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DRIVING/TOWING

TOWBALL WEIGHT AND TRAILER STABILITY – Updated June 2015

Science outweighs the rule of thumb.

We've all heard of the 10-percent rule: conventional wisdom has it that a trailer coupling should bear around one tenth of the total trailer weight.

The purpose of this percentage is manifold: guaranteeing that the trailer won't lift the rear wheels of the towing vehicle under acceleration or when climbing a steep grade; ensuring that the trailer tracks accurately behind the towing vehicle; and preventing trailer sway.

In North America virtually all trailer and caravan makers endorse the 10-percent rule and some go so far as to suggest the towball load should be as high as 15 percent. In the case of a 2000kg trailer that means a towball load of 200kg to 300kg.

In Europe it's an entirely different story: the typical EEC car and 4WD towball load is between 50kg and 75kg, and even heavy trailers – above 3500kg – have towball loads around 100kg.

In Australia we have largely adopted the North American model. Most trailer and caravan makers endorse the 10 percent rule, regardless of the trailer configuration and the number of axles.

Many car and 4WD makers hate the 10-percent rule, because it forces them to design heavier rear sections and stiffer rear suspensions than they need in most markets.

Some makers, like Subaru, limit the permissible towball load to a set figure (90kg for most models) and insist that if a Subaru is coupled to a trailer or caravan with a heavier towball load the owner must fit weight-distribution bars, to pull the towball weight back to 90kg.

We've towed a variety of caravans and camper trailers behind Subaru Outbacks, with towball weights less than 90kg and no weight-distribution bars and have had no sway issues.

Why have a heavy towball weight in the first place, many people ask?

The marketplace is full of theories, but very light on actual test results. It's a popular belief that a heavy towball load reduces the chance of trailer sway.

If that were the case the new EEC trailer regulations would surely have mandated heavy towball loads, because European caravans mix it with high-speed traffic on multi-lane roads and need all the stability they can get.

European and Australian light and heavy truck 'pig' trailers – drawbar trailers with centrally positioned tandem or tri-axle bogies – have very little or no towball weight and don't have significant sway problems.



Ongoing vehicle manufacturers' analysis and Society of Automotive Engineers' testing has shown the factors that influence trailer sway include driver skill, speed, vehicle and trailer weight, vehicle and trailer load centres of gravity, number of trailer axles, aerodynamics, heavy-vehicle air turbulence, weather conditions, road surface undulations, wheel bearing condition, trailer brake adjustment, towball to coupling clearances and friction, tyre pressures and the suspension dynamics of towing vehicle and trailer.

The prospect of negating all these factors by simply upping the towball weight is unlikely.

Interestingly, on the subject of driver skill, the EEC trailer towing regulations limit car-licence drivers to 750kg trailers, with or





without brakes. To tow a trailer weighing 750kg up to 1750kg requires two days of driver training and an upgraded licence test.

Towing trailers that weigh more than 1750kg requires a truck licence. Can you imagine our weak-kneed polities implementing such 'repressive' legislation?

European police regularly spot-check trailers for roadworthiness, gross mass violations and excess towball loading. All cars or 4WDs towing trailers above 80km/h, up to a maximum of 100km/h in Germany, must have a friction-type coupling to reduce the likelihood of trailer sway, but North American and European vehicle makers are increasingly turning to electronic stability control (ESC) to counter trailer instability. AL-KO has recently introduced its ESC system Down Under.

As with solo-vehicle ESC the system applies selective wheel braking to towing vehicle and trailer, to prevent a 'pendulum' effect developing. Trailer ESC is activated when the trailer plug is connected to the towing vehicle.

We've driven a 42-tonne EEC-spec' prime mover and trailer combination fitted with ESC on all axles and found the stability improvement almost unbelievable, but European truck makers stress the point that ESC won't make up for a poorly loaded or badly driven combination.

Towball Weight Research



Until 2009 there was virtually nothing published anywhere on the topic of real-world, light vehicle and trailer towing stability, although it's known that some vehicle makers have done considerable R&D in this area. In contrast, heavy truck and trailer R&D is well documented and all prime movers and semi-trailers sold in Europe can be ordered with stability control.

