

Vehicle Standards Bulletin 14

**NATIONAL CODE OF PRACTICE
for
LIGHT VEHICLE CONSTRUCTION
and
MODIFICATION**

**SECTION LS
TYRES, RIMS, SUSPENSION
AND STEERING**

1st February 2006

National Code of Practice for Light Vehicle Construction and Modification (NCOP)

Warning to Users

Users of the NCOP need to be aware that this document needs to be used in conjunction with the appropriate administrative requirements of the jurisdiction in which they wish to either register a vehicle or to obtain approval for a modification for an already registered vehicle. "Administrative requirements" include, amongst other things, processes for: vehicle registration, obtaining exemptions, obtaining modification approvals, vehicle inspections, preparation and submission of reports and the payment of appropriate fees and charges.

If unsure of any of these requirements, or if more information is needed for any other issues or processes, users should contact their relevant registration authority prior to commencing any work.

Whilst the NCOP provides assistance with respect to the construction of ICVs and the execution of modifications, it is not to be taken to be a design manual. Determination of component strength, performance, suitability and functionality must be either calculated or determined on a case by case basis by suitably qualified personnel experienced in each matter under consideration.

Users of the NCOP also need to ensure that they refer to the most recent version of the relevant Section/s when working on a job or project. The version is identified by the date on the face page of each Section. On the website, each Section has the version date contained in the Section file name for easy identification.

It is prudent to check for new versions if a job or project is taking a long time to complete.

If they have not already done so, users must also download the Preface and Introduction.

These two Sections provide the necessary background information to assist users in understanding how the NCOP is administered by registration authorities across Australia, on how it is structured, and the meaning of the types of modification codes specified in the NCOP.

Understanding these requirements is important to ensure that the correct processes are followed thereby reducing the likelihood of having work rejected by authorities.

*Many of the Sections refer to other Sections for further information or additional requirements. Users **must** download all relevant Sections. Lack of information due to insufficient downloads will not be accepted as an excuse by authorities.*

If in doubt about any issue concerning or contained in the NCOP, users should seek clarification from the appropriate state or territory registration authority.

Please do not contact the Department of Transport and Regional Services (DOTARS) about the NCOP. DOTARS provides the central NCOP website as a service only.

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1 SCOPE

This Section outlines the minimum design, installation and fabrication requirements for the following light vehicle modifications involving tyres, rims, suspension and steering.

1.1 MODIFICATIONS NOT REQUIRING CERTIFICATION

- Tyre and rim substitution carried out within the limits specified in this Section.
- Lowering and raising suspensions (by not more than one third of the original suspension travel)
- Shock absorber substitution
- Spring and sway bar substitution
- Track rod and strut brace installation
- Power steering (manufacturer's option) conversion

1.2 MODIFICATIONS REQUIRING CERTIFICATION UNDER LS APPROVAL CODES

- Left to right hand drive steering conversions
- Steering and suspension modifications
- Power steering (non-standard) conversion
- Rack and pinion steering conversion
- Suspension strut or upright substitution
- Rear axle substitution
- Raising the vehicle beyond 50mm but not more than 150mm

1.3 EXCLUSIONS

The following modifications are not covered by this NCOP.

VEHICLE LIFTS THAT EXCEED 150MM: Raising vehicles beyond 150mm is not permitted under this Code of Practice.

VEHICLE LIFTS TO ANY VEHICLE THAT HAS HAD ITS TRACK REDUCED: Vehicles that have had a track reduction will need to be assessed on a case-by-case basis.

REMOTE STEERING SYSTEMS: Steering systems that operate without complete mechanical connection (such as hydraulic or electric actuation) are not covered in this Code of Practice.

STEERING WHEELS FITTED WITH INTEGRAL AIRBAGS: This Code of Practice does not cover steering wheels fitted with air bags.

NOTE: The main design installation and fabrication requirements are contained in the relevant part of sub-sections 4 or 5. However, these sub-sections must be read in conjunction with the contents of sub-section 2 *General Requirements* which apply to all vehicles.

2 GENERAL REQUIREMENTS

This sub-section applies to all light vehicles and should be read in conjunction with the other sub-sections of the LS Code and the specific Approval Code for the modification or conversion.

NOTE: The use of the word 'wheel' means the tyre and rim combination.

2.1 DRIVEABILITY

Owners wishing to alter the appearance and/or road handling characteristics of their vehicles often alter suspensions and fit tyres and rims different from the original manufacturer's specifications. Some changes can achieve improvements in cornering stability, but other changes, including unsuitable tyre and rim selection can lead to dangerous situations. The following should be considered:

STEERING BEHAVIOUR

Fitting wider rims and tyres usually involves altering the steering "scrub radius". This can result in unpredictable steering response characteristics.

Tyres contacting body and suspension components can reduce the vehicle's turning circle.

ROADHOLDING AND HANDLING

The roadholding and handling qualities of a modified vehicle must not be adversely affected.

BRAKING BEHAVIOUR

Some non-standard rims and tyres fitted to cars with diagonally split braking systems can cause reduced directional stability in the event of brake failure. Larger diameter tyres reduce braking capacity.

GROUND CLEARANCE

The vehicle must have sufficient ground clearance to meet the Australian Design Rule and Australian Vehicle Standards Rules requirements and ensure safe operation of the vehicle on the road.

TURNING CIRCLE

The vehicle must have a sufficient turning circle in each direction and must meet all Australian Design Rule dimensional requirements.

TYRE DEFLATION

Any modifications to suspension and steering, including replacement tyres and rims, must ensure that vehicle's body, exhaust system, axles, suspension or steering components do not contact the road when tyre(s) deflate. Therefore, if one or more tyres deflate when the vehicle is on a level road, the rims and tyres must be the only part of the vehicle in contact with the road.

RIDE HEIGHT

Ride height is a very important parameter as it has a direct influence on a vehicle's Centre of mass (centre of gravity) and hence its stability and performance.

2.2 STRENGTH & FLEXIBILITY

When replacing wheels and tyres, and modifying suspension and steering components, consideration should be given to the following:

STRENGTH OF SUSPENSION AND STEERING COMPONENTS

Changes in wheel width and offset, and bump clearance can cause significant increases in stress levels in suspension and steering components of both independent and beam axle suspensions.

FATIGUE STRENGTH

Some modifications that are satisfactory in the short term (e.g. on competition cars that travel relatively short distances) are often completely unsuitable for road use because of the effects of metal fatigue. A suspension component on a road car can break from metal fatigue at stresses much less than that experienced during competition use.

FLEXIBLE ARMS AND JOINTS

Some suspension components (flexible arms and joints) are designed to twist when the suspension moves vertically. "Boxing-in" these components and/or using stiffer replacement bushes can cause large stresses in mounting bolts and brackets causing them to break or tear out. It is recommended that replacement of rubber flexing bushes with harder bushes should only be done in applications where single plane movement occurs.

2.3 FABRICATION

All work must be performed in accordance with recognised engineering standards. Cutting, heating, welding or bending of suspension or steering components should be avoided by choosing unmodified production components wherever possible.

WELDING

Welding of components, except where expressly specified to a higher standard, must be performed in accordance with recognised general engineering practices taking into account the function of the welded joint. This typically involves, for each task in question:

- choosing the appropriate welding method together with the most suitable welding materials
- ensuring appropriate job preparation is performed
- ensuring all subject joints and heat affected areas are effectively prepared and sealed in accordance with current trade techniques to minimise the onset of corrosion.

In addition, welds, particularly on structural members, should not be ground back to such an extent that the strength of the joint would be affected.

Where a higher or alternative weld standard is specified, the requirements of that standard must be satisfied.

Guidance on good welding techniques can be found in AS/NZS 1554.1:2004 *Structural steel welding - Welding of steel structures*.

FASTENERS

Unless supported by specific engineering design, all fasteners on transmission mountings or in highly stressed locations must be high tensile ISO Grade 8.8 (mm sizes), SAE Grade 5 (inch sizes) or equivalent, as a minimum specification. All other fasteners are to be at least of similar strength and number to those in the original installation. Self-locking nuts should be used in preference to spring washers.

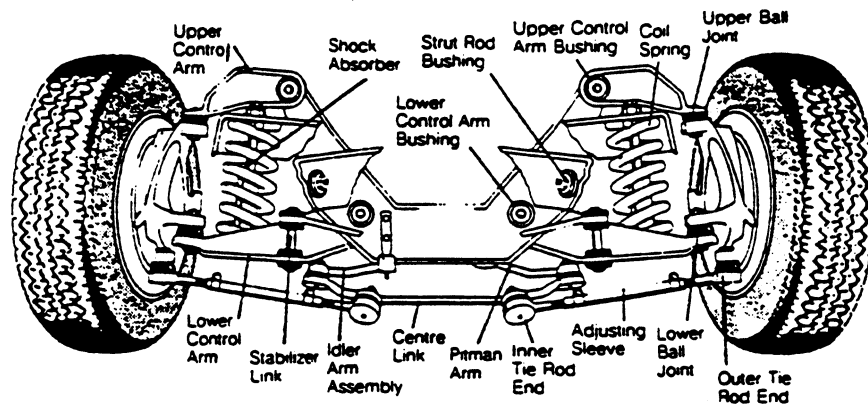
MATING PARTS

Standard features such as splines, tapers and keyways must conform to published standards and their mating parts must conform to matching standards.

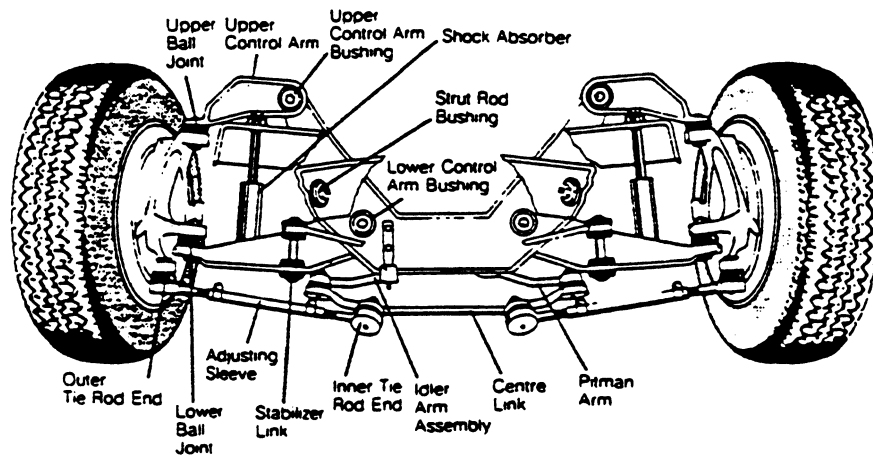
ELECTROPLATING

To prevent cracks forming under chromium plating or from hydrogen embrittlement of steel components, electroplating of steering and suspension components including bolts is not permitted, unless a part of the original manufacturing process.

