

Guideline



Tyre safety, fires and explosions



Department of
Industry and Resources
Safety and Health Division

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Further details of publications produced by the Safety and Health Division can be obtained by contacting:

Safety and Health Division — Publications
Department of Industry and Resources
Mineral House
100 Plain Street
EAST PERTH WA 6004

Telephone: +61 8 9222 3229
Facsimile: +61 8 9325 2280
Email: shed@doir.wa.gov.au

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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 everyone handling tyres, and those with a duty to prevent:

- injuries when working with tyres
- fires and explosions in tyres in service.

Foreword

The *Mines Safety and Inspection Act 1994* established the Mines Occupational Safety and Health Advisory Board (MOSHAB) comprising representatives of employers, employees, unions and government. MOSHAB has the function of advising and making recommendations to the Minister for State Development on occupational safety and health matters concerning the minerals industry in Western Australia.

MOSHAB is also empowered to prepare or recommend the adoption of codes of practice, guidelines, standards, specifications or other forms of guidance for the purpose of assisting employers, employees or manufacturers to maintain appropriate standards of occupational safety and health in the minerals industry.

This guideline was developed through this consultative process, and the views of all parties have been considered. It is issued by the Department of Industry and Resources (DoIR) under the *Mines Safety and Inspection Act 1994*, with endorsement by MOSHAB.

The Act

The *Mines Safety and Inspection Act 1994* 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 a further tier of statute, commonly referred to as regulations, together with lower tiers of non-statutory codes of practice and guidelines.

Regulations

The Act is supported by regulations, which 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.

Application

The provisions of this guideline apply to all mines as defined in section 4(1) of the Act.

1 Introduction

The purpose of this guideline is to describe some of the hazards associated with tyres, and provide guidance and preventative measures to avoid or minimise those hazards when working with tyres or combating tyre fires, explosions and potential explosions. The information provided is derived from extensive operating experience, and is based on incidents and accidents reported to inspectors at DoIR.

2 Nature of the hazard

The hazards associated with tyres are considered here as:

- those relating to working with tyres
- those relating to fires and explosions in tyres in service.

This guideline deals with these separately, but care should be exercised to ensure that areas of overlap are adequately dealt with in operating procedures.



Divided wheels, split-rim and locking-ring wheel and tyre assemblies are particularly prone to damage and explosion, especially due to poor maintenance or incorrect fitting

KEY POINTS — COMPRESSED AIR

- Where possible, deflate all tyres before removing them from vehicles.
- Store equipment such as air lines properly. Do not leave them lying around where they can cause accidents or get damaged.
- Never point an air hose at yourself or anyone else.
- Never use damaged air hoses or fittings.
- Do not kink an air hose to stop or decrease the airflow — this can weaken the hose. Use the pressure or flow control.
- Do not leave air hoses and fittings where vehicles or other heavy equipment can run over them, as this can weaken or damage them. Never leave unattended air lines attached to tyre assemblies.
- Never use an air line that is not fitted with a pressure gauge or a pressure control device.
- Check the accuracy of pressure gauges regularly.
- Never heat a rim with an inflated tyre on it.
- Compressed air should only be used to inflate tyres or operate tools.
- Compressed air should never be used for cleaning. A vacuum cleaner should be used to clean work areas.

3 Working with tyres

There are four major hazards when working with tyres:

- compressed air
- manual handling of heavy objects
- exploding or disintegration of wheels and tyres
- noise.

As with any engineering discipline, lack of training or experience in the handling and maintenance of wheel and tyre assemblies (especially with bead lock systems) can increase the hazard potential.

3.1 Compressed air

The eyes are particularly at risk when compressed air is in use, both from high-velocity air and from particles of dust, metal, oil and other debris, which can be propelled by the air. Suitable eye protection should always be worn.

Injuries to other parts of the body also present a risk when using compressed air. Suitable overalls or other substantial clothing will protect the skin from light particles and debris, provided they are not blown at a high velocity.

However, overalls cannot offer protection against high-velocity air at close range. Particles can be blown through overalls and skin and into the body. Air can be blown into the bloodstream, causing swelling and intense pain, particularly if any cuts, punctures or sores are present, making entry easier. The air can be carried to the small blood vessels of the brain, lungs or heart, resulting in death.

All pressure gauges and control devices must be checked against a master pressure gauge at regular intervals or immediately after any heavy impact or other damage. Good practice would prescribe sound maintenance of compressed air hand tools, and their condition should be monitored on an ongoing basis.

Compressors and associated equipment such as air-receivers should be regularly inspected, in accordance with a schedule of planned maintenance, to ensure that they meet legal requirements and the dictates of safe usage.

3.2 Manual handling of heavy objects

The tyre and wheel assemblies of large vehicles are commonly too heavy to be handled safely by one person. Even the strongest person can suffer a hernia, slipped disc, sprain or broken bone when handling loads that are too heavy. Such injuries can be very painful and limiting.

