

NATIONAL CODE OF PRACTICE



VSB 6

HEAVY VEHICLE MODIFICATIONS

Section E
Front Axle Steering Wheels & Tyres

HEAVY VEHICLE MODIFICATIONS**1. SCOPE**

This section outlines the minimum design, installation and performance requirements for the replacement of front axle assemblies, alterations to the steering systems and the fitting of non-standard replacement wheel rims and tyres to the front axle of commercial vehicles in excess of 4.5 tonnes Gross Vehicle Mass. It covers the modifications required specifically to replace the manual or power steering originally fitted, also the actions required when modifications to other areas affect the steering system.

WARNING! Pneumatic power steering systems are **not** accepted.

Definition

In this code, non-standard rims and tyres on front axle(s) are defined as those with a section width exceeding the original equipment suppliers specifications by more than 40 mm and/or which, when installed, increase the front track width by more than 25 mm beyond that of the original vehicle manufacturers specification.

2. GENERAL INFORMATION

A diagram of common steering linkage nomenclatures is in Appendix 1 of this Section for reference. This has been included to identify the components that are unique to steering systems.

3. ADR's AFFECTED

Australian Design Rules that may be applicable to heavy vehicle steering systems are:
ADR10/.. - Steering Column (1 July 1990 for category MC, MD1, MD2)
ADR 24/.. - Tyre and Rim Selection up to 9/12/2003
ADR 42/.. – General Safety Requirements
ADR 35/.. - Commercial Vehicle Braking Systems
ADRs (Third Edition) Definitions

4. AFFECTING MODIFICATIONS

Modifications that would affect the front axle/steering system include:

- Installation of steering axle with increased load rating.
- Installation of additional steering axle (non-standard 'twin steer').
- Conversion from manual to power steering.
- Conversion from left hand to right hand drive.
- Installation of dual front steering control.
- The fitting of non-standard wheel rims and tyres to the front axle(s).

5. GENERAL REQUIREMENTS

- The correct functioning of steering components is critical to vehicle safety. Modifications to the steering systems must be designed and carried out by appropriately experienced engineers and tradespersons.

HEAVY VEHICLE MODIFICATIONS

- It is preferable to maintain a vehicle at its standard manufacturer's specification as far as possible, i.e. install axles, brakes, steering components, etc. which are the standard options offered by the manufacturer of the particular vehicle model.
- All replacement components must have rating suitable for the rating of the vehicle. If a change in the vehicle rating is sought, Section S - Vehicle Rating of this National Code of Practice should be followed.
- **Heat working of steering components: Avoid cutting, welding or heating steering components, particularly forged and heat treated components, unless absolutely essential to the correct functioning of the modified vehicle; and it should be undertaken only when the final properties of the material can be predicted and subsequently confirmed. Any heating or welding must be performed by a qualified welder and in strict accordance with any instructions from the component manufacturer - e.g. axles. All welded components must meet the requirements of AS 2177 - Radiography of Welded Butt Joints in Metal.**
- Recommendations by the original vehicle manufacturer and the component and/or assembly manufacturer must be strictly adhered to in all modifications.
- The steering components e.g. steering gearbox, power cylinders (rams), pitman arms must be so selected that their ratings exceed the loads encountered in the modified vehicle.
- When the ratings of components or assemblies are not available, stress analysis must be carried out to prove that an adequate factor of safety (i.e. not less than that provided by the original vehicle manufacturer) for the most critically stressed parts of the assembly is ensured. This also entails verifying the material properties.
- For axle and steering system attachments, threaded fastenings (unless supplied by the subassembly manufacturer) must be equivalent to SAE Grade 8 or ISO 10.9 (refer to Australian Standard AS 1110) and must be assembled using vehicle or component manufacturer's recommended tightening torques and locking methods.
- All standard parts such as splines, tapers and keyways must conform to the published standards and mating parts to the corresponding matching standards.
- Hoses, steel tubing and reservoirs must be in accordance with the hydraulic standard, size, flow and pressure rating recommended by the manufacturer of the steering box or power cylinder and be suitably located and secured for ease of maintenance and top-up. Hose routing must be clear of heat sources and any moving parts.
- The manufacturer's ratings for the end fittings of the ball joints, plain bearings and idler arm pivots must exceed the loads and angular movements encountered in the modified vehicle.
- Guards must be provided to prevent fouling with moving components and any potential injury to vehicle occupant(s).
- After modifications to the front axle, steering or front wheels, the components must be checked under simulation for adequate clearance under full travel of the steering and the front suspension systems.