A paper entitled "An experimental investigation of car-trailer high-speed stability" was published in mid-2009 by the Department of Mechanical Engineering at Bath University in the UK.

The paper, by J Darling, D Tilley and B Gao, summarises the findings of tests carried out on a standard UK-built caravan and on an adjustable trailer, in which different dimensional and mass factors could be evaluated.

The tests began with matching the adjustable trailer so that it replicated the dynamic behaviour of the caravan, then altering one dimension change and one mass change at a time, to evaluate the results of the changes. More than 600 different trailer parameters were examined.

In summary, the engineers discovered that the three most significant parameters affecting trailer stability were trailer yaw inertia, nose mass and trailer axle position. Interestingly, the total weight of the trailer wasn't a stability issue of itself, but weight distribution was critical.

Weight Distribution in Trailer Design and Loading



The researchers concluded that the best way to minimise trailer yaw inertia – the tendency for the trailer to sway laterally – was to position any trailer load at or near the centre of gravity. Loads fore and aft of that position increased the likelihood of towing instability.

The optimum nose mass (ball load) was found to be 6–8 percent of the trailer's gross mass. This is quite different from the common 'rule of thumb' relied on in Australia and the USA, where ball loads of 10–15 percent are common.

Provided the measurement didn't increase the ball weight beyond eight percent of trailer gross mass the greater the distance between the coupling and the axle, the more stable the trailer was in test manoeuvres.

The researchers evaluated car ESC, by performing stability manoeuvres with ESC alternately switched on and off. The trailers did not have TSC, yet even without this program, car-only ESC produced more stable behaviour than did the non-ESC tests.



Checking your trailer's ball weight

There are two professional ways to check trailer ball weight: split-weighing at a public weighbridge and using a ball-weight scale. Fiddling around with a vehicle and trailer at a weighbridge takes time and split-weighing can be tricky at busy weighbridges, where truckies are anxious to get a printout of their axle weights and get on the road.

Using a ball-weight scale means setting up the trailer in its loaded state, on a level surface and using the scale to measure the ball weight as load is wound off the jockey wheel. One such compact device – the Towsafe ball weight scale – is available from Repco and caravan accessory outlets for less than \$90 – a low price for safety and peace of mind, in our view. An adaptor allows this scale to measure ball weights of trailers with any type of coupling.

The optimum device for measuring towball weight is the Reich Caravan Weight Control device. This European-designed and made scale measures axle weights as well, giving a total picture of tow vehicle and trailer.

The Reich CWC comes in two models, with wheel capacities of 1000kg (yellow finish) and 1500kg (orange finish), respectively. Being European, its ball weight calibration originally topped out at the EEC maximum of 100kg, but the CWC has now been recalibrated for Australian conditions and can register ball weights up to 455kg.

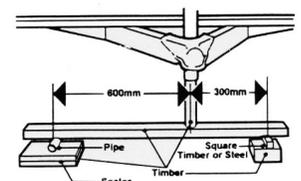
The scale measures and records each wheel weight in succession as the trailer is driven onto the scale. Towball weight is checked by placing the scale under the raised jockey wheel and then lowering the wheel onto it. When all axle weights and the jockey wheel weight are recorded the CWC displays the individual weights and the total.



However, some people won't invest in a ball-weight scale, so a set of bathroom scales can suffice, in conjunction with a sturdy piece of wood or steel tube between the scale and the ball receiver. It's necessary to use a load-spreading pad of wood on top of the scale, so you don't damage its upper surface.

Where ball weight is likely to exceed the capacity of the bathroom scale it's possible to use the 'ratio method' to measure ball weight. In this procedure a strong piece of wood, around 100mmx50mm thick, or square steel tube is used between the scale and a fulcrum that's the same height as the scale's upper surface. If the load-supporting piece of wood or steel tube is positioned exactly midway along this piece of wood or steel the reading on the scale will be half the actual ball weight. A piece of horizontally-laid dowel, thin square tube or pipe on top of the fulcrum and the scale allows accurate distance measuring.

If the half-ratio measurement would exceed the scale's capacity you can vary the position of the fulcrum and scale, so that the ratio alters from 2:1 to 3:1 or even 4:1. In the photo and diagram the ratio is 3:1, because the distance from the fulcrum to the ball is one third of the distance from the fulcrum to the scale.