The safe handling of many loads encountered in the fitting and maintenance of large earthmoving tyres and wheel assemblies can only be undertaken using specialist tyre-handling equipment. Special fittings may be required to modify standard handling equipment (e.g. fork lifts) to deal appropriately with large tyres and wheels.

3.3 Exploding wheels and tyres

This hazard presents in two forms:

- in the workshop or field maintenance situation
- as a result of operating error conditions.

The workshop situation is dealt with briefly below, and the operating implications are covered in more detail in Sections 5 and 6 of this guideline.

Large tyres and wheel assemblies are heavy objects, but when they explode they are thrown violently by the force of the escaping compressed air. An exploding wheel is a high-speed projectile that can kill or maim anyone in its path.



KEY POINTS — MANUAL HANDLING

- Get help with big loads.
- For large tyre and wheel assemblies such as those commonly found on earthmoving equipment, specialist tyre-handling equipment should be used.

KEY POINTS — EXPLOSIONS

- Tears in tyre sidewalls can expel shrapnel of rubber and steel that can penetrate skin and eyes. Escaping air can easily blow a wheel and tyre assembly across a workshop with considerable force.
- Tyre safety cages or other suitable restraining devices should be used whenever work is carried out on tyre and wheel assemblies.
- Training in the use of safety cages and restraining devices should be specific to what is available on site.

Safe handling of heavy objects — ramp is lowered and raised with the assistance of gas struts

KEY POINTS — NOISE

- Noise engineering is an important part of job design. Engineering solutions are always preferred to other means of dealing with the issue of excessive noise exposure.
- Hearing protective equipment must be provided where necessary and its use enforced.

Divided wheels, split-rim and locking-ring wheel and tyre assemblies are especially likely to explode if poorly maintained, incorrectly fitted, or if assembled or disassembled while inflated. The most common faults are over-inflation, removal of split-rim fastening nuts instead of wheel fastening nuts, failure to ensure correct seating of split rims or tyre beads, and the use of damaged parts, or replacement parts with lower strength than the original equipment.

Note that non-original after-market nuts and bolts and other fixings could be inadequate.

It is essential to deflate tyres before wheel removal to ensure that removing the wrong nuts does not result in a serious or fatal accident.

3.4 Noise

Hearing damage can affect tyre fitters just as easily as other at-risk occupations.

Causes of noise-induced hearing loss are compressed air blowing freely, noise from impact wrenches, and wheel parts and tools dropping on concrete workshop floors. Engineering solutions to the problem of excessive noise are preferred. The selection of air-tools for their noise-level characteristics should form part of the purchasing system.

The noise from steel impacting on concrete floors can be reduced with special floor surfaces or mats. Any residual noise above the action level must be dealt with by restricting the exposure of operators at risk. Where noise exposure cannot practicably be further reduced, hearing protection should be provided and its use must be enforced (see Mines Safety and Inspection Regulations 1995, r. 7.4–7.6).

4 Tyre safety cages

All tyres on split-rim and detachable-flange wheels should be contained by a cage guard or other suitable restraining device when being inflated after being dismantled or repaired.

All truck, bus, tractor, forklift or earthmoving plant tyres and other tyres that have a large volume, or are inflated to high

pressures, should similarly be contained by a cage guard or other suitable restraining device when being inflated after being repaired or otherwise removed from the wheel.

Most car or light vehicle wheels and tyres are strongly constructed and have small internal air volume. They therefore do not require high pressures. Such tyres pose minimal risk to the service person and, if correct fitting procedures are adhered to, problems would not normally be expected. However, some light vehicles have divided wheels that require special care. In general, light vehicle tyres should be inflated with the jaws of the tyre-fitting machine restraining the wheel.

It is strongly recommended that all tyres, including small units, be inflated within a suitable restraint. There have been serious accidents even with the smaller types of tyres.

5 Fires and explosions in tyres in service

5.1 Mechanisms of tyre fires and explosions

Definitions:

Pyrolysis The decomposition of a substance by the action of heat.

Flash point Temperature at which a substance (usually a fuel) ignites when a test flame is applied under standardised conditions. This is the yardstick by which fuels are classified for safety in storage and handling.

Auto-ignition Self-ignition or spontaneous combustion of a substance (usually a fuel) without the help of a spark or flame.

The primary cause of tyre fires is the application of heat to the tyre or the development of heat within the tyre structure by one or more of a variety of mechanisms (see below for causes). The same primary causes can result in a violent explosion of the tyre under some circumstances.

For example, heating of rim components or wheel nuts can conduct sufficient heat to an attached tyre to initiate an internal fire that can be accompanied by a violent failure sequence.