HEAVY VEHICLE MODIFICATIONS

6. COMPLETED VEHICLE TESTS

6.1 Road Testing

Road testing of the modified vehicle must be undertaken to confirm that the following requirements have been met:

- **Vehicle Handling:** The steering system must provide safe and acceptable handling of the Vehicle under all normal driving conditions, including abrupt maneuvers to avoid obstacles.
- **Steering Effort and Restriction:** A modified steering system must be free from restrictions to movement and steering effort in excess of the original vehicle's steering effort (refer paragraphs below).
- **Control Sensitivity:** Control sensitivity of the modified steering must closely follow the profile of steering input to wheel movement of the original vehicle.

6.2 Minimum Steering Effort

Minimum steering effort with power assist must not be less than 5 Newtons measured at the steering wheel rim under any condition.

6.3 Maximum Steering Effort

Maximum steering effort measured at the rim of the steering wheel must not exceed 250 Newtons, when tested under the following conditions:

- **Test Load:** The vehicle must be loaded to its maximum permissible gross vehicle mass and correct load distribution with tyre pressure as recommended by the vehicle & tyre manufacturer.
- **Commencement of Test:** The test will commence with the steering gear in the straight ahead position and the vehicle moving forward at a constant speed of 10 kph or less.
- **Turning Circle:** The steering wheel will be turned at a constant rate so that in 4 seconds (6 seconds in the assist failure mode - refer below) the steering angle is that required to obtain a turning circle with a maximum radius not exceeding 12.5 metres.
- **Right & Left Hand Turns:** The above sequence is to be followed turning to both right and left.

6.4 Simulated Power Assist Failure

In case of power assisted steering systems, steering effort must not exceed 600 Newtons with simulated failure of complete power assistance and under surface & speed conditions specified in 6.3 above.

7. OPTIONS FOR DEMONSTRATING COMPLIANCE

- **Australian Design Rules:** If modifications affect areas covered by Australian Design Rules (ADRs), continued compliance to ADRs must be demonstrated by acceptable methods.

HEAVY VEHICLE MODIFICATIONS

- Where critical components are modified, details of material composition and heat treatment must be obtained from the component manufacturer and modifications must be carried out without reducing the strength and durability. Appropriate tests are to be carried out to determine that there has been no degradation of component or assembly strength.
- Where modifications affect loading of the components, stress analysis must be carried out to determine that the factor of safety is no less than that provided by the original manufacturer for the critically stressed parts of the assembly.