Trailer Stability Control

Trailer Stability Control (TSC) is an extension of the towing vehicle's ESC program and is designed to intervene when vehicle sensors detect a dangerous yawing ('snaking') movement of the trailer. If a yawing movement begins and exceeds a certain limit, the towing vehicle is decelerated within milliseconds by throttle closure and brake application, until stability is restored.

By taking advantage of the ESC system's ability to manipulate engine output and apply wheel-specific braking, TSC seeks to extend the control-enhancing abilities of ESC to the vehicle's trailer.

Trailer sway can be caused by crosswinds, improper loading of the trailer, incorrect tyre pressure, road conditions or even the 'wind wave' from a passing heavy vehicle.

In general, TSC monitors the side-to-side motion of the tow vehicle to determine if the trailer is swaying. If the sensor detects yaw that isn't caused by the driver's steering inputs, it begins working to control the unwanted motion. Moderate brake pressure is applied to a single front wheel in an alternating fashion dictated by the severity and direction of the sway. Light brake pressure is applied to the other three wheels, helping reduce vehicle speed in a controlled manner.



AL-KO trailer anti-sway control

AL-KO is best known in Australia for its rubber-bushed, independently-suspended, torsion-bar trailer axles, but the company produces a range of caravan and motorhome chassis in Europe and is well advanced in trailer dynamics R&D.

AL-KO Trailer Control (ATC) consists of an axle-mounted sensor connected to an electro-mechanical actuator.

ATC monitors trailer stability in a similar manner to vehicle ESC and if a snaking motion starts the ATC sensor activates the trailer brakes, to slow the combination and eliminate the yawing action of the trailer.

For the Australian market AL-KO developed a version designed to operate with electric trailer brakes and this was initially offered in 2012 through new caravan outlets. In January 2013 AL-KO announced the release of Electronic Stability Control (ESC) technology as a retrofit product for older caravans.

From February 2013, AL-KO began a progressive rollout of its AL-KO ESC Certified Installer Network, with technicians trained in the installation of the product. AL-KO ESC is available for existing caravans with AL-KO running gear and brakes on approved suspensions. AL-KO claims the cost of retrofitting ESC to an existing caravan is \$1200 – \$1500.

The AL-KO system differs from your tow vehicle's ESC in that it applies equal brake pressure to all trailer wheels.



Dexter Sway Control



In mid-2014 Dexter Axle Co, a leading US manufacturer of trailer axles and trailer brakes for over 50 years, announced the launch of the Dexter Sway Control system (DSC).

This electronic system uses a yaw sensor, similar to the one fitted to your towing vehicle if it's equipped with ESC. In the event of trailer sway the system applies the brakes on one side of the trailer, independent of driver action, to correct the sway action.

"This next-generation technology detects trailer sway and applies either the left or right brakes dampening the sway much quicker than other systems that apply brakes on both sides at the same time," explained Bryan Thursby, Dexter's vice-president of sales and marketing.

The Dexter Sway Control is available through Dexter's agent in Australia, Melbourne Trailer & Caravan Supplies, for fitment to pre-owned units by a qualified technician.

We caught up with MT&CS during their testing program in Melbourne. It was a very, very interesting morning.

The test rig that MC&CS has been using wasn't suitable for filming, being a skeletal rig, with a 1.5-tonne block and wires and data sensors all over the place, but we will have a video as soon as possible, showing a typical caravan and tow vehicle performing some dynamic manoeuvres.

OTA's Allan Whiting couldn't believe the stable behaviour of the non-ESC tow vehicle and trailer, through what were tight S-bends on a mixture of surfaces at relatively high speed. We would have managed this test course at that speed in the solo vehicle, but could not believe it possible with the two-tonne trailer behind. However, it was a doddle.

"At one point, during a tight gravel section, I felt the rear end of the tow vehicle break away in a power slide and anticipated a power jack knife to follow instantly, but the trailer braked left side and right side and pulled the *tow vehicle* straight.

"A typical lane-change manoeuvre at 80km/h was as stable as it would have been without the trailer behind, thanks to the Dexter DSC system.

"I'm convinced."

We'll have a video test for you as soon as possible. In the meantime, check out how the system works:

