Guideline

Tyre safety, fires and explosions

Department of Industry and Resources
Safety and Health Division
Tyre safety, fires and explosions
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.
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.

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

### 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.

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**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.

**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
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...
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

<http://minesafe.org/minesafe_news/110055326018978.html>
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