8. RECORDING

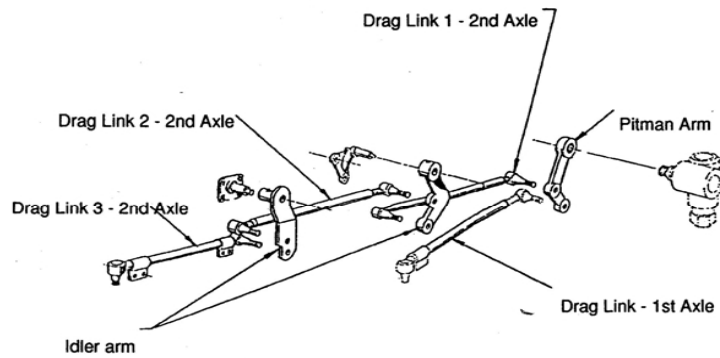
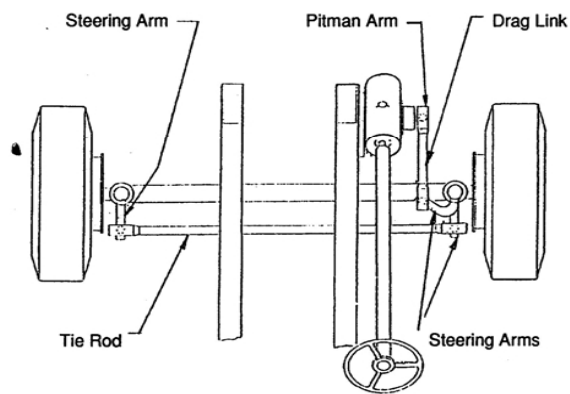
- Appendix 1 - Diagram showing steering system nomenclature.
- Appendix 2 - Pro-Forma Modification Report, Vehicle Steering. This form, completed in full, should be retained by the Certifying Officer.
- Appendices 1, 2 and 3 which:
 - Summarise the scope of modification work that may be certified out under modification codes E1, E2 and E3.
 - Include lists of other Sections of this National Code of Practice to cover areas of the vehicle which may have been affected by the modification and which should be analysed to determine whether they, too, require certification.
 - Include checklists, appropriate to the particular modification code, that should be completed.

It is suggested that records such as the analysis work, calculation sheets, sketches, vehicle specification data, and the completed Check List be retained by the Certifying Officer for at least the period specified in Part A of this National Code of Practice.

HEAVY VEHICLE MODIFICATIONS

Appendix 1

STEERING LINKAGE NOMENCLATURE



Appendix 2

Modification Report
Front Axle and Steering

HEAVY VEHICLE MODIFICATIONS

Appendix 1

Modification Code E1

FRONT AXLE(S) INSTALLATION

Modifications that are covered under this Modification Code are:

1. Fitting of alternative front axle assembly.
2. Fitting of additional front axle on load sharing or non-load sharing suspension.
3. Fitting of suspension brackets to axle housing; providing that welding and installation is in accordance with the axle manufacturer's recommendation.

Modifications that are **not** covered under this Modification Code:

1. Fitting of axle assemblies that are not compatible with the original vehicle's componentry.
2. Modifications to axle housings - other than that allowed by the axle manufacturer for fitment of suspension brackets.
3. Welding/alterations to axle beam or steering components.

NOTE: The modified vehicle/modifications must continue to comply with all applicable ADR's, Australian Standards or Regulations/Acts.

Outlined below are areas of the vehicle that may have been affected by the modifications and may require certification, testing and/or data to show compliance of the modified vehicle.

DETAIL	REQUIREMENTS
Replace front axles	National Code of Practice - Section E
Maximum vehicle width	2.5 metres for normal complying vehicles
Brakes	Braking System must meet design requirements in ADR 35/.. The system must be for an equivalent or greater GVM rating. Modification Code G4 in ADR 35/... Recertification is required if above criteria are not met.
Re-rating of GVM/GCM	Modification Code S1/S2
Turning circle	Maximum 25 metres
Steering	Modification Code E2
Suspension	Modification Code F1

