not comply with the definition of a crane or hoist and, therefore, it is not regarded as classified plant for the purpose of the regulations. Additionally, no Australian or international standards exist for the design, manufacture, inspection, testing or operation of tyre-handling machinery. Therefore, responsible persons should exercise care when selecting or purchasing tyre-handling machinery to ensure it is robust, safe to use, fit-for-purpose and, adequately inspected and maintained.

Since January 2014, there has been a nationally accredited unit of competency for the use of earth-moving and off-the-road tyre handlers (AURKTJ006). However, the operation of clamp-type tyre manipulators is not regarded as high risk work under the regulations, nor the *Occupational Safety and Health Act 1984*. Therefore, a high risk work licence is not required. However, machines with rated capacities of 5 to 15 tonnes are becoming common, and responsible persons should ensure operators are adequately trained and assessed.

One exception is when tyre-handling attachments are used in conjunction with Hiab-style hydraulic arms on trucks. In this situation, the operator is considered to be operating a vehicle-mounted crane and, depending on the rated capacity and reach of the arm, may require a crane licence (CV class) to operate legally. However, the crane licence is not an indication of being competent to use the crane with a tyre-handling attachment. Therefore, responsible persons should ensure operators are adequately trained and assessed as competent.

The absence of standards and regulations in relation to manipulator-type tyre-handling machinery means that responsible persons need to be diligent in taking a risk-based approach and exercising their duty of care in relation to such plant.

Vehicle-mounted cranes, whether used with tyre-handling attachments or hooks for suspended loads, are classified plant for the purpose of the regulations. They require registration if their rated capacity exceeds 10 tonnes. Furthermore, under the National Licensing Standard, the operator requires a high risk work licence if the capacity exceeds 10 metre-tonnes.

Operators of any industrial lift trucks are required to have a fork-lift truck (LF class) licence. However, fork-type loaders created by fitting fork attachments to bobcats, ITCs, tractors, telescopic handlers and other multipurpose machines are not regarded as industrial lift trucks, and a high risk work licence does not apply.

Appendix 5 – Example checklists

Tyre history checklist

Identification	Serial number	
	Manufacturer	
	Supplier (if different from manufacturer)	
	Cost (including transport and repair)	
Specification	Size including construction details (e.g. use three separate fields — 40.00 R 57)	
	Ply or star rating	
	Operational TKPH	
	Tread pattern (according to manufacturer's specification)	
	Tread compound (according to manufacturer's specification)	
	Sub-specification (according to manufacturer's specification)	
Location	Physical site (e.g. mine site #1, mine site #2)	
	Physical disposition of the tyre (e.g. truck number)	
	Date of delivery to site	
Operation status	Physical location of tyre (e.g. storage, position on vehicle, repairer, disposed)	
	Physical status of tyre (e.g. new, used, scrapped)	
	Recommended inflation pressure (according to manufacturer's specification)	
	Work order numbers (reference to physical aspects such as workers, equipment, re-torques)	
	All mount and demount, fitting and removal events, including vehicle identification, tyre position, machine hours and kilometres, date	
	Inflation pressure data as recorded during operations	
	Original tread depth (OTD)	

Inspection and repair	Remaining tread depth (RTD)	
	Results of condition inspections, including reasons for each fitting and removal event (e.g. cut, sidewall bulge, tread detachment, belt exposed)	
	Repair events (e.g. repair class, name of repairer, costs)	
	Re-treading events (serial number adjusted to reflect re-tread status)	
Disposal	Reason(s) for scrapping (e.g. unrepairable, worn, superseded)	
	Disposal details (organisation responsible for disposal for waste tracking verification) and disposal location	

Wheel and rim history checklist

Identification	Manufacturer	
	Model identification	
	Serial number, or branded number	
	Manufacture date	
Size	Diameter and width	
Events	All fitting and removal events by vehicle's identification, tyre position, date, machine hours and kilometres	
Inspection results	Visual, NDT	
Refurbishment details	Repair class, name of repairer, costs (optional)	
Disposal	Reason(s) for scrapping (e.g. unrepairable, worn, superseded)	

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