

Summary of Code Recommendations

The recommendations of the Code give guidance about the mixing of brake technologies on combination vehicles. They are:

General:

- It is preferable to use the same brake technologies on each vehicle part in a combination. In particular, if one part has an adaptive brake technology then it is preferable for all parts*

This makes it easier to achieved balance performance under all operating conditions.
- Where mixed brake technologies are installed, the same brake technology should be used on all the trailers of a multi-combination vehicle.*

The truck brake system is pre-eminent because it controls the trailers. It is difficult to achieve acceptable brake balance or even compatible performance when the trailer brake systems are substantially different.
- A suitable performance standard is that a combination vehicle – irrespective of load - should be able to achieve a stopping distance that is no more that double the theoretical stopping distance with perfect brake balance, without gross wheel lock-up occurring*

Such a vehicle will achieve a reasonably short stopping distance and remain directional stable up to high braking levels.
- A vehicle that has either antilock protection (ABS function) or adaptive brakes on all vehicle parts can be assumed to meet the performance standard if it is set-up appropriately.*

Wheel lock-up protection will eliminate gross wheel lock-up. Adaptive brakes that are correctly set will provide good brake balance. A vehicle with either (or both) features on each part is unlikely to lock-up wheels when stopping at 0.45g from 60 km/h.
- Despite recommendation 3, it is necessary to set-up electronically controlled braking systems and Load Sensing Brakes according to other recommendations.*

Antilock brakes should be programmed with the correct vehicle dimensions and tyre specification. Adaptive brakes (LSB and EBD) must be set according to the weight variations that occur.
- The onset (or threshold) pressures of all the brakes on a combination vehicle should be inside a 10 kPa range.*

This ensures that all brakes in good mechanical condition apply at about the same control level.
- Vehicle manufacturers should adopt the following design levels for onset braking pressure: Trucks 70 kPa and Trailers 65 kPa.*

These values are achievable on Australian vehicles. The values are consistent with international (ISO) recommendations.
- Vehicle manufacturers should publish the brake force values as a function of actuation pressure for the brakes on the vehicle.*

This information is important for basic brake balance calculations. Some information is publicly available for trailers. It is not usually published for trucks. Part 5 lists the publicly available information.
- The higher the roll stability index, the better for brake balance.*

Vehicles with high centres of mass are likely to experience substantial load transfers during heavy braking. Load transfers disturb the brake balance and this disturbance is difficult to adapt to. The lower the roll-over threshold the more stable will be the braking.

10. *Vehicle manufacturers should set the foundation brakes so that the brake compatibility characteristics pass through the point $ERC = 0.35$, $E=0.45$ (300 kPa) when the vehicles are laden to 'legal' axle-weight limits.*

As a general observation of Australian practice, the truck characteristics are set too low and the trailer characteristics too high. This recommendation aims to promote a common design reference point.