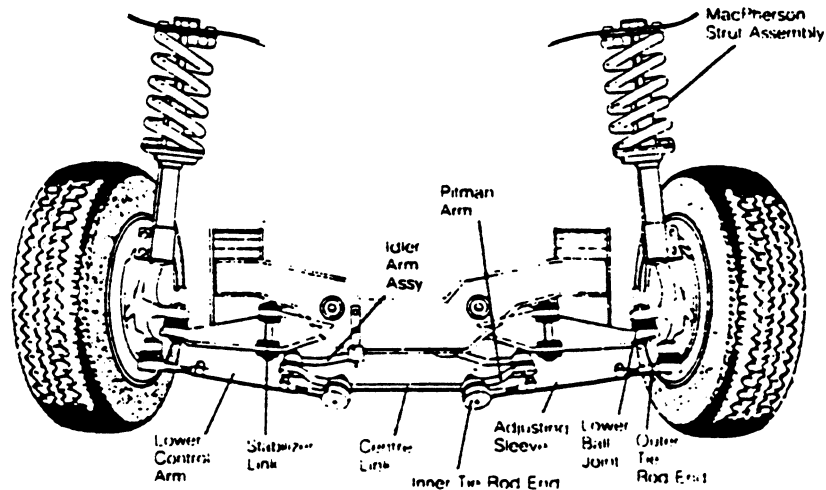
2.4 SUSPENSION & STEERING TERMINOLOGY



Conventional Steering and Suspension with Coil Springs

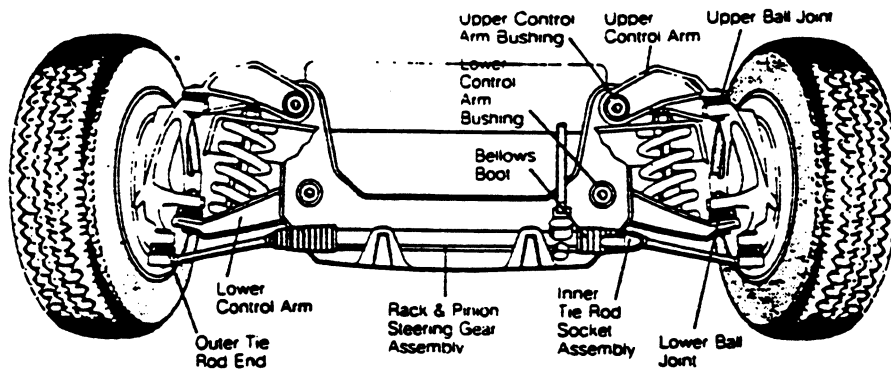


Conventional Steering and Suspension using Torsion Bar

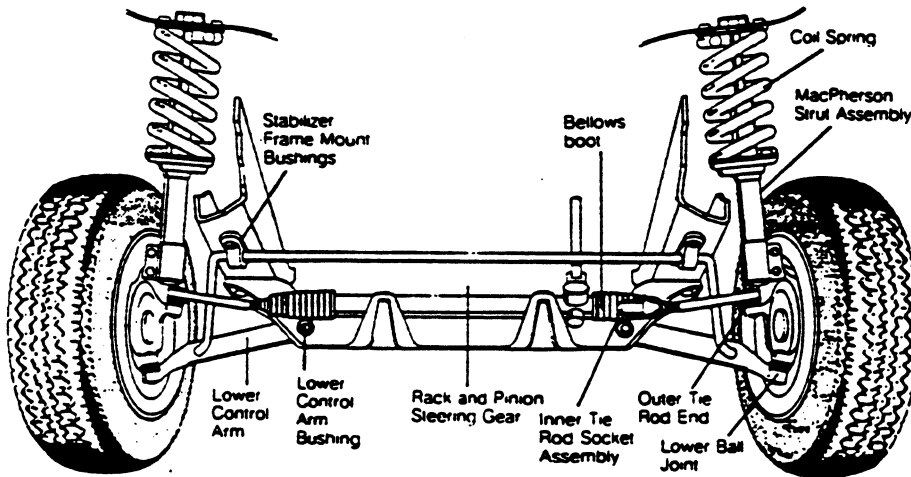


Conventional Steering with MacPherson Strut Suspension

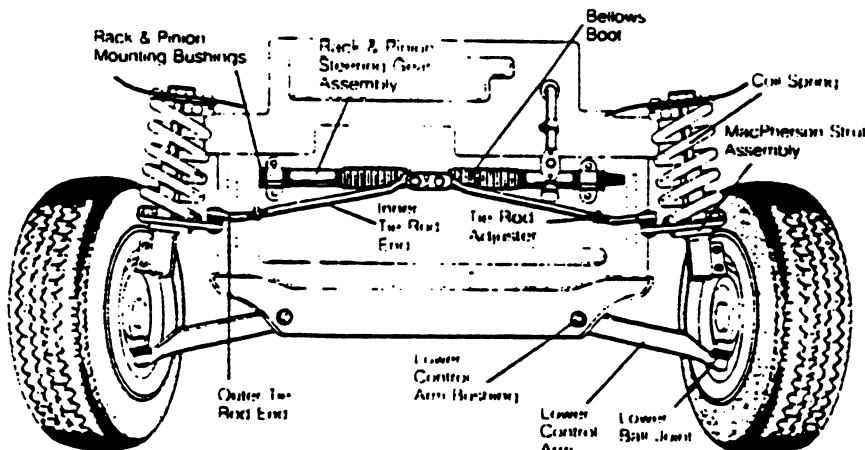
Figure LS1 Typical Steering and Suspension Systems