KEY POINTS — TYRE SAFETY CAGES

- Cage guards or restraining devices showing damage or excessive corrosion should be repaired or replaced.
- Tyre cages should be anchored to workshop floors or otherwise restrained to minimise movement.



Heat can be conducted through the rim base to the bead area of the tyre where a small quantity of rubber can be pyrolysed. The gases given off in the process can be ignited by the continued application of heat. An explosion could emanate from the point of heating, with the flame fronts travelling around the tyre in opposite directions and causing a rupture where they meet.

A temperature rise sufficient to cause problems can be generated by other sources of heat, such as:

- electrical earthing through the tyre as a result of lightning strike or power-line contact
- wheel component heating through misuse of brakes or electric-wheel motor problems
- internal tyre damage as a result of excessive speed, road camber deficiencies and ply separation.

There can be no guarantee that an uninflated tyre will not explode in the same manner as an inflated tyre if sufficient heat is applied to it.

Other factors that can exacerbate the likelihood of a fire or explosion are listed below.

- The liner rubber used inside tyres can begin to pyrolyse at about 250°C. The mixture of explosive vapours given off (including styrene and butadiene) begins to auto-ignite at temperatures around 430°C. It has been calculated that as little as about 20 g of liner rubber needs to pyrolyse to produce an explosion pressure equal to the burst pressure of a large earthmoving tyre. To form an explosive mixture, the vapours evolved during pyrolysis of tyre rubbers could require a local concentration of only 1–8%.
- The auto-ignition temperatures of different types of bead lubricants and other introduced materials vary widely. Before any material is introduced into the tyre air chamber, its auto-ignition temperature should be checked, and if the figure is lower than that for the tyre liner or bead, it should not be used. Auto-ignition information can be found on the MSDS (material safety data sheet) for a product.
- The accidental use of an incorrect inflation medium (e.g. LPG or other explosive gases) through contamination of the air supply or other means.

- Carbon dust given off from pyrolysis of the tyre liner. This dust can auto-ignite at temperatures as low as 200°C, the lowest auto-ignition temperature of any material likely to be encountered in a tyre.
- Low flash point fuels and solvents can be absorbed by tyre rubber and can increase the propensity for a tyre to catch fire in the presence of a heat source, increase the seriousness of any fire that does eventuate, or both.

A tyre explosion can occur even where no fire is visible. Thus smoking tyres or brakes should be treated as a potential tyre explosion and the vehicle isolated accordingly.

5.2 Causes of tyre fires

Brake problems

Whether induced by misuse or maintenance problems, brake problems can result in tyre fires and explosions. Operators should be trained to understand the consequences of, for example, service brake misuse. Truck manufacturers are to be encouraged to ensure that service experience worldwide is circulated to all users, no matter how trivial the issue of concern could seem.

Wheelmotor problems

Wheelmotor problems, including flashover and armature bearing collapse, can result in heat that makes tyre fires



Engine fires, especially fuel fires, can allow tyre fires to take hold quickly. Tyres can absorb fuels and lubricants in service or maintenance, increasing their propensity to ignite



and explosions more likely to occur. Correct maintenance helps to avoid these problems.

Gross under-inflation or run-flat

The more important aspect with respect to this hazard is the run-flat. Because under-inflation is a relative term, gross under-inflation can result from the gross overloading of tyres that are otherwise reasonably inflated. Operators should be instructed not to drive vehicles with dual flats or with flat single tyres such as steering tyres.

Separation

The type of separation most likely to lead to a tyre fire is heat separation. Correct tyre management will minimise the incidence of this problem.

Fuel spills

Rubber commonly absorbs fuels and solvents, greatly increasing the risk of the tyre catching fire if a source of ignition is available. Fuel and lubrication bay operators should be made aware of these risks.

Fire as the aftermath of a tyre explosion

A tyre explosion can result in a subsequent tyre and vehicle fire. The possibility of fire must be included in plans to deal with tyre explosions.

5.3 Prevention of tyre fires

To prevent tyre fires, eliminate the known causes listed above and consider implementing the options listed below.

Fire-resistant hydraulic fluids

An existing fire will be easier to extinguish if flammable liquids are not feeding it.

Onboard temperature sensors

If the driver can be warned of an over-temperature situation developing, it is possible to take action to avoid a fire.

Onboard extinguishing system

Any fire will be easier to extinguish if it is fought immediately.

5.4 Causes of tyre explosions

Tyre explosions can be caused by:

- brake or wheelmotor overheating or fire
- a heat source, such as a tyre fire
- welding or heating on rims or hubs
- electrification of the vehicle
- combustible materials, including introduced materials in the tyre, particularly those with low auto-ignition temperatures.

5.5 Prevention of tyre explosions

To prevent tyre explosions, and eliminate the known causes listed above, consider implementing the options listed below.

