# SHOCKS!

# monotube

VS

# twin-tube

As a reader of this publication, the chances are, you have already, or intend on modifying the suspension on a four-wheel drive vehicle. Completing a suspension upgrade is considered to be one of the most vital upgrades for four-wheel drive enthusiasts. Whether you are chasing more height, articulation, load carrying capacity or improved ride quality, the benefits of an aftermarket suspension upgrade are huge.

What was once a relatively simple task has now become a daunting exercise for many enthusiasts. There are now over 60 recognised brands of 4X4 suspension kits in Australia. Each brand sells their version of what they consider to be best for the Australian conditions.

Regardless of brand, there is one debate that continues to rage on within automotive circles; monotube vs twin-tube shock absorbers. Like many debates, the ‘facts’ being reguritated are often derived from advertising materials or websites like Wikipedia. This doesn’t always provide a true representation of the pros and cons of each design. In this article, we are going to address some of the key arguments to paint a clearer picture based on aftermarket technology. When comparing the two designs, it’s important to understand the basic construction and purpose of shock absorbers. To start with, the vernacular term ‘shock absorbers’ is misleading. Dampers, as they are technically called, do not actually absorb the shocks created by uneven terrain or changes in direction. Instead, these inputs are absorbed by tyre and spring deflection.

The role of the damper is to reduce or slow down kinetic energy created by the movement/spring oscillation resulting from such inputs. The damper achieves this by using fluid friction to convert the kinetic energy into thermal energy. As the shock absorber piston moves through the fluid chamber, the fluid is forced through precision orifices in the piston at high pressure. The heat generated by this friction is then dissipated through the shock body.

To allow for the displacement of the piston rod as it enters the chamber, there must be a compressible element within the shock absorber. This is typically air, nitrogen gas or a foam cell.


Rancho twin-tube shock absorber.

All shock absorbers work on this basic principle, but the efficiency and characteristics vary greatly based on the design, quality and construction of the unit. Let’s take a look at the pros and cons of both shock absorber types:

## Twin-tube fade and cavitation

Shock fade is a term we hear a lot about in the 4WD industry. This is when a shock absorber overheats and fails to provide adequate control over suspension movement. It is not caused by gradual wear-and-tear over time. Instead, shock fade is the term given to temporary shock failure under certain conditions.

If a shock absorber is subject to extreme use, such as a badly corrugated road, for a prolonged period, it can overheat. When this happens, the shock oil loses its viscosity (becomes a lot thinner) and experiences hydraulic aeration or ‘foaming’. Aeration is when the air and oil molecules separate due to the expansion caused by heat and pressure. It causes noise, and inconsistent performance as the oil flows through the piston with

less restriction, reducing damping control by up to 35 percent.

For most publications, comparing the twin-tube and monotube construction is simple and conclusive. A monotube shock absorber will 'outperform' a twin tube due to the occurrence of shock fade in a twin tube. A common problem with most comparisons is that simple 'hydraulic twin tubes' are used for testing. This type of shock absorber is not pressurised and relies on the compression of air to accommodate the piston rod displacement.

L: Orifice piston. R: Hi-flow piston

These Hydraulic Twin Tubes are rarely used in today's automotive industry. The design was a poor solution due to the volume of dissolved air in hydraulic fluid (approximately 10 percent) and the tendency for the oil to mix with the additional air inside the shock. As the fluid is forced through the piston orifices, cavitation (air bubbles) occurs quite rapidly due to the pressure difference on each side of the piston. The occurrence of aeration in twin tube shock absorbers is significantly reduced in aftermarket units by the following technologies:

**Gas Pressure:** Pressuring the oil with nitrogen gas (Gas Charged Shock Absorber) significantly reduces the occurrence of cavitation as the oil is constantly pressurised. Pressurising the fluid decreases the intermolecular space between the air and oil molecules, increasing its boiling and cavitation point.

**Foam Cell:** Another form of shock absorber which is common in the 4WD industry is the Foam Cell design. Instead of using gas or air to accommodate displacement, this shock type uses a special sleeve of closed cell foam. The foam cell contains thousands of small air pockets which compress and expand neutralizing the pressure generated by fluid displacement. As no air is used in the shock absorber, cavitation is significantly reduced as the oil cannot mix with air.