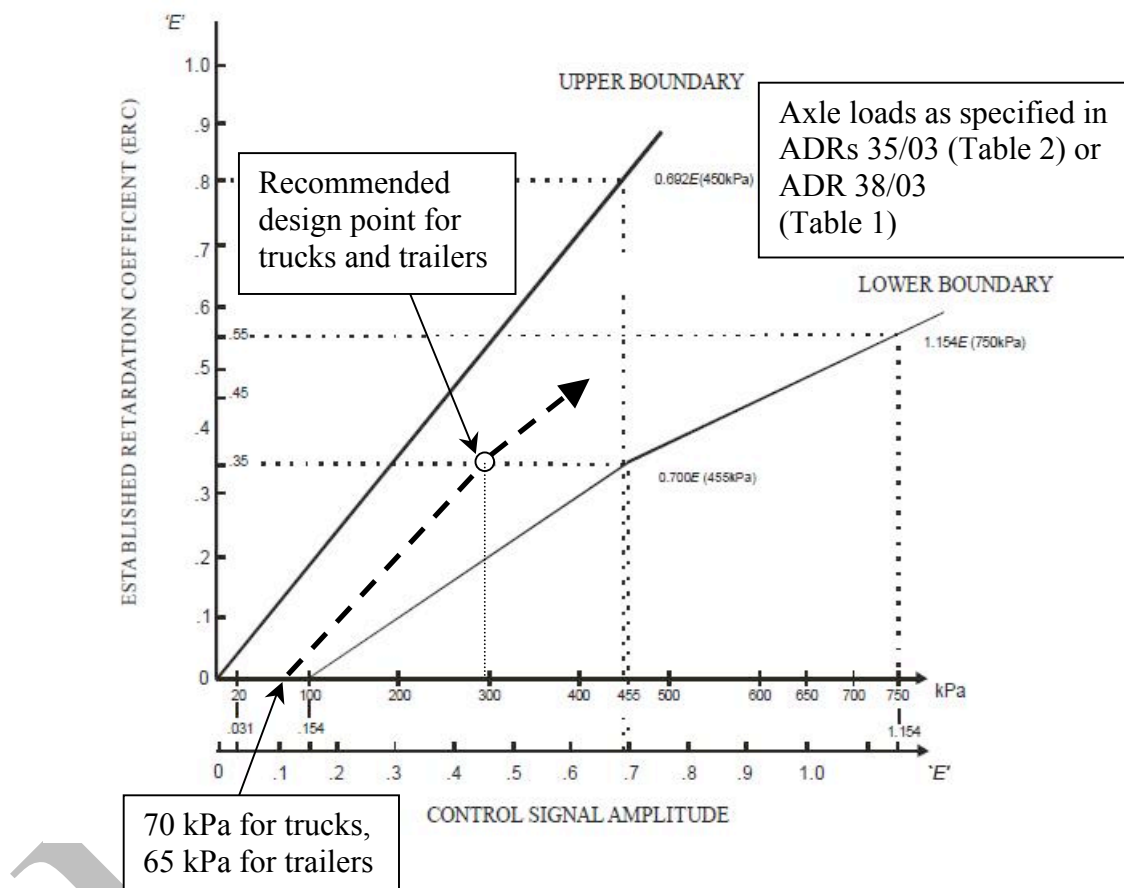


Figure 4 Recommended characteristic positions

With mixed disc and drum brakes on one combination vehicle:

11. *Because disc brakes always have automatic adjusters, a drum-braked vehicle used in conjunction with a disc-braked vehicle should also have automatic brake adjusters. Otherwise uneven brake wear is likely to occur.*
12. *When disc brakes are used on one vehicle part and drum brakes on another, it is particularly important that the vehicle braking coefficients are matched. The disc brake vehicle curve should be close to the drum-brake curve.*

The retarding force performance of disc and drum brakes change as they get hot. Brake balance that is assessed when the brakes are cold may not be appropriate. In particular, if the disc brake curve is higher than the drum brake curve when brakes are cold, the brake balance will deteriorate when the brakes are hot.

13. *The onset (threshold) pressures of disc and drum brakes can be different. The onset pressure needs to be set to give a minimal spread of values.*

Adjustment of *onset* (threshold) pressures, either by changing EBS set-up, adjustment of trailer valves or changing air valve crack springs may be necessary.

With powerful auxiliary brakes:

14. *Powerful auxiliary brakes (such as engine brakes or tail-shaft retarders) should not apply automatically when the throttle is released, but only due to a specific driver control action such as moving a control lever or by applying the service brake pedal.*

Powerful auxiliary brakes alter the brake balance because they apply force only via the drive wheels. Unexpected applications can be destabilizing.

Also see recommendation 28.

With automatic brake adjusters:

15. *When automatic brake adjustment is used on one vehicle part, it should be used on all vehicle parts in the combination.*

Otherwise some brakes will quickly get out of adjustment and brake wear will be unbalanced.

16. *Automatic brake adjustment should be always be used with electronically controlled braking systems (ABS, EBS, EBD, ...).*

This minimizes air consumption during modulation. All the systems incorporate an Antilock brake function. During modulation, air is released. The better the adjustment the less air is used and the shorter the modulation cycle. Performance is thereby improved.

