

Suspensions – Why Muck Around With Them

Apart from air-suspended 4WD wagons we can't think of any stock 4WD that won't benefit from suspension modifications that can improve load carrying capacity, off-road ability, ride quality and handling.



A 4WD novice may not see the need to fiddle around with what the 4WD maker has come up with, but experienced off roaders and trailer towers know better.

Standard suspensions are a compromise that is intended to suit the majority of owners and, as we all know, most 4WDs never do anything more adventurous than lightly loaded dirt road driving. Over the past 10-15 years most 4WD wagon makers have adopted different ways of achieving improved on-road handling, because of pressure from a market that perceives 4WDs as 'less safe' than passenger cars. One proved method of achieving better on-road behaviour is to lower the vehicle's centre of gravity. As a result, nearly all 4WD wagons have less ground clearance than those of 20 years ago.

Another problem is that Japanese 4WDs are notorious for suspension sag, where the standard springs take a 'set' that is lower than the standard ride height. This can happen to lightly loaded vehicles, but is almost a certainty with those that are used at gross vehicle mass or coupled to heavy trailers with high tow-ball loads.

If you intend to venture onto difficult 4WD trails, do long Outback expeditions or tow a heavy trailer your vehicle will benefit from a purpose-designed suspension.

However, when you depart from standard 4WD suspension components you discard a formula that the original vehicle maker feels is a reasonable compromise of ride, suspension travel and handling characteristics.

The advantage of after-market components is that they can be tailored to suit your use and aren't a compromise for a wide market. However, springs and shock absorbers need to complement each other and are best sourced as a complete, well-developed kit.

Most after-market suspensions incorporate a belly clearance lift of around 50mm. Note that this lift doesn't increase the ground clearance under live, beam axles, which receive a ground clearance boost only when the rolling radius of the wheel and tyre combination increases.

A combined suspension lift and tyre size increase that raises the vehicle more than 50mm can cause gearing, braking, handling and stability problems and may well be illegal in some jurisdictions.

In some States it's illegal to fit tyres that have more than a five percent increase over the standard diameter. The main driver behind this legislation is reduced braking ability, because the larger the diameter of the tyre the more the braking pressure requirement for the same stopping power.



A bonus of even five percent larger rubber is reduced engine rpm at cruising speeds, so there can be economy benefits, but off-road gearing is worse.

Your speedo will also be out of whack, so you'll need to fit a different speedo drive, use your GPS as a speedo, or make a mental adjustment when you scan the speedometer.

Any change to front or rear suspension ride height alters the alignment of the axles and suspension with the chassis and body. Well engineered suspension kits compensate for the lift.

Sourcing a New Suspension



You need to be sure of what you intend to do with your vehicle before you buy a new suspension for it.

A common scenario for a 4WD wagon is on-road towing, with little or no off-road driving. Provided most of the load you're putting on the vehicle is in the trailing bit, the starting point is a set of air-bellows helper springs at the back end of your 4WD. These come in a kit that isn't difficult to fit and provide variable spring rates to suit most load and road conditions.

If you intend to tow an off-road camper the vehicle can probably benefit from a suspension height boost, in addition to some rear spring rate increase, so a full suspension kit may be in order.

Most 4WD wagons we've seen in the bush are loaded to the hilt, or above it. By the time you bolt on a bar and winch, install a second battery, fill up with water and fuel and load up the interior and the roof rack, your 4WD wagon is at its rated gross mass at least. It's obvious that the vehicle's suspension is at its limit, because the axles are perilously close to the bump stops.

The cure is a set of stiffer springs that cope with the full-load condition, matched to shock absorbers that are valved to suit the spring rates.



Most 4WD owners who buy after-market suspensions opt for load-capacity and ground clearance improvements – longer, stiffer-rate coil springs, thicker torsion bars or more-cambered leaves that lift the chassis, matched with longer shock absorbers.

These components achieve an increased ride height at full load, but there are compromises when the vehicle is lightly loaded. Stiffer springs and larger shock absorbers often give a firmer ride than the standard 'softies'.

When you do take the suspension kit plunge it's important that you buy from a company that has done considerable research and development, and warrants its products.

Our suspension testing over the years has shown that some have done more homework than others.

You'd imagine that different suspension suppliers would come up with roughly the same spring rates and shock absorber settings for a given 4WD, but we've found wide differences in spring and shock absorber specifications.

Price is not always a reliable guide, because some of the cheaper kits have tested better than top-priced ones. We suggest you 'try before you buy' by riding in the suspension maker's demonstration vehicle, before you put in your order.



Avoiding Shock

All shock absorbers look roughly the same from the outside, but there can be a wide difference in the quality and ability of the internals.

In rank order, the most capable shockers are mono-tube types, but they can be damaged by flying stones. Mono-tubes have a second, floating 'piston' that separates the pressurising gas from the oil and that piston thickness limits the mono-tube's range of travel.

Twin-tubes are the most popular 4WD shocks, because the outer tube acts as a stone-damage shield for the internal one, in which the piston slides. Twin-tubes have only one piston and longer travel than an equivalent-length mono-tube.

Adjustable shockers can theoretically be set for different load and road conditions, but our testing of them has shown that there are wide quality variations between them and the adjustability isn't always consistent.



One of the great dangers in changing suspension components is finishing up with dampers that have open and closed lengths that don't match the travel limits of the springs. Dampers that are too short can be torn apart by extreme suspension travel, while those that are too long may bottom out and break shocker mountings. Satisfy yourself that the after-market suspension designer has done a relative-motion exercise on the suspension you intend to buy, to ensure that the shockers are correctly proportioned.