**High Flow Piston:** The piston design also plays a major role in shock absorber performance and the occurrence of hydraulic aeration. The majority of mass produced shock absorbers use a standard orifice piston due to cost, reliability and consistency with production. This piston design restricts all of the oil flow through small holes in the piston. When the shock absorber is working hard, this design can be too restrictive causing a large pressure difference on each side of the piston and increased cavitation.

Performance twin tube shock absorbers use high flow pistons with shim discs to restrict and meter the fluid flow. As the pressure increases with the piston movement, the shims open and allow oil to flow through the large piston ports with very little occurrence of aeration.

Bilstein diagram showing oil flow through piston.

**High-quality shock oil:** Without a doubt, the quality and composition of the oil is the most critical aspect of the shock absorber. Cheap, inferior oil, or oil which is designed for a different climate will have major problems with overheating and aeration.

The viscosity of the oil is crucial for maintaining correct dampening control. If the shock absorber overheats, a sudden drop in the oil viscosity will occur causing it to thin-out. The shock absorber design and oil type must be in sync for optimal performance.

## Monotube fade and cavitation

The standard monotube design does offer a superior solution for cavitation by having the gas and oil separated by a floating piston. This prevents the gas and oil from mixing while keeping it pressurised for reduced cavitation.

It's important to note that not all monotube shock absorbers utilize a floating piston to separate the gas and oil. Emulsion or air shocks are a monotube design where the gas and oil are mixed in the one chamber. Major shock absorber brands like Sway-A-Way, Fox, King, and Rad-Flo all manufacture these shocks for motorbikes and off-road buggies/rock crawlers. They are not intended for use on full-sized vehicles and will have issues with cavitation and on-road performance. Unfortunately, we have seen Australian consumers import or fit these shocks believing they are just a cheaper variant of the IFP (Internal Floating Piston) monotubes provided by these manufacturers.

## Monotubes stay cooler

The monotube construction provides unparalleled heat dissipation.

Airflow cools the shock absorber right where the piston is working keeping the shock cooler and maintaining better

**"Suspension is a safety critical system which also plays a big role in the comfort and capability of your vehicle. It's not something that you should skimp out on, but you don't always need the most expensive system either. "**

dampening control.

The twin tube construction does not cool down as efficiently. The heat is generated in the inner tube and has to transfer through to the outer tube wall before it is dissipated.

## Twin-tubes are more robust

Twin-tube shock absorbers are accepted as being more


**Above:** Shock size comparison: OEM Toyota Hilux Shock, Ultimate Suspension Aussie Ryder Twin Tube Gas Shock (bulge body oil reservoir), Fox 2.0 Performance Series Monotube. **Below:** Piston size comparison - OEM 30mm piston (right), Ultimate Suspension 36mm twin tube piston (centre), Ultimate Suspension 46mm Monotube Piston (left).

robust for off-road use due to the twin tube construction. The outer tube can sustain significant stone damage without interfering with the piston operation in the inner tube.

Some monotube shock absorbers do run a thicker wall tube for increased strength but are susceptible to stone damage. If there is a considerable impact which dents the tube, the piston can jam rendering the shock unusable. Stone guards on the shock absorber do help reduce this risk and are recommended for outback use.

## Monotubes are more prone to leaking

Any hydraulic component will leak once the seal is compromised. It's the leading cause of shock failure in every type of shock absorber. It can be argued that monotubes are more susceptible to leaking when compared to other shocks because of the design and application of the unit.

For a monotube shock absorber to function correctly, there needs to be the correct amount of gas pressure in the gas chamber to assist in the control of the compression stroke. This pressure can be anywhere from 60-350PSI depending on the brand and design of shock absorber. When the gas chamber is filled with high-pressure gas, there will be an equal amount of pressure exerted inside the shock absorber, as the effects of Pascal's Law. As a result, high amounts of pressure are applied to the oil seal, which leads to increased friction.
If the seal or manufacturing tolerances are of poor standard, leaks are common.

