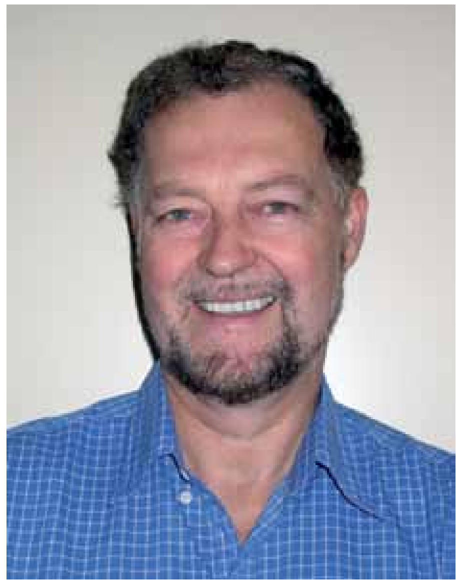

ARTSA's Brake Test Investigation – Part 1

ARTSA recently commissioned two separate investigations into the brake performance of semi-trailers. The tests were done to provide a basis for the recommendations in the ARTSA brake code. In this article I want to describe the results of an investigation into brake balance on a semi-trailer with various brake set-ups. Later articles will consider the performance of Antilock brakes (ABS) and Electronic Stability Control (ESC).

Stopping tests were conducted using a semi-trailer that had been modified so that the brake level on each axle could be set. Effectively, the brake level could be altered on each of the three axle groups by independently setting the brake air pressure. The maximum deceleration that could be achieved without the combination vehicle leaving a curved test lane was tested.

The tests were conducted by the Australian Road research Board (ARRB) at DECA's Shepparton test track. ARTSA gratefully acknowledges the excellent commitment of ARRB and the financial sponsorship of the Queensland Department of Transport and Main Roads.

The tests were modelled on the 'braking in a curve test' which is in the US braking rule FMVSS 121. This rule requires demonstration of directional control on a 500 ft (152.4 m) radius path of 9 ft (3.7 m) width, by a semi-trailer vehicle that has a prime mover with antilock brakes. The entry speed was 30 mph (48 km/h). In ARTSA's tests there were no electronic brake controls.

The test prime mover and its semi-trailer were modified so that the foundation brakes on each of the three-axle groups were supplied from an independently controllable and regulated air-pressure tanks. Braking was triggered by depressing the clutch pedal, which initiated sudden electrical operation of three solenoid valves, which applied the pre-set air pressure to the brake actuators of each axle group, with the engine disconnected. By varying the levels of the three regulated air supplies, the test vehicles could be set-up to simulate common Australian and European brake setups.

Typical Australian prime mover and trailer setting were made. These did not have load-sensing brakes. The Australian prime-mover ("ADR prime-mover") had 75 per cent brake capacity on the steer axle compared to the European ("ECE prime-mover") prime mover and the Australian prime-mover had 115% drive –axle group brake capacity compared to the European prime-mover. The laden Australian trailer ("ADR trailer") tri-axle group had about 140% brake capability compared to the laden European trailer ("ECE trailer").

For some tests the lightly laden and half-laden Australian trailer group was set-up to simulate load-sensing brakes; that is, the brake levels decrease as the weight on the axle decreases. Load-sensing brakes of the Australian set-ups were simulated by setting the trailer brake air pressure to 65 per cent of the full-load value ("ADR LSV"). The European truck and European trailer brakes were set to comply with the international brake rule ECE Regulation 13, which is mandated in Europe. A certified European brake calculation program was used to determine the necessary settings. The European set-ups both have simulated load-sensing brakes as this has been a long-time requirement in rule ECE R13. The European load-sensing valve set-ups are lower than 65 per cent.

Tests were conducted with four different load levels as shown in the table. A satisfactory brake set-up can achieve relatively high deceleration levels without losing directional control for all the loading conditions.

During testing, the brake control level was increased progressively until the vehicle could not be stopped within the 3.7 m wide lane on a wetted track. When a failure occurred, the brake control level was set to the previous pass level and the previous test was verified. This was the recorded pass level. Both the prime mover and the trailer had disk brakes and air-bag suspensions the rear axle groups. The steer tyres were 295/80R whilst all other tyres were 11R22.5. Preliminary straight-line tests were conducted to determine the force levels that each axle group produced at key air pressures.

Results

The graphs show the deceleration results for the six combinations and for the four load conditions that were tested. The best performance occurred when the trailer had load-sensing brakes (ADR LSV or ECE). The best overall performance was achieved by the Australian ADR prime mover pulling the Australian trailer with load-sensing brakes (ADR LSV). This achieved deceleration levels of about 0.25g in all loading conditions. The brake system was well balanced. The ECE prime mover with the ECE trailer was also a good performer. Its unladen deceleration was 0.22g, which was low because of a tendency for steer wheel lock-up (understeer). This highlights another important factor that is not evident in the graphs. The mode of failure needs to be considered.

If the performance is limited by front axle lock-up, which typically occurred for the European truck, understeer occurs but the driver can correct this by reducing brake level. If however, the performance is limited by the drive-axle group locking up, which results in jack-knife; it is unlikely that the driver can correct it. Locking up of the trailer tri-axle group leads to trailer swing, which is probably correctable, but it takes longer to control than understeer. Therefore, the way in which the loss of stability occurs is also important. Mixing the European prime mover with the Australian trailer and vice-versa results in poorer performance because these vehicles have poorly balance brakes.

The main conclusion from the tests is that best directional stability occurs when the trailer has load-sensing brakes. For a typical Australian trailer set-up setting the load-sensing valve to give 65% brake level when unladen results in good brake balance. The European combination also gives satisfactory performance because this combination is well balanced. It is brake balance that determines directional stability at high brake levels.

Peter Hart
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Calculated axle-group and kingpin weights for each test condition

Axle Group Loads	Unladen (t)	Half Load, Even (t)	Half Load, Drive Heavy (t)	Laden (t)
PRIME MOVER – STEER AXLE	4.90	5.19	5.65	5.7
PRIME MOVER – DRIVE GROUP	5.81	10.92	15.75	16.50
KING PIN IMPOSED LOAD	2.70	8.10	13.27	13.99
TRAILER – TRI-AXLE GROUP	5.90	12.40	7.53	18.81
LOAD WEIGHT AND HEIGHT	0	11.90 AT 1.14M BACK FROM KINGPIN. C OF M HEIGHT OF LOAD IS 2.2M	12.20AT 1.14M BACK FROM KINGPIN. C OF M HEIGHT OF LOAD IS 1.8M	24.22 AT 4.55M BACK FROM KINGPIN. C OF M HEIGHT OF LOAD IS 2.25M
TOTAL VEHICLE WEIGHT	16.61	28.51	28.81	40.82