

Aircraft Tyres – Construction and Maintenance

I spend too much time at the airfield, sometimes going flying and sometimes just chatting with other idle pilots looking at the maintenance standard of the parked aircraft. Some are well looked after, some are not, but a common issue that is shared by many is lack of tyre maintenance. Many tyres are under-inflated and worn. The tyre is a very misunderstood component of the aircraft and as such is being neglected. By looking after it you will be able to extend its life and get more landings for your money.

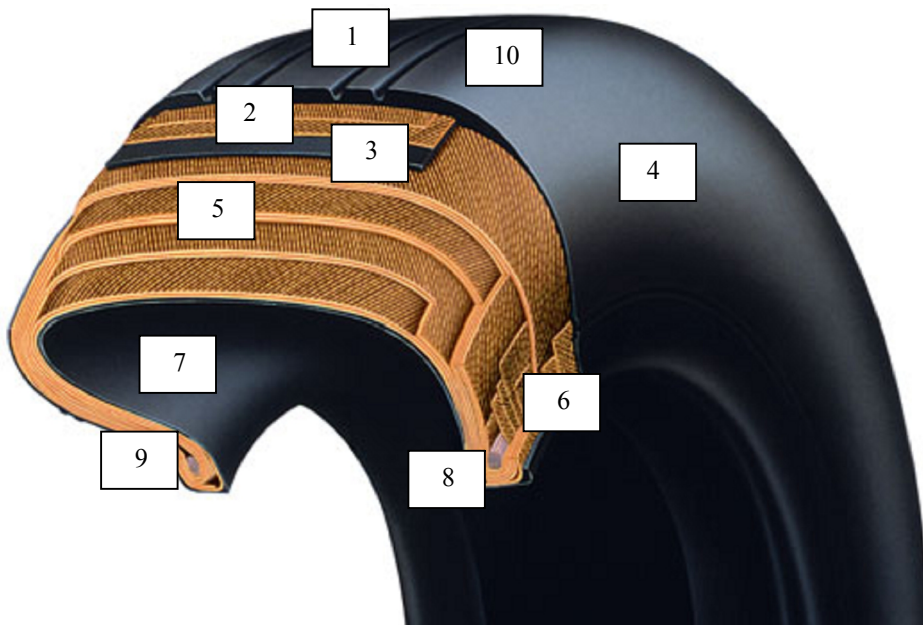
This article was written with reference to “Goodyear” and “Michelin” tyre companies maintenance manuals.

Tyre Construction

In general tyres are divided into two groups, ‘Radial’ tyres and ‘Bias’ tyres.

Bias ply tyres are constructed with the carcass plies laid at angles between 30° and 60° to the centre line or rotation direction of the tyre. The succeeding plies are laid with the cord at angles that are opposite to each other. This provides balanced carcass strength. Most aircraft tyres in service today are bias ply tyres.

Both the ‘Bias’ and ‘Radial’ families have several sub groups according to application and requirements. The group of tyres that will be found on light aircraft (and indeed on most piston powered aircraft) is ‘Custom III’. A typical tyre will be a combination of rubber, fabric and steel, each material designed to perform a specific task that helps to achieve the required tyre performance.



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|---------------------------------|--------------------------------|
| 1. Tread | 6. Carcass ply turn-ups |
| 2. Tread reinforcing ply | 7. Liner |
| 3. Under-tread | 8. Bead |
| 4. Side-wall | 9. Chafer |
| 5. Carcass plies | 10. Shoulder |

Source: Michelin Tyre company

1. Tread – The “tread” is made of a rubber compound which is designed to provide good wear resistance. The “tread” is the area of the tyre that makes contact with the ground. The tread of most tyres contain grooves that are designed to remove water from between the tyre and the runway surface, by doing so improving ground traction on wet runways.

2. Tread reinforcing ply – this is made of one or more layers of fabric and rubber that is laid half way beneath the tread grooves and top carcass ply. These plies help to strengthen and stabilise the tread area by reducing tread distortion under load and high-speed operations as well as adding resistance to puncture and cuts at the tread area.

3. Under-tread – The “under-tread” is a layer of rubber that is designed to improve the adhesion between the carcass of the tyre and the tread reinforcing plies

4. Side-wall – this is the layer of rubber that covers the outside of the carcass plies of the tyre. It protects the cord plies and contains anti-oxidant chemicals that were added during the manufacturing process. These chemicals are slowly released and aim to protect the tyre from UV rays and ozone damage.

5. Carcass ply – a carcass ply consists of fabric cords (modern tyres use nylon), coated by rubber. The carcass body itself is made from multiple layers of carcass plies that are laid at opposite angles to one another, each layer adds to the strength and load bearing capacity of the tyre. The carcass plies are anchored by wrapping them around **bead wires**, thus forming the **(6) carcass ply turn-ups**.

7. Liner – in a tubeless tyre, this is a layer of rubber that resists the permeation of nitrogen and moisture through to the carcass, it acts as a built-in tube. It is vulcanised to the inside of the tyre and extends from bead to bead. On a tubeless tyre, the liner replaces the inner tube. For tube-type tyres a thinner rubber liner is used to prevent tube chafing against the inside ply

8. Bead – the bead is made of several bead wires and holds the tyre to the wheel. The bead wires are made from steel wires that are layered together and embedded in rubber to form a bundle. This bundle is then wrapped with rubber coated fabric for reinforcement. Generally, bias tyres are made with 2–6 bead bundles (1–3 per side).

9. Chafer – The chafer is a protective fabric or rubber laid over the outer carcass of the tyre in the bead area to protect and minimise chafing between the tyre and the wheel’s rim.

10. Shoulder – The area where the tread and the side wall meet.

Operating environment

One of the major differences between aircraft tyres and car tyres is that aircraft tyres are designed for intermittent operation. As a result of this and because of the need to minimise the tyre pressure on the ground the aircraft tyre, when compared to other tyres, is designed to work with large deflection.

During landing the aircraft tyre has to sustain heavy loads and impact forces as well as acceleration to high speed at very short period of time, suffers sudden high temperature and centrifugal forces that cause to compression and shear and tensile forces. Heavy landing, a high-speed landing and hard braking will increase these forces well above their normal level to a point that the tyre can be damaged and will have to be replaced.

The tyre is predominantly made of rubber that is a good insulator, the result is that the heat generated in it during taxi, take off and landing is stored and takes time to dissipate therefore a long taxi at high speed should be avoided. As the air pressure affects the size

of the area that contacts the surface it directly affects the temperature in which the tyre has to operate.

Too fast taxi or too fast landings (or even forcing the aircraft to remain on the ground well above rotating speed) will cause high centrifugal forces. These forces which are dependent on the tyre pressure can cause traction waves that might cause groove cracking and in extreme cases separation of tyre components due to the internal shear forces. When a tyre turns, the tensile forces on the outer plies will be greater than those on the inner plies. As a result shear forces develop between the various layers of the tyre carcass. An under inflated or overloaded tyre will cause an increase in these shear forces and will decrease the life of the tyre, in extreme cases causing carcass separations.

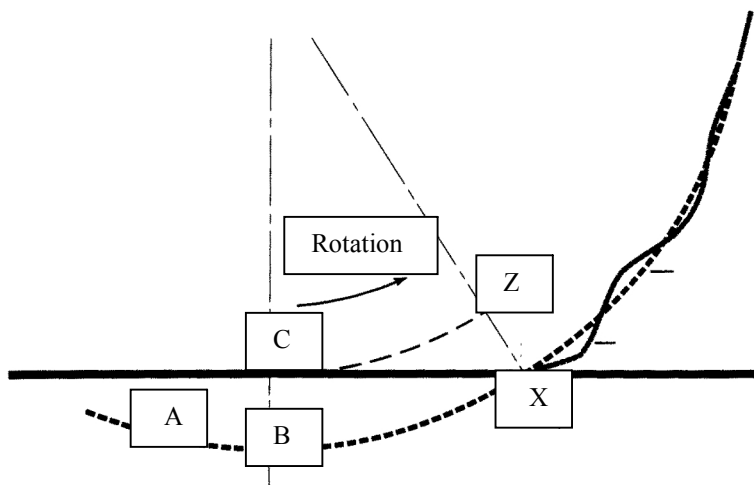
The following was taken from Goodyear's maintenance manual.

CENTRIFUGAL FORCE is combination of LOAD & SPEED

Both heavy loads and high speeds contribute to the strong centrifugal forces acting on an aircraft tyre. The relationship of speed versus centrifugal force is obvious. The effect of coupling speed with a heavy load is shown in the drawing below.

This drawing depicts a tyre rotating counter clockwise. The heavy solid horizontal line represents the ground or runway. The distance "CX" is half the footprint length. Because the tyre is pneumatic, it deflects when coming into contact with the ground. This deflection is represented by the distance "BC" or "XZ". In the same length of time that a point on the surface of the tyre travels the last half of the footprint "CX", it must also move radially outward the distance "XZ".

As the tyre leaves the deflected area, it attempts to return to its normal shape. Due to centrifugal force and inertia, the tread surface doesn't stop at its normal periphery but overshoots, thus distorting the tyre from its natural shape. This sets up a traction wave in the tread surface.





...and in reality this is how it looks

The following parameters help explain the magnitude of forces acting on the tire carcass and tread as it runs on a test dynamometer.

Speed	250 MPH
Revolutions per Minute	4,200
Deflection	1.9 inches

At this speed, it takes only 1/800 of a second to travel 1/2 the length of the footprint (CX). In that same time, the tread surface must move radially outward 1.9 inches. This means an average radial acceleration of 200,000 ft./sec./sec. That's over 6,000 G's! This means the tread is going through 12,000 to 16,000 oscillations per minute. Obviously, a tire cannot withstand this type of punishment.

The above demonstrates the effects of an under inflated tyre fitted to an airliner, the same, although at lower speeds and forces is also true to light aircraft tyres.