Relative motion measures the distance each shock absorber travels as the spring travels from full stretch to full compression, or bump-stop contact. It's quite common for the relative motion on one side of a vehicle to be slightly different from the other and the shock absorber lengths need to allow for that.

Ute Suspensions

Although 4WD enthusiasts use their utes for play the designers must think firstly of work. Inevitably, a working machine becomes a compromise play vehicle.

A ute suspension is designed primarily to carry the vehicle's rated load capacity. Ride quality and handling are important design factors, but payload considerations are paramount. Cost is a significant factor as well, because base model 4WD utes are expected to be very competitively priced.



Up front, ute suspensions are almost universally independent these days, with torsion bar or coil springs. The three 'toughies' - Patrol, Defender and LandCruiser - retain live front axles with coil springs. The most common ute rear end is a live axle with leaf springs, because leaves are simple, robust and...cheap.

The leaf spring has certain advantages when it comes to coping with varying loads, because it's easy to make a leaf spring pack act progressively as the load increases. Typical leaf packs have two or more full-length leaves, backed up by one or more heavy-load, shorter-length leaves.

The full-length leaves provide lower-rate springing for light-load conditions and the 'helper' leaves stiffen the spring pack when heavy loads are applied.

In recent years some 4WD ute makers have sought to improve leaf spring ride quality by using springs that don't have interleaf friction, with better quality shock absorbers.

But even with the best available springs and dampers there's a limit to what can be achieved with leaf springs. On rough roads a lightly laden leaf spring deflects as far as the helper leaves, giving the typical early 'bottoming' feel to the suspension action. In rebound the powerful, initial spring movement upward off the helpers is almost impossible for the shockers to control.

Off-road the leaf spring must twist as the live axle moves diagonally over track undulations. This twist destroys spring, shackle and shocker bushes.



Coil springs give much improved ride quality, but are more difficult to produce with varying load capacity.

Coil springs can be made progressive in load capacity, by using unequal pitch windings or, better still, tapered wire, but this latter technology has not been widely adopted by 4WD ute makers. The best known example of variable-rate coil suspension is the inner and outer spring arrangement on the back of the Land Rover Defender 130 and the Mercedes-Benz Unimog.

Air springs would seem to be the future for the back ends of 4WD utes, with all European and several Japanese light and medium truck makers adopting this method of avoiding sag and coping with a wide range of rear suspension loads. As the load increases an on-board pump raises pressure in the rear air springs to preserve ride height and to increase the spring rate of the suspension.

Improving What You've Got

After-market rear springs have an advantage over the original springs in that they can be tailored to suit your actual payload, rather than maximum load. In return for reducing the payload capacity of your ute a set of after-market rear springs can be more supple and thereby improve ride quality and wheel travel.

Some of that lost load capacity can be regained by fitting low-pressure airbags on top of leaf springs or inside coils.

Most owners opt for a suspension lift at the same time as they fit after-market springs, but bear in mind that 50mm lift is plenty. Leaf springs that are heavily cambered to increase ride height above 50mm can be very hard-riding. Other not insignificant factors are that a lift above 50mm may be illegal and too much height may give an insurance company an 'out' in the event of an accident.

If a heavy bar and winch, and a second battery are loaded up front it's wise to upgrade the load capacity of the front suspension. Heavier coils or torsion bars are available and a 30-50mm lift is OK.

The revised front and rear springs need to be matched with quality shock absorbers. It's vital that the open and closed damper lengths and the valving match the front and rear suspension characteristics. Not many after-market suppliers are qualified to do this.



There is now an increasing number of rear air suspension kits for 4WD utes. These suspensions replace coils or leaves with large airbags and are different from the small airbag types that are intended only to assist steel springs.

An important suspension component that's often ignored is the humble bump stop. Factory bump stops are usually hard-rubber types that offer some last-resort protection from metal to metal contact, but progressive bump stops are available that have a more graduated action. After-market bump stops can improve wheel travel and ride quality.

Air Suspension is the Future

Air suspension is the hallmark of today's leading-technology 4WD wagons and after-market fitments are available.



Because of the height-adjustability of air suspension, a 4WD can be designed to have a low centre of gravity for optimum on-road handling and high ground clearance for off-road driving. No mechanical suspension can duplicate this design feature.

Air suspension's other benefits include progressive-rate springing, automatic height and levelling control, and less mechanical vibration transfer to the chassis and bodywork.

However, the only air suspension components available in the 4WD after-market have been replacement kits for the rear axles of some utes and light trucks and the well-known Polyair auxiliary air springs for leaf and coil suspensions. However, neither of these add-ons offers full-air suspension for both axles of a 4WD.

Full-air suspension conversion componentry has been around for a while, but there's still work needed to refine the system.

Nearly all truck, bus and heavy trailer air suspensions use a 'rolling-lobe' design and so does the 4WD full-air system. In this air suspension layout the top of the air spring (bellows) is bolted to an adapter plate that sits where the coil spring's upper wear collar normally is found. The connection is by way of a hollow stud, so that air can pass in and out of the bellows.

The bottom bellows location is on a shaped 'piston' that bolts to the axle, or the lower suspension arm in the case of independent suspensions.

The air bellows is tapered top and bottom, so as the air bellows is compressed by bump action, its lower section forms a 'lobe' that rolls up inside the bellows, following the action of the piston, to which it's attached: hence, a rolling-lobe design.

The piston can be tapered, parallel-sided or wine-glass shaped, for differing spring-rate effects.

Adapting a coil-sprung vehicle to full-air requires calibrated fine-tuning and the services of a suspension specialist, such as Yass-based Suspension Technology Australia.