Nitrogen inflation

Although no guarantees can be given that nitrogen inflation will totally eliminate tyre explosions (and in many cases it will not influence tyre fires other than where the explosion starts the fire), it does appear capable of reducing the risk of explosion significantly. Note that there are oxidising agents other than oxygen (such as



Run-flat and gross under-inflation are prime causes of heat build-up in tyres and can result in sufficient temperature rise to induce pyrolysis of the inner tyre surface, with consequent risk of explosion



chlorine or ozone), which can enter the tyre and create an explosion risk. The aviation safety authorities now insist on the use of nitrogen inflation for most aircraft tyres as several fatal aircraft crashes have been attributed to chemical tyre explosions.

Inhibiting agents

Consider the use of fire inhibiting agents and fireproof coatings on the inner surface of the tyre.

Tyre-based solutions

Encourage tyre manufacturers to look for other tyre-based solutions to the problem.

Earthing vehicles

Consider earthing vehicles against lightning strikes so that the tyres do not provide the earthing path.

6 Combating tyre fires, explosions and potential explosions

6.1 Basic principles

Minimum safe approach distance

There is no known minimum safe distance from a potential tyre explosion. Debris from tyre explosions has been thrown 300 m or more. It is suggested that this distance (300 m) be used as a minimum for the setting up of roadblocks. It is possible that material could be thrown further, and this should be considered when designing emergency or remedial actions.

Safe direction of approach

There is no known safe direction of approach. Some tyres have blown out through the sidewalls, and others through the tread. The 300 m-approach distance mentioned above is a minimum suggested exclusion radius around a potential tyre explosion.

Do not expose personnel

All unnecessary personnel should be kept away from the area. Persons combating the fire should not be exposed directly to any possible blast.

The situation is unpredictable. Often it will not be known when a tyre is likely to explode and whether other tyre explosions are likely to follow.

Deflated tyres can explode

It cannot be assumed that tyres from which the pressure has been released are incapable of exploding. If the pressure is being released (e.g. due to a fire having melted the valve extensions) during the pyrolysis process, then some of the vapours generated could be expelled and this will slow the build-up of vapours to the explosive concentration, and possibly prevent an explosion. However, such a mechanism has not been proven to exist and should not be relied upon. Also, it would be extremely hazardous to have anyone attempt to deflate the tyres if an explosion was thought imminent, and this should not be contemplated.

Isolate the vehicle

Vehicles with the potential for tyre explosion should be isolated for 24 hours after removal of the heat source likely to lead to an explosion. An emergency crew should remain in attendance during this period. From experience to date, it appears safe to approach the vehicle after this period. Operators must be trained to park a suspect vehicle only in designated areas around the mine that have been chosen to allow full and safe access to the stricken unit, without affecting others should an explosion occur.

6.2 Nitrogen inflation

Nitrogen has been used to inflate aircraft tyres since World War II. Formula One racing car drivers use nitrogen in their tyres for the same reasons — safety. Nitrogen gas is virtually chemically inert and at room temperature and atmospheric pressure has no taste, colour, odour or toxic properties.

Nitrogen inflation of tyres greatly reduces the possibility of auto-ignition. In fact, when the oxygen concentration within



the tyre is less than 5.5%, auto-ignition cannot occur, since there is insufficient oxygen to support combustion.

Nitrogen is available in three forms for use in tyre inflation:

- gas delivered in cylinders
- liquid form for large consumption rates
- manufactured on site by the use of the pressure swing absorption method.

The form in which nitrogen is made available on site depends on the amount required and the frequency of withdrawal from stock.

The use of nitrogen virtually eliminates rim corrosion in tubeless tyres, leading to better sealing and longer rim life.

Pressure retention in nitrogen-filled tyres is better because nitrogen diffuses through rubber at only one-third the rate at which air diffuses.

It must be noted that the use of nitrogen will not prevent a high-pressure blowout nor external tyre ignition.

Some purging of the tyres could be required to decrease the oxygen content to below the 5.5% level at which the remaining oxygen will not support combustion.

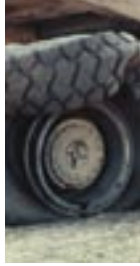
6.3 Potential hazards from the use of nitrogen

Note that the extensive venting of nitrogen into a confined space where people are working can deplete the oxygen level and create a hazard.

As with all gases under pressure, refrigerated, or both, the use of nitrogen can introduce a new suite of pressure- or cryogenics-related hazards that need to be properly accounted for in the safety management system.

7 Further information

MINEsafe 2004, MINEsafe News: Tyre fitters workshop – minutes and presentations, 11 November 2004: viewed 23 February 2005
<http://minesafe.org/minesafe_news/110055326018978.html>



Department of
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Mineral House
100 Plain Street
EAST PERTH WA 6004

Telephone: +61 8 9222 3092
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