Pitting or damage on the piston rod is also a common cause of shock failure. This has become more prevalent on monotube shock absorbers when no dust shield is fitted to protect the shaft from stone damage. We highly recommend a stone guard to be fitted especially when the shock has been mounted upside down on the rear suspension.

The number of seals used on a monotube shock absorber will also impact the reliability and longevity. Most traditional units have one main oil seal where the piston rod enters the shock. If the shock absorber is fitted with a remote canister, there are additional seals for the hose, canister and Schrader valve.

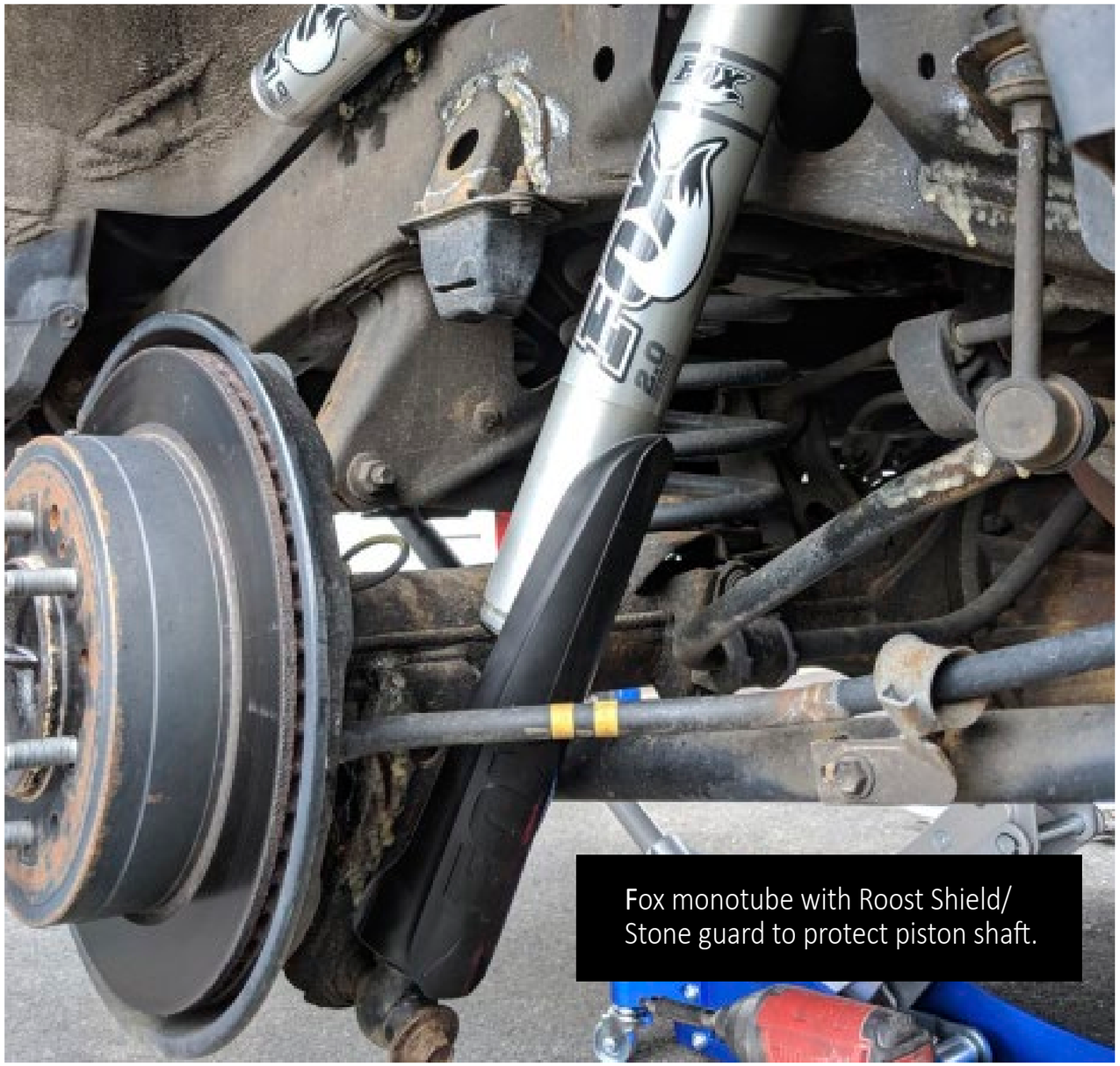
For independent front suspension, the relationship between the coil spring and shock design is also critical. If the shock absorber coil seat does not perfectly match the coil design, an excessive side force is placed on the oil seal and mounting bushes. This causes accelerated bush wear and excessive friction which will wear down the piston rod and oil seal. While this does occur on twin tube shock absorbers as well, we do see a higher occurrence of leaks on monotubes because of this issue. As a consumer, you need to trust and rely on the supplier of the suspension system to ensure the compatibility of different brands.


Comparison photo with a Bilstein and Fox coilover showing different coil seats.

Some brands of performance suspension eliminate this issue with custom coil-over designs that utilise flat coil seats top and bottom, but that doesn't solve the problem for a lot of suppliers that need to provide shocks suitable for fitting with vehicle-specific OEM and aftermarket coils.

## Maintaining significant stroke is difficult with monotube

The compressed length of the monotube shock absorber is somewhat compromised by the gas chamber and floating piston. In some streetcars, this compromise can render the monotube unsuitable




for lowered applications as there is insufficient stroke to accommodate uneven road surfaces. For 4WD applications (up to 2” lifts), this is rarely an issue. When raising a vehicle higher than 2” or running a long travel suspension system, the longer compressed length of the monotube can be a disadvantage when compared to the twin tube. To maintain the same length as the twin tube and prevent the shock from bottoming out on bump (uptravel), it is often required to fit extended bump stops or a remote reservoir which moves the gas chamber out of the main shock body providing an improved closed length.

## Monotube pistons are bigger



Most publications will stress the point that Monotube shock absorbers have larger pistons which allow for more oil flow and precise control over valving. While this is especially true with OEM units, aftermarket twin tube shock absorbers are now running pistons up to 45mm in diameter which provide similar performance to standard 46mm monotube pistons.

When comparing the two, the size of the piston rod is also important to consider. A monotube with a 46mm piston and 20mm piston rod has less surface area on the piston and creates more fluid displacement than a 45mm twin tube piston with a 18mm piston rod.

Some monotubes are available with larger pistons up to 60mm, but these are less common than the standard 46mm piston.

## Monotubes ride firmer because of the gas pressure

I strongly disagree with this statement. With modern tuning and coil technologies, the ride quality of monotube shock absorbers is the same or better than twin tubes. It just comes down to the configuration of the suspension and the intended application. If you fit monotube coil overs designed for track use, they aren’t going to ride well on uneven road surfaces. If the shock is designed for your vehicle type and application, the results are normally very good.

## Monotubes have a larger oil capacity

This statement is commonly used in discussions about the two shock types but is becoming redundant. Shock absorbers now come in all shapes and sizes depending on the vehicle application. Many twin tube shock absorbers have enlarged outer tubes/reservoirs which increases the oil capacity. Brands like Profender even supply twin tube variants with an external reservoir similar to what’s used on monotube shock absorbers. Bigger isn’t always better. The quality and tuning of the shock absorber are paramount.

## So which is best?

I strongly believe that both designs have their place in the Australian 4WD market and the ‘better’ design is based on the application. Suspension is a safety critical system which also plays a big role in the comfort and capability of your vehicle. It’s not something that you should skimp out on, but you don’t always need the most expensive system either.

For value, durability and all-round performance, I believe the twin tube gas design ticks all of the boxes. For performance applications, you can’t simply go past the monotube design.

With so many options available, it’s crucial to make sure that the supplier of the suspension understands your vehicle and application. Even the best quality shock absorber will not perform well if it is not suited to the application.

Brendan O’Keefe is our resident suspension guru. His family has been in the suspension game for decades and their business *The Ultimate Suspension* is respected as an industry leader.