Rack and Pinion with Conventional Suspension



Rack & Pinion with MacPherson Strut Suspension



Rack & Pinion Centre Steer with MacPherson Strut Suspension

Figure LS2 Typical Steering and Suspension Systems

REAR SUSPENSION

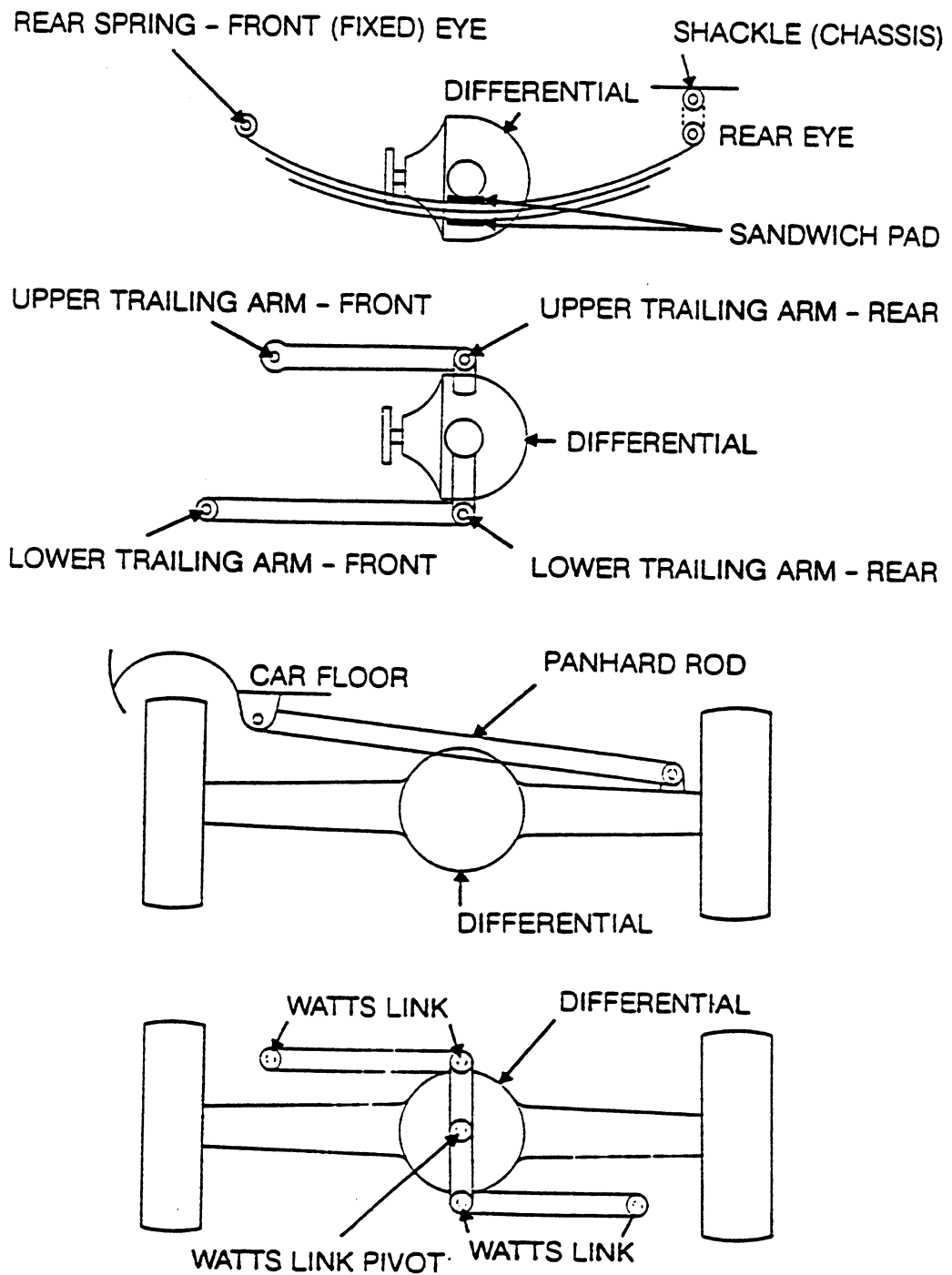


Figure LS3 Rear Suspension Systems

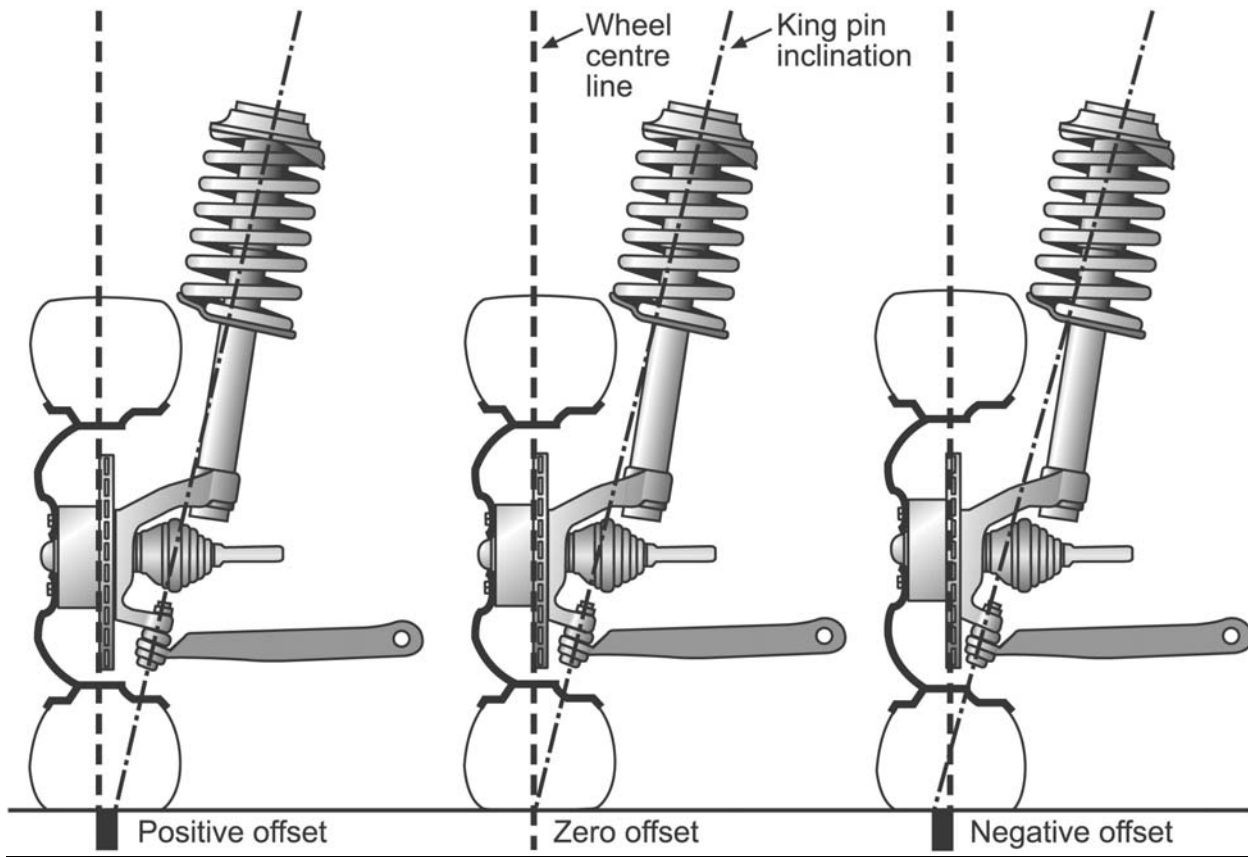


Figure LS4 Front Wheel Drive Steering Geometry

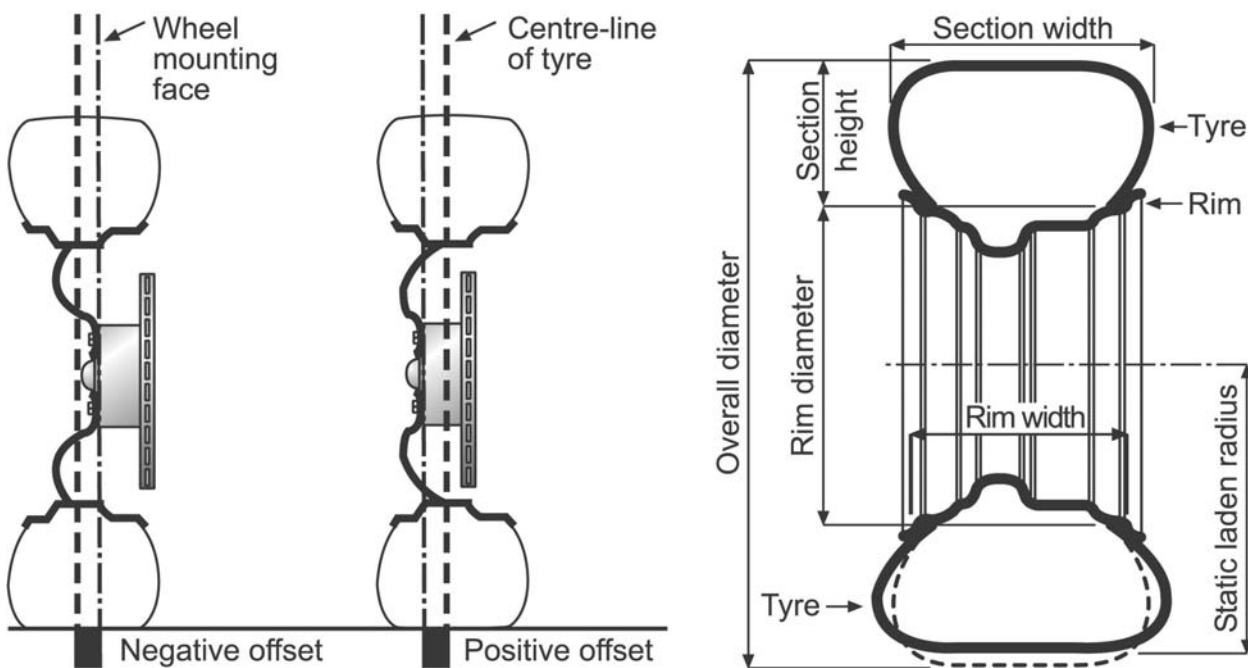


Figure LS5 Rim Offset

2.5 RELEVANT PUBLICATIONS

- Automotive Suspensions – Campbell, Colin - ISBN 412-16420-5
- Vehicle System Components Design and Safety – Limpert, Rudolf - ISBN 0-471-08133-7
- Automotive Suspensions Steering Alignment and Brakes – Billiet, Walter & Alley, Walter - ISBN 0-8269-0122-2
- Theory & Practice of Chassis Tuning – Norbye, Jan – ISBN 0-85113-076-3

3 AUSTRALIAN DESIGN RULES

The Australian Design Rules (ADRs) most likely to be affected by steering and suspension changes are those relating to rims, tyres, brakes and general safety requirements.

Some changes will also affect rules relating to collapsible steering columns, glare reduction, windscreen demisting and instrumentation that may be affected by modifications covered in this section are included in the following list:

ADR	Title & Comments
7, 7/...	Brake Hoses
10, 10/...	Steering Column
12, 12/...	Glare Reduction in Field of View
13, 13/...	Installation of Lighting and Light Signalling Devices on other than L-Group Vehicles
15, 15/...	Demisting of Windscreen
18, 18/...	Instrumentation
20, 20/...	Safety Rims
21, 21/...	Instrument Panel (RHD, LHD steering conversion)
23, 23/...	Passenger car tyres
24, 24/...	Tyre and Rim Selection (tyre placard, speed rating)
31, 31/...	Braking
42, 42/...	General Safety Requirements
43, 43/...	Vehicle Configuration & Dimensions (ground clearance)

A modified vehicle must continue to comply with the Australian Design Rules to which it was originally constructed, except as allowed for in the Australian Vehicle Standards Rules for in-service vehicles.

The applicable ADRs are individually listed on the Identification Plate of 2nd Edition ADR vehicles. For 3rd Edition ADR vehicles, the Identification Plates contain the vehicle category and the date of manufacture, from which the applicable ADRs can be determined (refer to the applicability tables in Section LO *ADR Compliance*).

4 MODIFICATIONS WITHOUT CERTIFICATION

The following modifications may be carried out provided they do not affect compliance with Australian Design Rules and provided they meet the following general safety requirements:

4.1 REPLACEMENT TYRES ON STANDARD (OR MANUFACTURER'S OPTIONAL) RIMS

Some tyre sizes have become obsolete and are no longer available. Equivalent replacement tyres with different size designations may be fitted without specific approval under this Section.

Every passenger car manufactured after 1972 (ADR 24) is fitted with a tyre placard that contains information on original and optional tyres and rims for that vehicle model.

A motor vehicle under 4.5 tonne which is required to comply with ADR 24 may be equipped with tyres other than those listed on the tyre placard provided that:

- the load rating of the tyres is not less than the lowest load rating listed on the tyre placard of the vehicle or equivalent variant of that model vehicle;
- the speed rating of the tyres fitted to a passenger vehicle is at least 180 km/h ("S") when the tyre placard requires a higher speed rating than "S";
- the speed rating of the tyres fitted to vehicles with special features for off-road use of at least 140 km/h ("N") when the tyre placard requires a higher speed rating than "N", and;
- for all other vehicles a speed rating of at least 120 km/h
- In special circumstances, the speed rating may be less than the ratings specified above if the speed rating of the tyre is more than the vehicle's maximum speed.

Where a vehicle has its GVM re-rated, the tyre load capacity must be capable of carrying the revised GVM, both in total and across individual axles.

Replacement tyres must also conform with the following requirements:

- the tyres are rated by the tyre manufacturer as being suitable for road use,
- the tyre construction (e.g. radial) and size must be the same on each axle; and
- where retreaded tyres are used, they must have been retreaded and marked in accordance with the provisions of Australian Standard AS 1973-1993 *Pneumatic Tyres — Passenger Car, Light Truck and Truck/Bus — Retreading and Repair Processes*.

4.2 NON-STANDARD TYRES AND RIMS

When wheels that do not comply with the vehicle manufacturer's specifications are fitted to a vehicle with standard axles and suspension, the following requirements must be met:

TYRE AND RIM CONSTRUCTION

The combination of tyre and rim must meet size and construction requirements of ADR 23, or if the vehicle was manufactured before 1 January 1974, one of the following standards:

- Tyre and Rim Standards Manual of the Tyre & Rim Association of Australia;

- 1981 Tire & Rim Association Inc. Year Book;
- British Standard BS AU50;
- Japan Automobile Tire Manufacturers Association Year Book;
- Japanese Industrial Standards (JIS-D4202).

Replacement aluminium alloy rims must comply with one of the following standards:

- Wheel Industries Association (Australia) (WIA);
- Standards Association of Australia (SAA);
- Technischer Überwachungsverein (TÜV);
- Japanese Industrial Standards (JIS).

Rims must not have a full circumferential weld, other than one that attaches the rim to the wheel centre.