HEAVY VEHICLE MODIFICATIONS

FRONT AXLE(S) INSTALLATION

SPECIFIC REQUIREMENTS

1.0 General

- 1.1 If a front axle(s) is being replaced, the replacement axle(s) must have a mass rating which is suitable for the mass ratings of the vehicle.
- 1.2 If a front axle(s) is being replaced, the spring spacing on the replacement axle must be compatible with the spring mounting on the chassis.
- 1.3 All welding on the axle(s) must be performed by a qualified welder and in accordance with the axle manufacturer's welding instructions. **Note:** No welding or other rework is to be performed on an I-beam axle.
- 1.4 The axle(s) must be installed so that the caster angle is within the limits specified by the axle/vehicle manufacturer's recommendation. If camber angle requires change, the angle must be changed in accordance with AS/NZS 4737:2002 I Beam Steer Axle Camber Adjustment.
- 1.5 The brakes on any replacement axle must be compatible with the remainder of the brake system and have a mass rating compatible with the axle being replaced, if the vehicle mass rating remains unchanged. In the case of an axle substitution, it is preferable to transpose the existing brakes to the replacement axle if the brakes are suitable for the required vehicle mass rating. Should the modifier choose to use different brakes or is installing an additional axle, the guidelines in Section G - Brakes of this National Code of Practice should be followed.
- 1.6 If alterations to the suspension or steering are required, the manufacturer's recommendations or the appropriate sections of this National Code of Practice should be followed.
- 1.7 If a change in axle ratio is performed on a vehicle with a driven front axle, the modifier should ensure that a suitable ratio is selected for road speed and startability & gradeability. Refer to Code B in this National Code of Practice.
- 1.8 After replacing front axle(s), the wheel alignment should be checked and adjusted to the appropriate specification.

HEAVY VEHICLE MODIFICATIONS
Checklist for Modification Code E1
FRONT AXLE INSTALLATION

HEAVY VEHICLE MODIFICATIONS

Appendix 2

Modification Code E2

STEERING ALTERATION

Modifications that are covered under this Modification Code are:

1. Fitting alternative steering box.
2. Fitting power steering systems.
3. Fitting dual control systems e.g. street sweeper.
4. Alteration of existing controls for special vehicles e.g. through loaders
5. Fitting tandem steering axle control systems.
6. Conversions of left to right hand drive on commercial vehicles.

Modifications that are **not** covered under this Modification Code are:

1. Fitment of components that are not compatible with original vehicle componentry.
2. Welding of steering shafts or linkages that is not in accordance with this National Code of Practice.
3. Use of chain driven steering system.
4. Fitment of components not designed for automotive use.

NOTE: The modified vehicle/modifications must continue to comply with all applicable ADR's, Australian Standards and Regulations/Acts.

Outlined below are areas of the vehicle that may have been affected by the modifications and that may require certification, testing and/or data to show compliance of the modified vehicle.

DETAIL	REQUIREMENTS
Relocation of existing steering box	Good Engineering Practice, Alternative manufacturer's specifications, if available
Fitting of power steering systems	National Code of Practice - Section E Manufacturer's specifications
Fitting of dual control systems	National Code of Practice - Section E
Special vehicle controls	National Code of Practice - Sections E, H Modification Code K1
Tandem steering axle controls	National Code of Practice - Section E
Suspension substitution	Modification Code F1
Repositioning brake system	Modification Code G1
Chassis frame alteration	Modification Code H4

HEAVY VEHICLE MODIFICATIONS

Left to right hand drive

National Code of Practice - Section E,
Manufacturer's specifications and Good Engineering
Practice

Cabin alteration

Modification Code K3

Inspection and radiographic testing

AS 2177 - Radiography of Welded Butt joints in
metal

HEAVY VEHICLE MODIFICATIONS
STEERING ALTERATION SPECIFIC REQUIREMENTS

1. STEERING COMPONENTS

1.1 Pitman Arm Modifications

Should the pitman arm require modification by heating, welding, bending or drilling, the pitman arm must be stress-relieved, and if welding has been carried out, the affected area of the arm must be subject to non-destructive X-ray inspection, with a certificate produced to confirm the component is safe and sound.

1.2 Steering System Design

The steering system, including the steering gearbox, steering linkage, pitman arm, power cylinder must be so designed to give a balanced system capable of safely providing the performance required as set out in Part 6 of Section E, with specific attention to:

- Maximum steering angles;
- Steering arm length;
- Steering linkage geometry;
- Power cylinder installation geometry (ram type power steering);
- Pitman arm length and geometry (length, angular travel);
- Steering gear ratio;
- Steering wheel diameter

1.3 Steering Stops

Must be set strictly in conformance with the requirements set by the steering gearbox manufacturer

1.4 Caster Angle

As specified by the vehicle manufacturer.