With adjustable Trailer Relay Valves:

17. *Adjustable trailer relay valves should not be used on vehicle parts that are often reconfigured because the settings could be inappropriate in another combination.*

Adjustable trailer relay valves can provide useful ‘fine-tuning’ of the average brake compatibility balance on a particular combination vehicle. When a vehicle is reconfigured, the adjustment should be reset. Satisfactory performance should be verified by a road test.

18. *The characteristics of adjustable trailer relay valves should be appropriate for the type of combination vehicle.*

That is, reducing lead for a semi- (or B-type) trailer and a constant lead for a dog (or A-type) trailer. The different characteristics reflect the load-transfer behaviour during heavy braking.

19. *Limiting valves (which limit the trailer control level to some preset valve) should not be used.*

Limiting valves reduce the potential emergency braking performance and invalidate the vehicle brake certification. There are better solutions, such as an appropriately set load sensing brake valve.

With Load Sensing Brake Systems (LSBs):

20. *Load Sensing Brakes can be used on a trailer only to improve the brake balance. They should not be used on a truck only.*

LSBs should always be set-up for a particular combination. The LSB must be set appropriately so that the trailer braking coefficient curve is close to but not below the truck curve. It is unlikely that this positioning of curves can be achieved if the LSB is on the truck only.

21. *Calculations of the braking coefficients should be conducted to verify that the LSB valve shifts the unladen vehicle-part braking curves closer together.*

When an LSB is installed it is always necessary to verify that the vehicle complies with the unladen brake compatibility limits in the applicable ADR. The aim is to have the unladen curves close together. Further information is in Box 5.

22. *As a guide, the unladen setting of Load-Sensing Brake valve(s) should not be set to less than 60% of the full-load setting (100%).*

There is a danger in setting LSB valves too low because any vehicle reconfiguration could result in poor brake balance. For a particular vehicle this recommendation can be ignored, however, the vehicle should not be reconfigured.

23. *If a trailer with an LSB is pulled by a vehicle without an LSB, antilock brakes should be used on the towing vehicle to protect against jack-knife.*

The antilock brakes will protect against any tendency to jack-knife that arises if the LSB setting is too low.

Box 5

Setting of Load Sensing Valves

LSBs can improve the compatibility brake balance when they are used only on the trailer, if the trailer curve moves closer to the truck curve. Because trailers usually experience a greater proportional load change between the fully-laden and the unladen conditions, the curve for the unladen trailer will be well above that for the unladen truck. This is illustrated in Figure 6

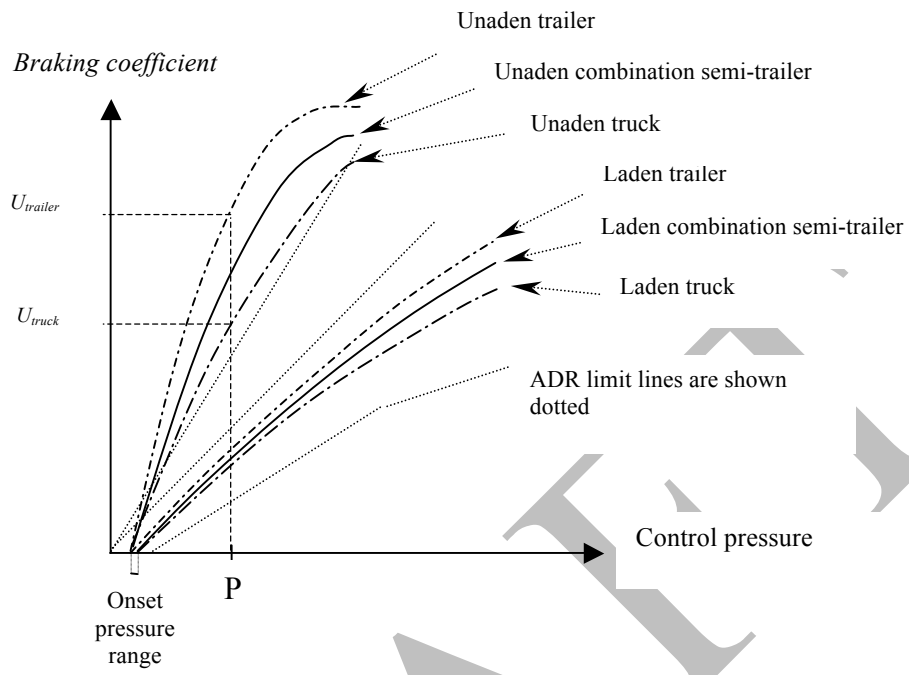
In (a) the unladen curves for the trailer are well above that of the truck. There is a risk of trailer swing. In (b) a load sensing valve has been used to drop the trailer curve down. The LSB setting in this illustration is too great because the unladen trailer curve is now well below that of the unladen truck. There is a risk of truck jack-knife.

If the truck only has a *Load Sensing Brake System*, then the situation is made worse. The LSB on the truck will reduce the truck curve and move it away from the trailer curve. This increases the risk of trailer swing when the vehicle is lightly laden.

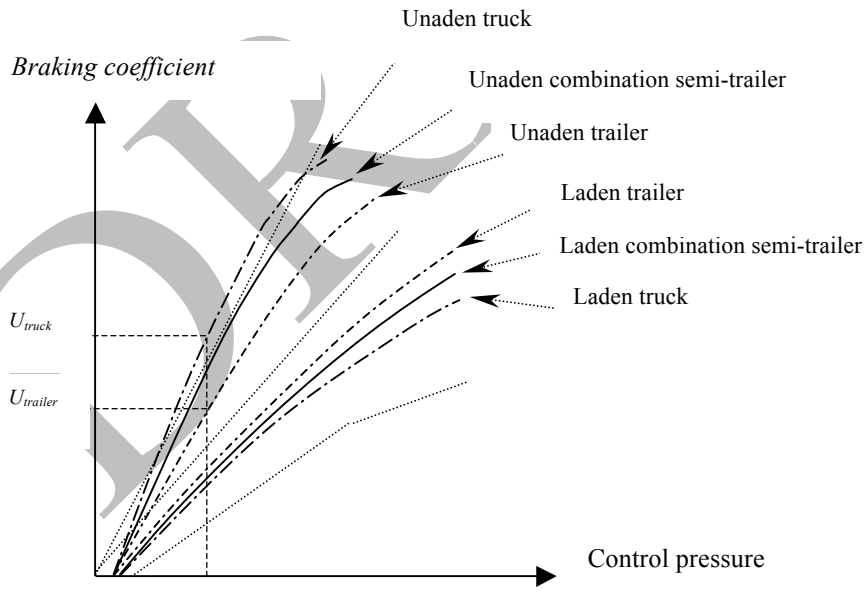
Further examples are in Part 2.

Note: the curve for the combination vehicle is obtained as a weighted average of the two vehicle part curves.

Box 5 continued



(a) No load sensing brakes



(b) Load sensing brakes on the trailer only

Figure 6 The effect of adding a load sensing valve to the trailer is illustrated.

With Antilock Brakes (ABS):

24. *Anti-lock brakes are the base-level electronic control technology. People who specify vehicles should consider choosing systems with advanced features such as Electronic Brake Distribution or Electronic Stability Control.*

There has been remarkable technical progress over the past decade. ABS now provides a platform on which other advanced controls are built. It is preferable to use a system that has adaptive braking as one of its features.

25. *ABS should be used on towing vehicles, particularly on lightweight ones, to give protection against jack-knife, unless adaptive brakes are installed.*

Relatively light-weight vehicles are likely to have a large variation in the axle braking coefficients between laden and unladen conditions. Adaptive brakes will reduce the axle braking coefficients so that gross wheel lock-up does not occur. Otherwise, antilock protection is recommended.

26. *Vehicles with ABS should also be fitted with automatic brake adjusters.*

Otherwise, ABS modulation cycle time will be increased.

27. *When ABS is installed on a towing vehicle, an ABS electrical connector should always be provided for the towed vehicle.*

Otherwise, a trailer with ABS will not be powered. Note that there is no design rule requirement to provide a connector.

28. *Truck ABS should be wired to have veto control over powerful auxiliary brakes.*

Auxiliary brakes act through the drive-axle group and may contribute to wheel lock-up. Truck ABS should be able to disable the auxiliary brake to assist in regaining wheel rotation. ABS systems have an output that can be used for this.

29. *For trucks that are (or could be) used on unsealed roads, an off-road mode for all vehicle parts should be available and be controllable at the driver console. At each ignition start, the ABS should revert to on-road mode.*

This feature allows limited wheel lock-up and shortens stopping distance on loose surfaces. It provides a reasonable balance between stopping performance and lateral stability performance.

30. *The axle in each group most likely to lock-up during braking should be sensed (i.e. 'sense-low strategy'). Other axles may also be sensed. In particular, for a tri-axle group at least two axles (front and rear) should be sensed.*

The sense-low strategy ensures that wheel lock-up does not occur in the controlled axle group during braking. This is the best result for good directional control and it avoids any tyre flat spotting. A tri-axle group should have two axles sensed to achieve acceptable wheel lock-up protection.

31. *For an A-type trailer (which consists of a dolly trailer supporting a semi-trailer), it is recommended that the dolly trailer have load sensing brakes and the semi-trailer have an ABS / EBS.*

A Load Sensing Brake System (LSB) will minimize any propensity for wheel lock-up on the dolly trailer. The EBS and RSS features are not paramount on a dolly trailer. By not installing electronic brake control on the dolly one electrical connection is avoided, which helps to improve the capacity of the electrical supply for electronic units on a roadtrain.

With Automatic Traction Control (ATC):

32. *If the truck has both Antilock brakes and Automatic Traction Control, at least two axles on the drive-axle group should be sensed. That is, the recommended system for a 6x4 truck has 4 modulators and 6 sensors.*

The proposed system enables the full performance of ABS and ATC to be achieved.

With Electronic Brake Distribution (EBD):

33. *When Electronic Brake Distribution is used on a truck, the trailer should have Antilock brakes as a minimum. It is preferable for the trailer to have an adaptive brake system such as LSBs or Trailer EBS.*

Truck EBD will reduce the drive-group brake power to achieve about balanced wheel slips on the sensed axles. Proportionately the trailer will take more of the braking load. There is a risk that gross wheel lock-up might occur. Therefore ABS should be installed as a minimum. An adaptive brake system would better balance the truck and trailer.

With Electronic Braking Systems (EBS):

34. *Trailers attached to vehicle parts with EBS should either have load-sensing brakes (LSB) or Trailer EBS.*

EBS implements *Trailer Response Management*. Poor brake balance can occur if the trailer is not matched to the truck. EBS is usually set-up assuming that a European trailer is being towed. Therefore, the trailer should have an adaptive brake system; otherwise the vehicle is likely to exhibit gross wheel lock-up.

35. *Suppliers of EBS vehicles into the Australian market should develop an Australian set-up specification. In particular, the truck should be set for a trailer onset braking level of 65 kPa and there should be no 'lead' given to the trailer.*

Effectively the recommendation is to assume that the trailer does not have EBS or LSBs. Truck EBS should be set so that the onset-braking pressure of the truck is 70 kPa, as per recommendation 6.

With Electronic Stability Control Systems (ESC):

36. *If the truck has an Electronic Stability Control system then the trailer should, as a minimum, have an antilock braking system (ABS).*

The ESC will activate the trailer brakes during operation. Antilock brake protection is necessary (as a minimum) to protect against gross wheel lock-up.

General recommendations with electronic brake controls:

37. *The CAN communicating bus should operate at the same voltage level as the power circuits – either 12V or 24V as appropriate.*

Some systems supply 12V (using a power converter) from the truck to the trailer but keep the CAN bus at 24V. This is unacceptable because the trailer is unlikely to be able to communicate with the truck via the CAN bus.

38. *'Multi-volt' electronic brake controllers may have the electrical connector keying with both a 12V and 24V keyway. The keyway position on all single voltage systems should be that specified in the standard (ISO 7638).*

Operators must have confidence that the connectors are keyed to provide reliable connections at the correct voltage level. Multi-volt systems can work with either 12V or 24V, so long as it is consistently used on both power and CAN circuits.

39. *For non multi-volt systems the connector keying should accord with the standard ISO 7638-1 (24V) or -2 (12V).*

This is important so that operators have confidence that equipment will not be damaged when connections are made.

40. *The adjustment of wheel-speed sensors should be routinely checked when the brakes are serviced.*

Wheel speed sensors sometimes get out of adjustment. Resetting is simple and involves using a blunt prod to push the sensor onto the pole ring and then allowing the gap to be reset by spring action. If sensors are out of adjustment the system will not function to full potential.

41. *When wheels are sensed on a tri-axle or quad-axle group, at least two axles should be sensed.*

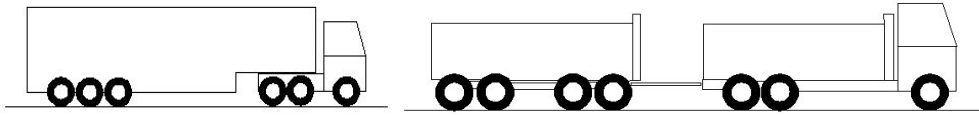
This is a requirement in ADR 38 for trailers. It is not a requirement in ADR 35 for trucks. Tri-axle drive groups are now available on some trucks. Two axles (at least) should be sensed so that gross wheel lock-up can be protected against. Sensing on one axle group may not achieve this.

42. *Electronic signaling is preferred.*

Vehicles should be configured to have electronic signaling to all the parts that have electronic brake controls. It is undesirable to have a vehicle part in the middle of a multiple combination that cannot relay the electronic signals to following vehicles.

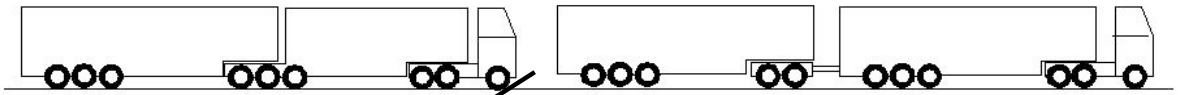
Combinations That Are Likely to Meet the Code’s Recommendations

The following Tables summarize the mixtures of brake technologies that accord with the recommendations of this Code. That is, a high degree of confidence exists that they will meet the performance standard if appropriately set-up.



Semi-Trailer	Prime Mover	Dog Trailer	Truck
EBS	EBS	EBS	EBS
LSB	EBS	LSB	EBS
ABS	EBS	ABS	EBS
EBS	EBD	EBS	EBD
ABS	EBD	ABS	EBD
LSB	ABS	LSB	ABS
LSB	LSB	LSB	LSB
ABS	ABS	ABS	ABS
ABS	ESC	ABS	ESC
EBS	ESC	EBS	ESC

Table 2 Preferred mixtures of brake technologies for single-trailer vehicles



B-Trailer	A-Trailer	Prime Mover	Second Trailer	Dolly Trailer	Semi-Trailer	Prime-Mover
EBS	EBS	EBS	EBS	LSB	EBS	EBS
LSB	LSB	EBS	LSB	LSB	LSB	EBS
ABS	ABS	EBS	ABS	LSB	ABS	EBS
EBS	EBS	EBD	EBS	LSB	EBS	EBD
ABS	ABS	EBD	ABS	LSB	ABS	EBD
LSB	LSB	EBD	LSB	LSB	LSB	EBD
LSB	LSB	ABS	LSB	LSB	LSB	ABS
LSB	LSB	LSB	LSB	LSB	LSB	LSB
ABS	ABS	ABS	ABS	LSB	ABS	ABS

Table 3 Preferred mixtures of brake technologies for two-trailer vehicles

Mixtures of brake technologies other than those shown in Tables 2 & 3 might meet the performance standard. This should be proven by calculations for the particular vehicle.