WHEEL ATTACHMENT

Replacement wheels must be designed for the particular hub/axle and have the same bolt/stud pitch circle diameter and the same centre location method. The wheel nuts or bolts must have the same tapers as the wheel. Wheels with slotted bolt/stud holes are not allowed.

Replacement aluminium alloy rims must be located on the hub/axle by the same diameter centre spigot as the original wheel, using metal adaptor rings where necessary.

Wheel nuts and bolts must have a thread engagement length at least equal to the thread diameter, except where specified otherwise by the vehicle manufacturer.

Fitting of wheel spacers (or adaptors for dual wheel conversions) between the wheel mounting face and the road wheel is not allowed unless fitted as original equipment by the vehicle manufacturer.

Modifications to disc brake callipers, hubs and suspension and steering components to enable the fitting of replacement wheels are not allowed.

CLEARANCE

No part of the wheel must touch any part of the body or suspension under all operating conditions. To check this, the vehicle must be fully laden and capable of negotiating raised obstacles that would normally be encountered whilst driving such as speed humps and driveway entries. This test should be conducted at full lock without any part of the rim or tyre contacting the mudguard or suspension. Test weight for passengers is 68kg plus 15kg per person for luggage where luggage space is provided.

The wheels must be contained within the bodywork, or mudguards (including “flares”) when the wheels are in the straight ahead position.

OVERALL DIAMETER

The overall diameter of any tyre fitted to a passenger car or passenger car derivative must not be more than 15mm larger or 26mm smaller than that of any tyre designated by the vehicle manufacturer for that model.

The overall diameter of any tyre fitted to an off-road passenger vehicle or a commercial vehicle must not be more than 50mm larger or 26mm smaller than that of any tyre designated by the vehicle manufacturer for that model.

Speedometer accuracy must be maintained for the selected tyre and rim combination to within the degree of accuracy specified in ADR 18 where applicable.

TYRE ASPECT RATIO

Because of the different handling characteristics, the aspect ratio of tyres fitted to the front axle should not vary by more than 10 from the aspect ratio of tyres fitted to the rear axle (e.g. 175 **65** R14 front and 205 **45** R14 rear, has an aspect ratio difference of 20 and is not recommended, whereas 175 **65** R14 front and 195 **60** R14 rear has a difference of 5 and has similar handling characteristics).

WHEEL SIZES AND AXLES

All rims fitted to a front axle or a rear axle must be of the same diameter, offset, width and mounting configuration (except for spare wheels used in an emergency situation).

Where a two-axle vehicle is fitted with different width single tyres, the narrower tyres must not be less than 70% of the width of the wider tyres.

HIGH PERFORMANCE SPECIFICATIONS

When converting a passenger car's wheels and tyres to those fitted to a high performance version of that model, the matching suspension components such as springs, shock absorbers and sway bars from the high performance model should also be used.

MAXIMUM PASSENGER CAR TYRE AND RIM WIDTH

Tyres fitted to passenger cars or passenger car derivatives must not be more than 30% wider than vehicle manufacturer's widest optional tyre.

The rim width must not exceed the recommendations for the tyre fitted.

For example, if the original widest optional tyre is 185mm, the maximum tyre width is 1.3 times 185mm = 240.5mm, i.e. a 235mm wide tyre. The maximum rim width for a 235mm tyre is 9 inches if the aspect ratio is 60 or below.

Section LS Tyres, Rims, Suspension & Steering

The following is a list of passenger car tyres outlining the maximum allowable tyre and rim sizes taking into account the tyre aspect ratio (n/a = not available):

OE Manufacturer's Widest Optional Tyre (mm - inch)	1.3 x OE Manufacturer's Widest Optional Tyre (mm)	Max. Nominal Tyre Width (mm)	Maximum Allowable Rim Size for the Maximum Allowable Nominal Tyre Width (inches)	
			Aspect Ratio 65 to 85	Aspect Ratio 60 & Below
W	1.3 times W	Actual Tyre Size		
135 (5.20)	175.5	175	6.0	7.0
145 (5.60)	188.5	185	6.5	7.0
155 (6.00)	201.5	195	7.0	7.5
165 (6.40)	214.5	205	7.5	8.0
175 (7.00)	227.5	215/225	7.5/8.0	8.5/9.0
185 (7.25)	240.5	235	8.5	9.0
195 (7.50)	253.5	245	9.0	9.5
205 (8.00)	266.5	255/265	9.5	10.0
215 (8.50)	279.5	275	10.0	11.0
225 (9.00)	292.5	285	10.0	11.0
235 (9.25)	305.5	295/305	10.0	11.0
245 (9.50)	318.5	315	n/a	12.5
255 (10.00)	331.5	325	n/a	13.0
265 (10.50)	344.5	335	n/a	13.0
275 (10.75)	357.5	355	n/a	13.0

PASSENGER CAR WHEEL TRACK

The wheel track of passenger cars must not be increased by more than 25mm beyond the maximum specified by the vehicle manufacturer for the particular model. This means that the rim offset must not be changed by more than 12.5mm.

Reduction in wheel track is not permitted without approval of the relevant registration authority.

On vehicles with diagonally split brake systems, the front wheel offset (and front wheel track) should remain as original, except where the original manufacturer specifies differently with optional rims for a particular model.

Section LS Tyres, Rims, Suspension & Steering

MAXIMUM TYRE AND RIM WIDTHS FOR OFF-ROAD PASSENGER AND COMMERCIAL VEHICLES

Tyres fitted to off-road passenger and commercial vehicles must not be more than 50% wider than vehicle manufacturer's widest optional tyre.

The rim width must not exceed the recommendations for the tyre fitted.

The following is a list of original tyres with the maximum allowable tyre and rim sizes.

OE Manufacturer's Widest Optional Tyre (mm - inch)	1.5 x OE Manufacturer's Widest Optional Tyre (mm)	Max. Allowable Nominal Tyre Width (mm)	Maximum Allowable Rim Size for the Maximum Allowable Nominal Tyre Width (inches)	
			65 to 85 Series	60 Series & Below
W	1.5 times W	Actual Tyre Size		
175 (7.00)	262.5	255	9.5	10.0
185 (7.25)	277.5	275	10.0	11.0
195 (7.50)	292.5	285	10.0	11.0
205 (8.00)	307.5	295/305	10.0	11.0
215 (8.50)	322.5	315	10.0	11.0
225 (9.00)	337.5	335	n/a	13.0
235 (9.25)	352.5	345	n/a	13.5
245 (9.65)	367.5	365	n/a	n/a
255 (10.00)	382.5	375	n/a	n/a
265 (10.50)	397.5	385	n/a	n/a
275 (11.00)	412.5	405	n/a	n/a
285 (11.25)	427.5	425	n/a	n/a

OFF-ROAD AND COMMERCIAL VEHICLE WHEEL TRACK

The wheel track of off-road and four wheel drive vehicles must not be increased by more than 25mm beyond the maximum specified by the vehicle manufacturer for the particular model, except for vehicles fitted with front and rear beam axles, where a maximum wheel track increase of 50 mm is allowed.

LOAD RATING AND SPEED RATING

Every passenger car manufactured after 1972 (ADR 24) is fitted with a tyre placard that contains information on original and optional tyres and rims for that vehicle model.

A motor vehicle under 4.5 tonne which is required to comply with ADR 24 may be equipped with tyres other than those listed on the tyre placard provided that:

- the load rating of the tyres is not less than the lowest load rating listed on the tyre placard of the vehicle or equivalent variant of that model vehicle;
- the speed rating of the tyres fitted to a passenger vehicle is at least 180 km/h (“S”) when the tyre placard requires a higher speed rating than “S”;
- the speed rating of the tyres fitted to vehicles with special features for off-road use of at least 140 km/h (“N”) when the tyre placard requires a higher speed rating than “N”, and;
- for all other vehicles a speed rating of at least 120 km/h
- In special circumstances, the speed rating may be less than the ratings specified above if the speed rating of the tyre is more than the vehicle’s maximum speed.

NOTE: The load rating is usually expressed as a load index, a number marked on the tyre in conjunction with the speed rating capital letter:

e.g. 94H has a load rating of “94” and a speed rating of “H”. The meaning of these ratings can be found in manufacturer’s documentation or publications such as the Tyre and Rim Manual.

DUAL WHEELS

Dual wheel assemblies must meet the following requirements:

- The effective tyre width of a dual wheel assembly is the addition of the widths of each tyre in the assembly;
- If replacement single wheels are fitted to a commercial vehicle originally fitted with dual wheels, then the tyre width must not be less than the sum of the widths of the original two tyres fitted on the dual rims (except in the case where a complete single wheel axle assembly from another vehicle is substituted). The load rating of the single tyre must be at least the sum of the load ratings of the dual tyres;
- If a vehicle originally fitted with single wheels is changed to dual wheels, then the maximum combined tyre width of the two wheels must not exceed the maximum allowed for the original tyres on the vehicle (except in the case where a complete dual wheel axle assembly from another vehicle is substituted). The sum of the load ratings of the dual tyres must be at least the load rating of the single tyre.

4.3 REPLACEMENT TYRES & RIMS ON VEHICLES WITH MODIFIED AXLES, SUSPENSION OR BRAKES

Replacement tyres and rims on a vehicle that has been previously modified in accordance with Approval Code LS3, LS5, LS7 or LG1, must comply with the requirements of the original approval document in relation to overall diameter, tyre width and rim offset. No reduction in load rating or speed rating is allowable.

4.4 SHOCK ABSORBERS

Replacement shock absorbers (including struts and strut inserts) may be used provided that they have been manufactured as replacement units for the particular vehicle model and have compatible mountings and dimensions.

4.5 SWAY BARS

Replacement or additional sway bars (anti-roll bars, stabiliser bars) may be fitted to front and rear suspensions. Because additional roll stiffness at the front will increase understeer and additional roll stiffness at the rear will increase oversteer, the incorrect choice or combination of sway bars could lead to unpredictable handling.

4.6 TRACK RODS

Track rods may be fitted to control rear spring “wind-up” provided that they meet the minimum ground clearance requirements of ADR 43 or the in-service AVSRs where applicable.

4.7 STRUT BRACES

Transverse strut braces may be fitted between suspension strut and spring mounting towers. Front strut braces should be kept as low as possible below the bonnet to minimise head injury to a pedestrian from any downward impact on the bonnet.

4.8 POWER STEERING

A power steering system that is a manufacturer’s option for that vehicle model may be installed provided that all standard steering components and mounting hardware from that vehicle model are used. Modified systems must be approved under Codes LS3/4.