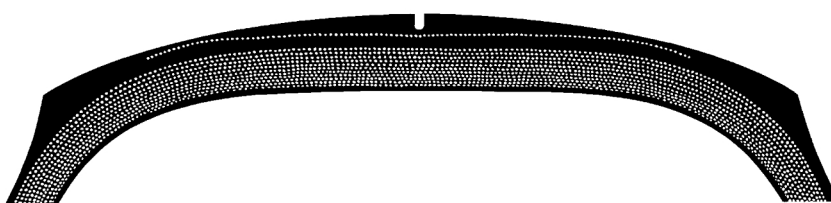
Common tyre wear and damage

During their life the tyres will wear but with a bit of attention we as owners can slow the process and extend the tyre's life. The following wear can be seen on many tyres.

1. Uneven Wear

There are three types of uneven wear. This wear is common in under or over inflated tyres or to tyres where their horizontal centre line (back to front) is not parallel to the tyre's rolling line.

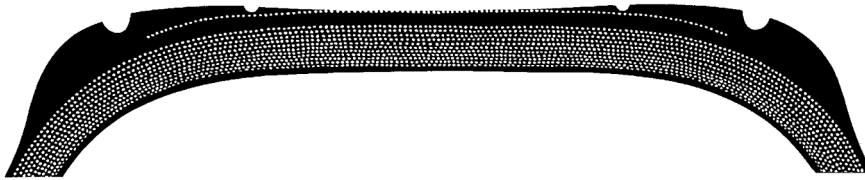
- Under inflation



Source: Goodyear

Under inflation causes the shoulders to suffer accelerated wear due excessive tyre flexing. The tread flexes towards the tyre's centre therefore causing the tyre to roll on its shoulders.

- Over inflation



Source: Goodyear

Over inflation causes centre tread wear. As the tyre becomes 'rounded' It reduces the contact area between the tread and the surface resulting in loss of traction while making the tread more susceptible to cutting.

- Asymmetrical wear



Source: Goodyear

A tyre that does not roll in parallel to its horizontal centre line is effectively being dragged across the surface, this will manifest itself by wear to one of the shoulders.

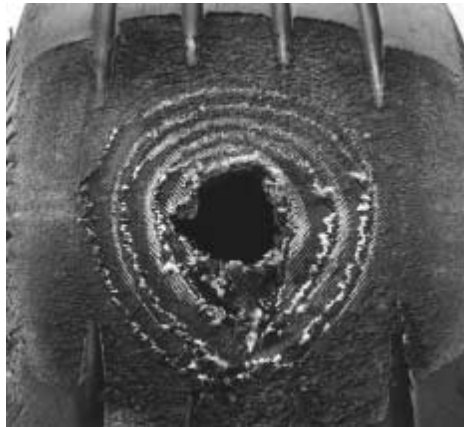
2. Other wear/damage

- Tread cuts
Inspect tread for cuts and other foreign object damage and mark with crayon or chalk. If the cut exposes 'tread reinforcing ply' (fabric) the tyre has to be removed from service.



Source: Goodyear

- Fabric fraying/groove cracking
Tyres should be removed from service if groove cracking exposes 'tread reinforcing ply' (fabric) or if cracking undercuts tread ribs.
- Bulges
Bulges in any part of tyre tread, side wall or bead area indicate a separation of tyre components or damaged tyre. The tyre should be removed from service.
- Tread wear
Inspect treads visually and check remaining tread. Tyres should be removed from service when tread has worn to the base of any groove at any spot and the tyre turns flat. Tyres worn to fabric in the tread area should be removed regardless of the amount of tread remaining.
- Flat spots
Generally speaking, tyres need not be removed because of flat spots due to touch down and breaking or hydroplaning skids. The tyre should be removed from service if 'tread reinforcing ply' (fabric) is exposed.



Source: Goodyear

- chemicals and oil damage
Oil, grease, hydraulic fluids all have a negative affect on the rubber which the tyre is made of. If not cleaned immediately with alcohol the rubber will starts to develop soft soggy spots of decomposed rubber. when aircraft are serviced, tyres should be covered with a waterproof barrier.
3. Environmental effects
- Ozone effect on tyres
Most of the natural and synthetic rubber used in aircraft tyres are susceptible to ozone and will react to its presence. This will result in a degradation of the rubber which lead to cracks. Continued stress due to service causes the crack to grow until it is visible as a surface crack, at right angle to the direction of the applied stress.



Source: Michelin



Source: Goodyear

- Aircraft tyres, like any other rubber product, are somewhat affected by sunlight and extremes of weather. While weather deterioration does not worsen performance, it is possible to minimise its effects by tyre protective covers. These covers should be made of light coloured materials to reflect sunlight and should be placed over tyres when an aircraft is parked outside.

By now, the reader could understand that the major reason for tyre degradation is due to neglect by the aircraft operator/owner, i.e. being under inflated or covered with oil during oil change. If the tyre is inflated to the correct pressure and kept clean of oils it will operate as intended and its life will be extended.

Also do not forget that...



Source: Goodyear

can keep you on the ground. Keep the area around your hangar and parking clean.