1.5 Steering box location

Preferably, the new steering box should be mounted in the original steering box location, or in an area of equivalent strength. Frame member reinforcement may be required to obtain equal strength and rigidity in a new location.

1.6 Mounting Strength

Must be re-assessed if an adaptor bracket is used

HEAVY VEHICLE MODIFICATIONS

1.7 Ram Type Power Steering

- **Power Cylinder Mounting:** The power cylinder mounting for a ram type power steering must be designed to withstand the cylinder's peak loading and the resulting deflection. The fatigue strength must cater for the number of load reversals imposed on the mounting by the steering linkage, with a factor of safety not less than that provided by the original vehicle manufacturer for the critically stressed parts of the assembly.
- **Power Cylinder Articulation:** Most power cylinders are designed to operate with the axis in a near- horizontal position. The power cylinder must also be articulated to provide a direct axial force to the steering linkage through the full range of steering and suspension movement of the point of attachment to the steering linkage.
- **Power Cylinder Mounting on Axle Beam:** Mounting of the power steering cylinder between the front axle beam and the tie rod should be avoided.

1.8 Steering Linkage Assemblies

- The steering system must incorporate steering stop mechanisms which are compatible with the steering system and do not overload other components when the stops are engaged.
- If the length, cross section or shape of a steering link is changed, stress calculations will be required to determine that strength of the component has not reduced.
- Drag links must be made from one continuous length of material between end fittings.

1.9 Power Steering Pump

The power steering pump must be securely mounted on the engine by direct mounting provided by the engine manufacturer or belt driven on a suitably designed and adjustable bracket to give adequate belt contact and tension. The pump and its installation must:

- produce flow and pressure outputs as specified by the power steering gearbox or power cylinder manufacturer.
- incorporate sufficient length of steel tubing to ensure adequate cooling of power steering fluid under all operating conditions.

1.10 Location of Power Servo Valve

The power servo valve must be integral with the steering gearbox or linkage power cylinder.

1.11 Pressure Relief

Power steering system must be fitted with a pressure relief valve.

HEAVY VEHICLE MODIFICATIONS

2. LEFT HAND TO RIGHT HAND DRIVE CONVERSIONS

2.1 Steering Gearbox Relocation

When a left hand drive to right hand drive conversion involves a steering box mounting relocation to the right hand side of the chassis, this must conform to the original vehicle manufacturer's right hand drive design details and specifications, if these are available, or alternatively must be shown to be equal to the original system in all safety and performance requirements.

2.2 Steering Gearbox Modifications

If a left hand drive steering gear box assembly is modified to adapt it to the right hand drive system, proof must be provided that no components have been weakened or will be stressed more in the new application.

2.3 Steering Control Relocation

When a right hand drive conversion is made by transfer of the steering control only, leaving the steering gear box and linkage unchanged, the following requirements must be met:

- **Relay Drive Shafts and Gears:** The torque capacity of all relay drive shafts, gears and joints must be adequate and at least equivalent to the original steering input shaft and must take into account any torque multiplication in relay gears etc.
- **Universal Joints:** Dual universal joints must be fitted to the cross shaft and all connections must be positively keyed and locked.
- **Relay Gear Box Mounting:** Mounting provided by the relay gear box manufacturer must be used wherever possible and must not distort or overstress the part of the vehicle to which it is attached.
- **Relay Gear Box Torque Capacity:** If industrial bevel drive gearboxes are used, their rated static torque capacity must provide a safety factor of no less than that provided by the original manufacturer for the most highly stressed part of the assembly.
- **Relay Gear Box Adjustment:** Any relay gearbox must have provision for adjustment to remove backlash.
- **Cab:** Installation of the system must not limit original vehicle manufacturers' specification for full cab tilt or other cab features.

3. DUAL STEERING CONTROLS

The manufacturer's right hand drive steering geometry must be maintained without degradation of either function or durability with this modification. The following requirements apply to the additional controls:

- Proof must be provided that any modified or replacement components (e.g. steering column) at least have the same strength as the original components and are free from defects.
- Any additional steering components in the cabin of the vehicle (except the steering wheel)

HEAVY VEHICLE MODIFICATIONS

must be provided with guards to prevent fouling by other components or injury to vehicle occupants.

- All electrical systems must function correctly and be in accordance with the manufacturer's specifications and the ADR's.
- The installation of additional braking system controls must not interfere with the requirements of ADR 35/..; *Commercial Vehicle Brake Systems*.
- Any modifications to the vehicle's existing brake system must be performed in accordance with Section G - Brakes of this National Code of Practice.
- The modifications to the braking system must not result in any reduction of service or parking brake performance and must not impair the correct functioning of original equipment failure warning systems and secondary braking systems.
- Additional service brake failure visual indicator shall be installed as per ADR 35/..; for the additional driving position.
- Rear vision mirrors must be installed on the right side of the vehicle to ensure the driver, when seated in the left side driving position, has adequate rear vision for all driving conditions.
- Suitable signs must be attached to the vehicle in a prominent position adjacent to steering controls indicating safety and operating procedures.
- Throttle, brake and clutch must be in conventional locations in both driving positions.
- A speedometer shall be installed so that its indication is readily visible to the driver when seated in both driving positions.
- All chassis modifications must be performed in accordance with the manufacturer's recommendations or with Section H - Chassis Frame of this National Code of Practice.

HEAVY VEHICLE MODIFICATIONS
Checklist for Modification Code E2

STEERING ALTERATION

HEAVY VEHICLE MODIFICATIONS

Appendix 3

Modification Code E3

FITTING OF NON-STANDARD FRONT WHEEL COMPONENTS

Modifications that are allowed under this Modification Code are:

1. Fitting of non-standard front wheels i.e. rims and/or tyres

Modifications that are **not** allowed under this Modification Code are:

1. Fitting of front wheels i.e. rims and/or tyres that are not compatible with the original vehicle's specifications.
2. Modifications to wheel rim assemblies - other than those permitted by the wheel rim manufacturer.
3. Welding/alteration to wheel rim or steering components.
4. Modification of vehicles other than heavy vehicles exceeding GVM/ATM of 4,500 kg
5. Fitting of front wheels i.e. rims and/or tyres that exceed the regulatory limits on vehicle dimensions.

NOTE: The modified vehicle/modifications must continue to comply with all applicable ADR's, Australian Standards and Regulations/Acts.

Outlined below are areas of the vehicle that may have been affected by the modifications and that may require certification, testing and/or data to show compliance of the modified vehicle.

DETAIL	REQUIREMENTS
Replace front axle	National Code of Practice - Section E
Width of vehicle (maximum of 2.5 metres)	ADR 43/.. - Vehicle Configuration and Dimensions
Brakes	The complete brake system should be in accordance with an ADR 35/.. certified system for an equivalent or greater GVM rating Modification Code G4 for ADR 35/... Recertification will be required if above type system is not used
Re-rating of GVM/GCM	National Code of Practice - Section S Modification Codes S1/S2)
Turning circle (maximum radius of 25 metres)	ADR 43/..
Steering	National Code of Practice - Section E (Modification Code E2)

HEAVY VEHICLE MODIFICATIONS

Suspension substitution

National Code of Practice - Section F
(Modification Code F1)

Fitting of power steering systems

Manufacturer's specifications and Section E

If any of the areas listed above have been affected by the modifications, they must comply with the prescribed standards and, where necessary, must be approved certified by an authorised person holding the appropriate modification code.

HEAVY VEHICLE MODIFICATIONS

FITTING OF NON-STANDARD FRONT WHEEL i.e. TYRE AND/OR RIM
SPECIFIC REQUIREMENTS**1.0 General**

- 1.1 When in the straight ahead position, the wheels and tyres of any vehicle must not project beyond the extreme width of the mudguards or cause vehicle width to exceed the limit applicable to the maximum width of the vehicle.
- 1.2 The fitting of non-standard front wheels i.e. rims and/or tyres must take into account change in wheel offset characteristics which may cause increase in bending moments, reduced wheel bearing life and reduced maximum vertical loadings of vehicle componentry.
- 1.3 The fitting of wider wheels to a vehicle alters the track and scrub radius (the distance between the centre of the contact area that a tyre makes with the road and the theoretical point where the centre line of the steering axis meets the ground). When fitting wider rims and tyres to a vehicle, it is normal to fit rims with a positive offset, as this allows wider rims to clear suspension and steering components. However, the following will result:
- the vehicle will have heavier steering
 - loads on steering linkages and steering system will be increased.
 - loads on wheel bearings will be increased

Note: The fitting of non-standard front wheels i.e. rims and/or tyres must take into account the axle manufacturer's reduction in Ground Axle Weight Rating (GAWR) due to the increase in wheel track. This reduced rating compensates for the increase in bending moments that cause reduced wheel bearing life and increased king pin and stub axle loads.

The reduced GAWR may affect the vehicle's Gross Vehicle Mass (GVM) and therefore require a revised GVM rating as per Section S2 - Gross Vehicle Mass Rating Approved Design Certification for non-standard vehicles or special vehicles.

- 1.4 It is necessary that consideration be given to the many variables that occur as a result of the fitting of non-standard front wheels i.e. rims and/or tyres. As such, it is essential that the steering geometry (wheel alignment) take into consideration the resulting variables such as wheels fouling vehicle componentry, tyre life and changing angles of the steering mechanism. Compliance with ADR 43/... turning circle requirements must be maintained.
- 1.5 As a result of increased tyre and wheel mass and an increased scrub radius (the distance between the centre of the contact area that a tyre makes with the road and the theoretical point where the centre line of the steering axis meets the ground) higher dynamic loadings (the loading on a wheel while it is rotating) may be imposed on the steering componentry. It is necessary that this loading be considered when evaluating proposed modifications.
- 1.6 Replacement tyres must only be fitted to wheel rims approved as suitable by the Tyre and Rim Association of Australia or tyre manufacturer and in accordance with relevant ADR's. Wheel rim widths, flange heights and flange angles affect the service life, performance and safety of a tyre and rim. The fitting of tyres to incorrect rims can lead to premature wheel failure. For the best service performance, tyres should be fitted to their approved rims.
- 1.7 The offset of tie-rod arms dictates the Ackermann geometry generated during wheel turns where the inside wheel will turn at a sharper angle than the outside wheel. If incorrect tie-rod arms are used, increased tyre wear, vehicle understeer and an increased turning circle could result.

HEAVY VEHICLE MODIFICATIONS

- 1.8 Any increased tyre and wheel mass may cause increased loading on steering componentry, including power steering pumps and increased dynamic loading in the steering system. During operation, the gyroscopic effect due to the rotation of the wheel will result in increased dynamic loads imposed on the steering system with any impact forces (i.e. from hitting a pot hole) experienced by the wheel resulting in violent wheel oscillations. The contributing factors to this are vehicle speed, mass of the rotating tyre, rim, brake drum and hub assembly, condition of the dampers, vertical load on the front axle and axle caster.
- 1.9 The fitting of wider tyres may increase the likelihood of 'aquaplaning' under lightly laden conditions.
- 1.10 Where a front axle assembly is replaced, it is important that the original drag link geometry, relative to the original steering arm ball stud centreline, the front spring eye centreline and the pitman arm ball stud centreline, be maintained. Failure to maintain this relationship may result in bump or roll steer (i.e. front wheel oscillation about the king pin as the suspension is displaced).

HEAVY VEHICLE MODIFICATIONS

Checklist for Modification Code E3

FITTING OF NON-STANDARD FRONT WHEEL i.e. TYRE AND/OR RIM