4.9 STEERING WHEELS

Replacement steering wheels must not affect compliance with ADR 10 (after 1970) and ADR 69 (after June 1995). Unless a steering wheel is marked, or has accompanying information, as having been tested to the appropriate ADR, it cannot be used as a replacement. In addition, steering wheels for vehicles required to comply with ADR 69 are only acceptable if the steering wheel assembly is identical to one fitted as an option to the same model by the vehicle manufacturer. Alternatively, a steering wheel that has been certified by the replacement wheel manufacturer as a complying wheel for the specific make and model may be used.

Replacement steering wheels should not be less than 330mm outside diameter. If the original steering wheel was designed with a recessed or padded hub, the replacement wheel should be of a similar design.

4.10 LOWERING OR RAISING VEHICLES

None of the codes in this NCOP allow for the raising of any vehicle where the wheel track has also been reduced. These vehicles are subject to individual approval on a case-by-case basis.

Modifications that result in raising the vehicle body greater than 50mm are to be carried out and approved in accordance with Codes LS7 and Code LS8.

When lowering a vehicle, the ride height of an unladen vehicle must not be changed by more than one third of the working travel of the suspension from its original height to a rigid bump or rebound position specified by the manufacturer. The suspension bump and rebound positions are measured with any deformable bump or rebound stops removed. The original relationship between the front and rear suspension heights must not be changed and therefore the front and rear suspensions must be both raised or both lowered by the same amount.

When raising a vehicle the original rebound travel amount must be maintained. The rebound shall be limited by the same method as originally employed by the manufacturer. For example limit straps or shock absorber full extension.

Section LS Tyres, Rims, Suspension & Steering

If coil springs are lowered, or replacement lower coil springs are used, they must have the same end shape as the original springs. They must retain some pre-tension and not come loose when the suspension is in its lowest position (full rebound). They must have clearance between coils at full bump.

Lowering blocks used with leaf spring suspensions must be steel, aluminium or metal of equivalent strength and must be positively located to the axle spigot hole and spring centre-bolt.

Extended or adjustable shackle plates must not be used to raise vehicles on leaf spring suspensions.

Bodies can be lifted up to 50mm using spacer blocks on the chassis mounts and can be approved under Codes LS3 & LS4 and LS5 & LS6.

Rubber or other resilient bump stops must be provided where the suspension and/or axle are likely to "bottom-out" on the body or chassis structure.

Where the vehicle manufacturer has fitted a load-sensing valve to the braking system as standard equipment, the brake system bias must be checked in both laden and unladen conditions. This check must confirm that the manufacturer's specifications are maintained. The vehicle's braking system may require re-certification to the ADR applicable to the category of vehicle at its date of manufacture.

5 CERTIFIED MODIFICATIONS (LS APPROVAL CODES)

This section specifies particular requirements and covers limitations on approvals carried out under individual LS Approval Codes.

Each Code is supplemented with a checklist.

	LS APPROVAL CODE DIRECTORY	PAGE
LS1	LHD Vehicle Steering Conversion (Design)	23
	Checklist	25
LS2	LHD Vehicle Steering Conversion	30
	Checklist	31
LS3	Front Suspension and Steering Conversion (Design)	35
	Checklist	43
LS4	Front Suspension and Steering Conversion	49
	Checklist	50
LS5	Rear Suspension Conversion (Design)	53
	Checklist	56
LS6	Rear Suspension Conversion	58
	Checklist	59
LS7	High Lift 50mm to 150mm (Design)	61
	Checklist	65
LS8	High Lift 50mm to 150mm	68
	Checklist	69

LHD VEHICLE STEERING CONVERSION (DESIGN)

CODE LS1

SCOPE

The following is a summary of the modifications that may be approved under Code LS1 – LHD Vehicle Steering Conversion (Design).

Approvals that are **allowed** under this Code include:

1. Design of steering and all associated controls for LHD to RHD steering conversions using standard components from a manufacturer's right hand drive variant.
2. Design of steering and all associated controls for LHD to RHD steering conversions using modified components or components from different vehicle models.

Approvals that are **not allowed** under this Code include:

3. Approval of the actual physical modification of particular vehicles (this is covered by Code LS2).
4. Design approvals for steering conversions on vehicles originally manufactured as right hand drive (these are covered by Code LS3).
5. Design approvals for rear suspension modifications (these are covered by Code LS5).

This section does not apply to L-group vehicles (e.g. motorcycles).

COMPLIANCE WITH APPLICABLE VEHICLE STANDARDS

The modified vehicle must continue to comply with all applicable ADRs, AVSRs, VSBs, Acts and Regulations.

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

DETAIL	REQUIREMENTS
Steering Column	ADR 10
Dashboard	ADR 12, 21
Demisting of Windscreen	ADR 15
Instrumentation	ADR 18
Braking System	ADR 7, 31, 35

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NOTE: To determine the ADRs that apply to the vehicle in question, refer to the Applicability Tables in Section LO. Vehicles manufactured after 1 January 1969 and prior to 1 July 1988 need to comply with the Second Edition ADRs whilst vehicles manufactured after this date need to comply with the Third Edition ADRs. Section LO has separate applicability tables for each edition.

The ADRs apply according to the vehicle's category and date of manufacture. It is the responsibility of the signatory to refer to the appropriate ADR applicable to the vehicle.

SPECIFIC REQUIREMENTS

The following are specific requirements to enable design approvals to be issued for left to right hand drive steering conversions under Approval Code LS1.

The design must comply with the requirements of Vehicle Standards Bulletin VSB4, *National Code of Practice – Steering Conversions for Left Hand Drive Vehicles*.

The approval should also comply with the general guidelines contained in both sub-section 2 *General Requirements* and *Specific Requirements* in Approval Code LS3 *Front Suspension and Steering Conversion – Design*.

Each design should be fully documented, with drawings, calculations, procedural details, test results and any other data necessary to fully describe the vehicle modifications and should have a unique design approval number.

The design approval document should contain:

- Details of all drawings needed to fully describe the full extent of the modification;
- Details of any special modification techniques, procedures or adjustments;
- Details of any testing of components (e.g.. X-rays of modified drag links) and performance (e.g. bump-steer plots) with related acceptance criteria.

CHECKLIST

LHD VEHICLE STEERING CONVERSION (DESIGN)

APPROVAL CODE LS1

(N/A= Not Applicable, Y=Yes, N=No)

1	STEERING CONVERSION – USING RHD BOX OR RACK			
1.1	Steering Box/Rack Selection			
	Is RHD steering box/rack used of equivalent capacity to original?		Y	N
	Is Pitman arm size/length and arc of travel equivalent to original?		Y	N
	Does Pitman arm spline match steering box spline?		Y	N
	Is the drag link attachment taper identical?		Y	N
1.2	Steering Box/Rack Mounting			
	Does location and angle of steering box/rack replicate original?		Y	N
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
	Is mounting of steering box/rack equivalent strength to original?		Y	N
1.3	Steering Box/Rack coupling			
	Is original column coupling (or equivalent) used?		Y	N
	Is original steering box/rack coupling (or equivalent) used?		Y	N
1.4	Idler arm			
	Is the mounting bracket adequately secured to chassis rail?	N/A	Y	N
	Does the idler arm location and angle replicate the original?	N/A	Y	N
1.5	Drag link			
	Is original left hand drive drag link used without modification? or	N/A	Y	N
	Is right hand drive drag link used without modification? or	N/A	Y	N
	Does modified drag link replicate original?	N/A	Y	N
	Are modifications as per Code of Practice guidelines?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No. LS1

(N/A= Not Applicable, Y=Yes, N=No)

1.6	Steering geometry			
	Is the turning circle in both directions retained?		Y	N
	Is original geometry replicated in right hand drive form?	N/A	Y	N
	If geometry is altered, is bump steer still within acceptable limits?	N/A	Y	N
2	STEERING CONVERSION – USING A CROSS SHAFT			
2.1	Right angle gearboxes			
	Are boxes designed for automotive steering application?		Y	N
	Are input and output shafts splined?		Y	N
	Are gearboxes securely mounted and correctly aligned?		Y	N
2.2	Couplings and Cross Shaft			
	Is cross shaft articulated at both ends?		Y	N
	Do couplings correctly mate with gearbox shafts?		Y	N
2.3	Design Loadings			
	Do all components have adequate strength for the application?		Y	N
3	STEERING CONVERSION – USING A CHAIN-DRIVE			
3.1	Is chain drive unit designed for automotive steering application?	N/A	Y	N
3.2	Is unit fully enclosed with provision for chain adjustment?	N/A	Y	N
3.3	Is at least duplex chain used and lubrication provided?	N/A	Y	N
3.4	Is the drive designed to withstand at least 200 Nm input torque?	N/A	Y	N
3.5	Are shaft connections to manufacturer's specification and/or are splines and cotter bolts sufficiently engaged?	N/A	Y	N
3.6	Are chain-drive unit and steering column adequately supported?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No. LS1

(N/A= Not Applicable, Y=Yes, N=No)

4	STEERING COLUMN			
4.1	Mounting			
	Is steering column location replicated in right hand drive?		Y	N
	Are support brackets equivalent strength to original?		Y	N
4.2	Collapse Mechanism			
	Does the column installation retain its designed collapse system?		Y	N
	Are original telescopic sections unmodified?		Y	N
5	BRAKE MASTER CYLINDER RELOCATION			
5.1	Firewall Modifications			
	Is firewall profile reproduced on right hand side?		Y	N
	Is strength and stiffness of right hand side firewall at least equivalent to original left hand side design?		Y	N
	Are all firewall openings sealed?		Y	N
5.2	Pedal Mountings			
	Is strength and stiffness of replacement or modified pedal mounting bracket at least equivalent to original?	N/A	Y	N
5.3	Brake Pedal			
	Is the original pedal used unmodified? or	N/A	Y	N
	Is a replacement pedal of equivalent strength to original?	N/A	Y	N
5.4	Operation			
	Is full stroke of the master cylinder possible?		Y	N
	Is the pedal lever ratio the same as original?		Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No. LS1

(N/A= Not Applicable, Y=Yes, N=No)

6	BRAKE CROSS SHAFT SYSTEM			
6.1	Strength			
	Is the system capable of transferring the design brake forces?		Y	N
	Is the deflection of the cross shaft acceptable at maximum torque?		Y	N
6.2	Bearings			
	Are self-aligning bearings/bushes installed?		Y	N
	Are self-lubricated bearings/bushes installed?		Y	N
	Is the shaft positively located with collars and/or spacers?		Y	N
6.3	Pedal and Levers			
	Are pedal and lever drilled for cross shaft attachment and full circumferential welds used?		Y	N
6.4	Bearing mounting			
	Are bearing mountings adequately secured?		Y	N
	Do bearing mountings have adequate stiffness?		Y	N
6.5	Pivots			
	Are original pivot pins used?	N/A	Y	N
	Are all new pins hardened steel or in self-lubricating bushes?	N/A	Y	N
	Are suitable retaining devices used on all pivot pins?		Y	N
7	WINDSCREEN WIPERS			
	Does the wiper design meet the requirements of VSB 4?	N/A	Y	N
8	FASTENERS			
	Are high tensile bolts specified on all new critical mountings?		Y	N
	Are self-locking nuts specified on all new critical mountings?		Y	N
	Are fasteners specified at least equivalent to the original in strength and quantity?		Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No. LS1

(N/A= Not Applicable, Y=Yes, N=No)

9	WELDING			
	Are all welding details specified?	N/A	Y	N
10	DESIGN			
	Does the design of the conversion comply with all of the requirements outlined in this LS Approval Code and VSB4?		Y	N

NOTE: If the answer to any question is **N (No)**, the design cannot be approved under Code LS1

Vehicle Make & Model

Description of Modification

.....

.....

.....

Design Approval Number

Designed by (Signatory)

Company (if applicable)

Signed

LHD VEHICLE STEERING CONVERSION

CODE LS2

SCOPE

The following is a summary of the modifications that may be approved under Code LS2 – LHD Vehicle Steering Conversion.

Approvals that are **allowed** under this Code include:

1. Left to right hand drive steering conversions using standard components from a manufacturer's right hand drive variant;
2. Left to right hand drive steering conversions using modified components or components from different vehicle models.

Approvals that are **not allowed** under this Code include:

1. Steering conversions that do not have a Design Approval in accordance with the requirements of Code LS1.

This section does not apply to L-group vehicles (e.g. motorcycles).

CHECKLIST

LHD VEHICLE STEERING CONVERSION

APPROVAL CODE LS2

(N/A= Not Applicable, Y=Yes, N=No)

1	DESIGN			
1.1	Insert LS1 Design Approval No.....			
1.2	Has the vehicle been modified exactly in accordance with the plans and specifications issued under the LS1 Design Approval Number given above?		Y	N
2	WORKMANSHIP			
2.1	Is the quality of workmanship including welding to a satisfactory standard?	N/A	Y	N
2.2	Are replacement fasteners equivalent to or better than original in strength and quality?		Y	N
2.3	Are high tensile bolts and self-locking nuts used on all new critical joints and mountings?		Y	N
3	STEERING – USING RHD BOX OR RACK			
3.3	Steering Box Mounting			
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
3.4	Idler Arm			
	Does idler arm location and angle replicate original?		Y	N
	Are mounting bolts replaceable?		Y	N
3.5	Drag Link			
	If modified, does drag link comply with Code LS1 guidelines?	N/A	Y	N
	Are weld X-ray and hardness results satisfactory?	N/A	Y	N
3.6	Steering Geometry			
	Is turning circle in both directions retained?		Y	N
	Is bump steer still within acceptable limits?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS2

(N/A= Not Applicable, Y=Yes, N=No)

4	STEERING – CROSS SHAFT/CHAIN DRIVE			
4.1	Couplings			
	Are couplings correctly mated with cross-shafts and gearboxes?	<input type="checkbox"/>	Y	N
4.2	Gearbox Mountings			
	Gearboxes securely mounted and correctly aligned?	<input type="checkbox"/>	Y	N
5	STEERING - MANUFACTURER'S RHD COMPONENTS			
	Have the original vehicle manufacturer's steering and braking system parts been used as specified for the right hand drive variant of the vehicle being modified?	<input type="checkbox"/>	Y	N
6	STEERING COLUMN			
6.1	Mounting			
	Is steering column location replicated in right hand drive?	<input type="checkbox"/>	Y	N
6.2	Collapse Operation			
	Are original telescopic sections unmodified?	<input type="checkbox"/>	Y	N
7	BRAKE SYSTEM – MASTER CYLINDER RELOCATION			
7.1	Firewall Modifications			
	Are firewall modifications in accordance with Design Approval?	<input type="checkbox"/>	Y	N
	All firewall openings sealed?	<input type="checkbox"/>	Y	N
7.2	Brake Pedal			
	Are results of non-destructive testing of welded pedal satisfactory?	N/A	Y	N
7.3	Brake Pipes			
	Are all new brake lines one piece Bundy tubing?	<input type="checkbox"/>	Y	N
	Are correct flares, tapers and threads used for connections?	<input type="checkbox"/>	Y	N
	Is pipe work adequately supported?	<input type="checkbox"/>	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS2

(N/A= Not Applicable, Y=Yes, N=No)

7.4	Brake System Electrical Connections			
	Are circuits correctly connected and secured?		Y	N
	Do brake failure/low fluid level warnings operate correctly?		Y	N
7.5	Brake System Operation			
	Is full stroke of master cylinder possible?		Y	N
8	BRAKE SYSTEM - CROSS SHAFT SYSTEM			
8.1	Bearings			
	Are self-aligning bearings/bushes installed?		Y	N
	Are self-lubricated bearings/bushes installed?		Y	N
	Is the shaft positively located with collars and/or spacers?		Y	N
8.2	Pedal and Levers			
	Are the pedal and lever drilled to fit cross-shaft and full circumferential weld used?		Y	N
8.3	Bearing Mounting			
	Are mountings adequately secured?		Y	N
8.4	Pivots			
	Are suitable retaining devices used on all pivot pins?		Y	N
	Are all new pins hardened steel or in self-lubricating bushes?	N/A	Y	N
8.5	Operation			
	Is full stroke of master cylinder available?		Y	N
9	AIR-CONDITIONING AND VENTILATION			
9.1	Do windscreen demisters retain effectiveness?		Y	N
9.2	Does ventilation system operate similar to original system?		Y	N
9.3	Is air-conditioner system securely mounted?		Y	N
9.4	Are hoses and pipes correctly routed and secured?		Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS2

(N/A= Not Applicable, Y=Yes, N=No)

10	DASH PANELS AND CONTROLS			
10.1	Is crash pad original or equivalent?		Y	N
10.2	Are instruments and controls correctly positioned for driver?		Y	N
11	ELECTRICAL WIRING			
11.1	Are connections, size, insulation, support and protection at least equivalent to original?		Y	N
12	WINDSCREEN WIPERS			
11.2	Are windscreen wipers fitted in accordance with Design Approval specifications?		Y	N

NOTE: If the answer to any question is **N (No)**, the modification cannot be approved under Code LS2.

Make Model Year of Manufacture

Chassis No. or VIN

Description of Modification

.....

Vehicle Modified by

Vehicle Approved by (Signatory)

Company (if applicable)

Signed Date

FRONT SUSPENSION & STEERING CONVERSION (DESIGN)

CODE LS3

SCOPE

The following is a summary of the modifications that may be approved under Code LS3 – Front Suspension and Steering Conversion (Design).

Approvals that are **allowed** under this Code include:

1. Design of power steering conversions using components from different vehicle model(s);
2. Design of rack and pinion steering conversions;
3. Design of front suspension modifications using different struts or uprights;
4. Design of conversions using a complete suspension and steering assembly from a different vehicle model;
5. Design of body lift kits up to 50mm;
6. Alternative wheel and tyre specifications for vehicles with modified axles or suspension;
7. Design of RHD to LHD steering and dual steering conversions.

Approvals that are **not allowed** under this Code include:

1. Design of left to right hand drive steering conversions (these are covered by Code LS1);
2. Approval of the actual vehicle modifications (this is covered by Code LS4);
3. Design approvals for rear suspension modifications (these are covered by Code LS5).

This section does not apply to L-group vehicles (e.g. motorcycles).

COMPLIANCE WITH APPLICABLE VEHICLE STANDARDS

The modified vehicle must continue to comply with all applicable ADRs, AVSRs, VSBs, Acts and Regulations.

Outlined below are areas of the vehicle that may be affected by the modifications and that may require re-certification, testing and/or data to show compliance for the modified vehicle

DETAIL	REQUIREMENTS
Steering Column	ADR 10
Dashboard	ADR 12, 21
Demisting of Windscreen	ADR 15
Instrumentation	ADR 18
Braking System	ADR 7, 31, 35
Tyre Speed Rating	ADR 24
Ground Clearance	ADR 43

NOTE: To determine the ADRs that apply to the vehicle in question, refer to the Applicability Tables in Section LO. Vehicles manufactured after 1 January 1969 and prior to 1 July 1988 need to comply with the Second Edition ADRs whilst vehicles manufactured after this date need to comply with the Third Edition ADRs. Section LO has separate applicability tables for each edition.

The ADRs apply according to the vehicle's category and date of manufacture. It is the responsibility of the signatory to refer to the appropriate ADR applicable to the vehicle.

SPECIFIC REQUIREMENTS

The following requirements apply to all suspension and steering Approval Codes:

Where change is made to the suspension or steering system "design", the basic functional and construction requirements are provided as a guide for suitably qualified and experienced signatories when designing or certifying such modifications or conversions.

Each design should be fully documented, with drawings, calculations, procedural details, test results, wheel alignment specifications and any other data necessary to fully describe the vehicle modifications and should have a unique design approval number. The design approval document should contain:

1. Details of all drawings needed to fully describe the full extent of the modification;
2. Details of any special modification techniques, procedures or adjustments;
3. Details of any testing of components (e.g.. X-rays of modified drag links) and performance (e.g. bump-steer plots) with related acceptance criteria.

It is recommended that suspension and steering conversions utilise production components that do not require cutting, heating, bending or welding.

SUSPENSION AND STEERING GEOMETRY

Modified or redesigned suspension systems should meet the following requirements:

- **Free Movement.** Suspension members and pivot bushes must be free to move through the full range of suspension travel from metal to metal positions at full bump and full rebound, without any geometric binding within the linkage and without any pivot being articulated beyond its design angles. This requirement applies when one wheel is at full bump and the opposite side wheel is at full rebound;
- **Roll Centre.** The vehicle's roll axis is determined by the relative roll centre heights of the front and rear suspensions. A higher roll centre will reduce body roll but can result in unsatisfactory track variations and camber change on independent suspensions. The front suspension roll centre should not be higher than the rear suspension roll centre;
- **Camber and Track Change.** The suspension design should minimise track change with vertical wheel travel and maintain the outside wheel as close to vertical (or at slightly negative camber) as the body rolls under cornering. This will maximise cornering adhesion and minimise tyre wear;
- **Anti-squat, anti-dive.** The amount of anti-dive geometry at the front suspension and anti-squat geometry at the rear is a matter of choice, depending on the vehicle characteristics desired. The pitch axis of the front suspension should be behind the front wheels while that for the rear suspension should be ahead of the rear wheels;
- **Vertical Wheel Travel.** Spring rates and damper settings need to be selected to suit the character required for the vehicle. Spring rates should not be so high that an uncomfortably firm ride is achieved while they should not be so low that vehicle handling is compromised. Similarly damper settings should be selected to complement the spring rates. The latter may require some development effort. In general, the more vertical wheel-travel the better, because it allows larger wheel movements before bump rubbers are contacted;
- **Bump steer.** When a wheel turns or "steers" as a result only of vertical suspension movement, this behaviour is called bump steer. A wheel can also steer as a result of longitudinal wheel movement in "longitudinally compliant" suspensions.

The bump-steer characteristic must be selected to suit the entire vehicle dynamics and should be established in conjunction with the rear suspension bump steer characteristics. As a guide, a very small toe-out on bump will produce a stable "understeer" characteristic. The toe-out must not be excessive because it produces unresponsive steering and tyre wear. Front wheels should never toe-in on bump (unless the rear suspension also toes-in) because this causes unstable "oversteer".

When the front wheels are deflected rearwards under the influence of road shocks, the wheel direction should either remain unchanged or should toe out slightly. Toe-out under these conditions produces a smoother ride - however too much can cause excessive tyre wear.

- **Ball joint operating angles.** The complete range of combinations of steering/suspension travel must be considered to ensure that there is no possibility of joints being over-articulated. Over-articulation, even by a small amount can result in joint failure. An allowance must be made for deflection of suspension bushes under dynamic loading, as this can be significant at the extremes of travel. The compound angle of articulation of all steering and suspension ball joints must be established and compared with the manufacturer's specification for each joint. Note that the specification will usually quote a slightly smaller angle than might be measured using a production component;
- **Operating Clearances.** All suspension members and steering levers and linkages must clear other vehicle components such as engine, transmission exhaust system and chassis members etc over the full envelope of steering/suspension travel, after allowing for any likely movement of engine or other mechanical assembly. It is recommended that a clearance of at least 10mm be provided between these components and 25mm be provided for tyres;
- **Track.** Where non-original axle or suspension cross-member components are fitted, the offset of the wheel in relation to the axle or hub assembly used must not be increased by more than 12.5mm each side of the vehicle based on the specifications of the axle components used. If an axle assembly is shortened then the track width limit is taken as the axle manufacturers original track dimension, less the amount the assembly has been narrowed, plus 25mm;
- **Linkage stability.** Steering linkages must be evaluated to ensure that they cannot "over-centre" at any stage, under the influence of either steering gear forces or road wheel forces. Allowance must be made for significant deflection and wear in pivot bushes in the steering and suspension and a large safety margin must be maintained;
- **Steering stops.** Must be provided and be installed as per those from the donor vehicle or as approved by the steering gear manufacturer. Reductions in steering gear travel are acceptable provided that operating loads or stresses on the steering system are not increased;
- **Ackermann principle.** The Ackermann principle ensures accurate wheel geometry and tyre contact in turns avoiding excessive scuffing. All vehicles should incorporate a reasonable degree of Ackermann steering geometry. This concept is important when designing replacement steering systems and when altering the wheelbase of vehicles, e.g. limousine conversions.

At full lock, the lock angles must be appropriate for the desired turning circle and must not change significantly over the range of suspension travel. The toe-out at full lock should be selected, bearing in mind the true *Ackermann* angle, the types of tyres to be catered for and the use intended for the vehicle.

At partial lock, the toe-out should be suitable for the vehicle application. This usually means slightly less than the true *Ackermann* angle due to the operating slip angle of the outside front tyre.

STRUCTURE

The body/chassis structure should meet the following requirements:

- **Body/Chassis.** Reinforcements must be added to achieve comparable structural strength and stiffness at body attachment points whenever a replacement suspension or steering system from a different vehicle model is used. The modifications must not create local stress concentrations;

- **Cross-member.** When a cross-member is modified, or when a cross-member from another vehicle model is fitted, it must be reinforced where necessary to maintain its original structural strength and stiffness.

COMPONENT STRESS LEVELS

The stress levels of any production component in the suspension system must not be increased over that at which it has been *demonstrated* to be capable of satisfactory operation.

Stress analysis should be carried out for modified or specially fabricated components and the following load conditions are suggested as a guide:

- bump loads: 4g vertical;
- rut loads: 1g vertical combined with $\pm 0.6g$ lateral;
- skid loads: 2g vertical combined with 1.2g skid (longitudinal).

Overturning loads: 2g vertical combined with 2.5g overturning; where g is the static load at the tyre contact patch when the vehicle is stationary. The stress levels that are acceptable under these conditions will depend on the materials and the number of times in the life of the vehicle that the loads can be expected to occur. Other factors which can affect suspension loads and should be considered are:

- rim offset;
- combination of braking at lock while striking an obstacle;
- steering scrub radius;
- the effect of steering system loads on the suspension components.

MODIFIED COMPONENTS

Where modifications of steering components cannot be avoided, the operations employed should be determined and controlled such that the final properties can be predicted and verified *on an individual component basis* by a NATA approved materials laboratory, using relevant Australian or International Standards as a reference. The following post process testing by the laboratory is a minimum for such components:

- Welded parts should have the weld material identified, a hardness test traversing across the weld area including the heat affected zone, an X-Ray inspection and a statement of weld integrity;
- Heated parts should be stress relieved, heat treated to a defined specification and undergo non-destructive testing such as magnetic particle or ultrasonic;
- Parts which have been cold worked (where allowed) must be checked to ensure that the cold working is not excessive, stress relieved if required and undergo non-destructive testing such as magnetic particle or ultrasonic.

Standard features such as splines, tapers and keyways must conform to published standards and mating parts to matching standards.

Machining of input shafts is allowable to reduce length, provided that welding is not involved, the same spline is machined at the new length and the minimum cross section, including radii, of the shaft is not reduced below that of the original. The modified pinion shaft should not be subsequently heat-treated.

Machining of any components must meet the relevant specifications of tolerance and radii.

All splines must meet the original vehicle specifications and must engage over the same length as the original.

Threaded bosses, where used for steering gear mounting, must provide full depth thread form engagement over 1.5 times the mating bolt diameter.

Welding of steering components to the chassis structure is not allowed under any circumstances.

Re-machining of ball joint tapered stud holes in steering arms is allowed provided that the re-machining does not reduce the safety of the design and the surface finish is equivalent to that of the original manufacture.

Tapered adaptor sleeves are allowed but must be made of suitable steel, i.e. equivalent in strength and hardness to the stud to be mounted.

Mounting surfaces for steering components must be such that no stress inducing deflection of either mounting surface or steering component occurs when the attachment bolts are tightened.

Braces, if required to achieve acceptable steering box/rack mounting stiffness, may be bolted into position to allow easy removal for subsequent vehicle servicing or dismantling.

Power steering conversions - *separate ram type* must be carried out in accordance with the following:

- Power cylinder location, orientation, articulation angles and operating pressures must be in accordance with the manufacturer's specifications, taking into consideration the full movement of the suspension and steering;
- The vehicle structure at the point of attachment of the power steering ram must be reinforced if required to accommodate the power cylinder loads, taking into consideration the peak hydraulic pressures, mounting bush deflection loads and the frequency of application of these loads.

Steering linkage installations must be carried out in accordance with the following:

- Steering gear linkage assemblies must be sourced from a vehicle of similar or larger mass than the finished vehicle as modified;
- Reshaping, sectioning, re-machining of draglinks, steering arms and the relocation of the inner and outer pivots or tie-rod pivots in order to achieve correct steering geometry is acceptable, provided that the processes are conducted under the controls described in this section;
- Ball joints and plain bearing end fittings and idler arm pivots must have manufacturer's ratings in excess of the loads and angular travel imposed on them in the modified vehicle. If the manufacturer's rating is not available, evidence of equivalent usage in a production vehicle, together with stress calculations may be used.

Rack and pinion steering gear installations must be carried out in accordance with the following:

- Rack and pinion assemblies must be sourced from a vehicle of similar or larger mass than the vehicle being modified;
- Rack and pinion type steering must not be used in conjunction with “beam” front axles if the independent arcs of the tie rods (upon suspension movement of the axle) creates toe-in or toe-out with suspension movement resulting in dangerous bump steer;
- Any rack extension (to achieve correct steering geometry) must be by means of machined adaptors provided that they are of the same strength as the steering rack. Retention of such adaptors must be identical to that of the original tie rods together with suitable thread securing compound. Welding of steering racks is not allowed. The effects on rack bending stresses of the additional ball joint offset as well as the strength of the connection between rack and adaptor must be assessed in accordance with this sub-section. Rack boot requirements must also be addressed;
- Rack shafts may be shortened by machining provided that the machining does not affect the teeth area;
- For variable ratio racks, any shortening must be performed at each end symmetrically to maintain the on-centre rack location with the road wheels straight ahead;
- Shortening a rack shaft by cutting and re-welding is not allowable;
- Rack housing length may be shortened. It is recommended that only housings in which the centre section is a steel tube are so modified and that the shortening be confined to this section. It is suggested that a close fitting steel sleeve of equivalent material and wall thickness be used to bridge the joint and be welded on both ends;
- On assembly, the preload of the rack must be checked every 25mm of rack travel to ensure no binding has resulted from the rework. The rack manufacturer’s preload specification should be used;
- Mounting of the rack should replicate the original mounting configuration.

Chassis mounted steering gear installations must be carried out in accordance with the following:

- Chassis mounted steering gear assemblies must be sourced from a vehicle of similar or larger mass than the finished vehicle as modified;
- Unless the steering column is aligned with the steering gear with no more than 5° of angular mismatch, fabric or rubber couplings may not be used at the steering gear input shaft. Where more than 5° angular mismatch exists, a metallic universal joint may be used. If the axes of the column and steering gear input shaft do not intersect at the position of the coupling, an intermediate shaft must be fitted with two universal joints to provide for the misalignment;
- Sector shafts may be reworked **only** by re-machining the master splines. The re-machined spline must replicate the remaining splines in all dimensions;
- Welding of the sector shaft to change length or alter spline details is not allowed;

Section LS Tyres, Rims, Suspension & Steering

- Where new chassis mounting boltholes are required, the chassis must be reinforced to carry the steering gear loads and the boltholes in box section chassis rails must be reinforced with tubes of 1.6mm wall thickness minimum to prevent crushing of the chassis section.

Pitman arms may be modified by:

- the removal by machining of the master spline; and/or
- cold working, hot working, sectioning and re-welding, provided that the processes are conducted under the controls described in this section.

Idler arms may be modified by:

- re-machining to accept revised pivots, provided that the strength of the component is sufficient to accept the maximum input load that can be applied by the steering gear; and/or
- cold forming, hot reforming and sectioning and re-welding are allowable provided that the processes are conducted under the controls described in this section.

Tie-rods may be modified by:

- shortening by extending the thread and removing the excess threaded portion, provided that the rod is suitable for this operation, the length of thread engagement is equal to or greater than the original manufacturer's specification; or
- extending by provision of threaded adaptors, provided that the original manufacturer's specification in respect to buckling strength, shear strength, thread engagement, thread locking and material selection are all maintained.

Steering arms may be modified by "hot-working", provided that the processes are conducted under the controls described in this section.

Draglink specific requirements are:

- A new draglink may be manufactured provided that it is one continuous length of material between end fittings and the selected material is suitable for the design and method of manufacture;
- Sectioning and re-welding of the draglink is allowable provided that the processes are conducted under the controls described in this section.

Steering column shaft couplings must be selected and installed as follows:

- Couplings which are designed for use on manual steering may be used on power steering vehicles;
- Couplings designed for use on power steering vehicles only, are not to be used on manual steering vehicles;
- Re-assembly of steering couplings utilising revised components is acceptable, provided that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm;

- Machining of couplings to alter the PCD of the attaching bolts is acceptable provided that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm;
- The alignment of the coupling must be maintained to within the manufacturer's specification and phasing of the universal joints must be correct.

Intermediate shafts must be selected and installed as follows:

- Intermediate shafts designed for use only on power steering vehicles must not be used on manual steering vehicles;
- Collapsible intermediate shafts designed in conjunction with a specific steering column to meet ADR 10 should be utilised with a matching column where the vehicle is subject to that ADR;
- Machining is allowed to accept a revised PCD for coupling attachment and/or to match a revised spline, provided that the resulting assembly and the modifications do not reduce the available collapse distance required to meet ADR 10;
- Sectioning and re-welding of intermediate shafts is allowed, provided that the processes are conducted under the controls described in this section. The weld should be ground smooth. The joint can be supplemented with a fitted sleeve spanning the welded area and attached by plug welding and/or fillet welding each end;
- The completed intermediate shaft must be straightened to achieve a maximum runout of 1mm Total Indicated Runout (TIR) and achieve the torsional strength to withstand an applied torque of 200Nm.

Steering columns must be selected and installed as follows:

- Steering column assemblies should be sourced from a vehicle of similar mass and specification as the vehicle being modified and, where ADR 10 applies, the column must have the design features and be suitably mounted to achieve this;
- Machining of steering column shafts to accept revised splines is allowed;
- If it is necessary to weld an alternative coupling flange to the lower end of the steering column shaft, both the shaft and flange materials must be suitable for the welding process used and successfully undergo appropriate non-destructive testing;
- The modified steering column must achieve the torsional strength to withstand an applied torque of 200Nm;
- All steering column shafts must be adequately supported, particularly where universal joints are used;
- Angles on universal joints in multi-column assemblies (sometimes fitted to clear other components) must not be greater than the universal joint manufacturer's specifications. Generally, the maximum angle is 30° to avoid excessive stress on the unit;
- Flexible couplings within steering column systems, otherwise known as "rag", fabric or rubber steering dampers, must not be used for direction change in the steering column shaft. Any change of direction must be made by the use of suitable steel universal or constant velocity joints.

CHECKLIST

FRONT SUSPENSION & STEERING CONVERSION (DESIGN)

APPROVAL CODE LS3

(N/A= Not Applicable, Y=Yes, N=No)

1	REPLACEMENT STEERING BOX OR RACK			
1.1	Steering Box/Rack Selection			
	Is steering box/rack used of equivalent capacity to original?		Y	N
	Is Pitman arm size/length and arc of travel equivalent to original?	N/A	Y	N
	Does Pitman arm spline match the steering box spline?	N/A	Y	N
	Is the drag link attachment taper identical?	N/A	Y	N
1.2	Steering Rack Modification			
	Are modifications as per Code of Practice guidelines?	N/A	Y	N
1.3	Steering Box/Rack Mounting			
	Does location and angle of steering box/rack replicate original?		Y	N
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
	Is mounting of steering box/rack equivalent strength to original?		Y	N
1.4	Steering Box/Rack coupling			
	Is original column coupling (or equivalent) used?		Y	N
	Is original steering box/rack coupling (or equivalent) used?		Y	N
1.5	Idler arm			
	Mounting bracket adequately secured to chassis rail?	N/A	Y	N
	Does idler arm location and angle replicate original?	N/A	Y	N
	Mounting bolts replaceable?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS3

(N/A= Not Applicable, Y=Yes, N=No)

1.6	Drag link			
	Is original drag link used without modification?	N/A	Y	N
	Does modified drag link replicate original?	N/A	Y	N
	Are modifications as per Code of Practice requirements?	N/A	Y	N
1.7	Steering geometry			
	Is the turning circle in both directions retained?		Y	N
	Is original steering geometry replicated?	N/A	Y	N
	If geometry is altered, is bump steer still within acceptable limits?	N/A	Y	N
2	REPLACEMENT FRONT SUSPENSION CROSSMEMBER SUSPENSION AND STEERING			
2.1	Cross member Mounting			
	Is mounting of cross member equivalent strength to original?		Y	N
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
2.2	Design Loadings			
	Do all components have adequate strength for the application?		Y	N
3	REPLACEMENT FRONT SUSPENSION STRUTS OR UPRIGHTS			
3.1	Ball Joints & Tie-rod Ends			
	Are all ball joint tapers compatible or modified in accordance with Code of Practice requirements?	N/A	Y	N
3.2	Steering geometry			
	Is the turning circle in both directions retained?		Y	N
	Is original steering geometry replicated?	N/A	Y	N
	If geometry is altered, is bump steer still within acceptable limits?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS3

(N/A= Not Applicable, Y=Yes, N=No)

4	STEERING COLUMN			
4.1	Mounting			
	Are support brackets equivalent strength to original?		Y	N
4.2	Intermediate Shaft			
	Does modified shaft meet Code of Practice requirements?	N/A	Y	N
	Do couplings & attachments meet Code of Practice requirements (VSB4)?	N/A	Y	N
4.3	Collapse Operation			
	Does the column installation retain its designed collapse system?	N/A	Y	N
	Are original telescopic sections unmodified?	N/A	Y	N
5	LHD STEERING CONVERSION USING LHD STEERING BOX OR RACK			
5.1	Drag link			
	Is original left hand drive drag link used without modification? or	N/A	Y	N
	Is right hand drive drag link used without modification? or	N/A	Y	N
	Does modified drag link replicate original?	N/A	Y	N
	Are modifications as per Code of Practice requirements?	N/A	Y	N
5.2	Steering geometry			
	Is the turning circle in both directions retained?		Y	N
	Is original geometry replicated in right hand drive form?	N/A	Y	N
	If geometry is altered, is bump steer still within acceptable limits?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS3

(N/A= Not Applicable, Y=Yes, N=No)

6	LHD OR DUAL STEERING CONVERSION USING A CROSS SHAFT			
6.1	Right angle gearboxes			
	Are boxes designed for automotive steering application?		Y	N
	Are input and output shafts splined?		Y	N
	Are gearboxes securely mounted and correctly aligned?		Y	N
6.2	Couplings and Cross Shaft			
	Is cross shaft articulated at both ends?		Y	N
	Do couplings correctly mate with gearbox shafts?		Y	N
6.3	Design Loadings			
	Do all components have adequate strength for the application?		Y	N
7	LHD OR DUAL STEERING CONVERSION USING A CHAIN-DRIVE			
7.1	Is chain drive unit designed for automotive steering application?		Y	N
7.2	Is unit fully enclosed with provision for chain adjustment?		Y	N
7.3	Is at least duplex chain used and lubrication provided?		Y	N
7.4	Is the drive designed to withstand at least 200Nm input torque?		Y	N
7.5	Are shaft connections to manufacturer's specification or by splines and cotter bolts?		Y	N
7.6	Are chain-drive unit and steering column adequately supported?		Y	N
8	BRAKE MASTER CYLINDER RELOCATION			
8.1	Firewall Modifications			
	Is strength and stiffness of left hand side firewall at least equivalent to original design?		Y	N
	Are all firewall openings sealed?		Y	N
8.2	Pedal Mountings			
	Is strength and stiffness of replacement or modified pedal mounting bracket at least equivalent to original design?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS3

(N/A= Not Applicable, Y=Yes, N=No)

8.3	Brake Pedal			
	Is the original pedal used unmodified? or	N/A	Y	N
	Is a replacement pedal of equivalent strength to original design?	N/A	Y	N
8.4	Operation			
	Is full stroke of the master cylinder possible?		Y	N
	Is the pedal lever ratio the same as original?		Y	N
9	BRAKE CROSS SHAFT SYSTEM			
9.1	Strength			
	Is the system capable of transferring the design brake forces?	N/A	Y	N
	Is the deflection of the cross shaft acceptable at maximum torque?	N/A	Y	N
9.2	Bearings			
	Are self-aligning bearings/bushes installed?	N/A	Y	N
	Are self-lubricated bearings/bushes installed?	N/A	Y	N
	Is the shaft positively located with collars and/or spacers?	N/A	Y	N
9.3	Pedal and Levers			
	Are pedal and lever drilled for cross shaft attachment and full circumferential welds used?	N/A	Y	N
9.4	Bearing mounting			
	Are bearing mountings adequately secured?	N/A	Y	N
	Do bearing mountings have adequate stiffness?	N/A	Y	N
9.5	Pivots			
	Are original pivot pins used? or	N/A	Y	N
	Are all new pins hardened steel or in self-lubricating bushes?	N/A	Y	N
	Are suitable retaining devices used on all pivot pins?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS3

(N/A= Not Applicable, Y=Yes, N=No)

10	WINDSCREEN WIPERS			
10.1	Does the wiper design meet the requirements of VSB 4?	N/A	Y	N
11	FASTENERS			
11.1	Are high tensile bolts specified on all new critical mountings?		Y	N
11.2	Are self-locking nuts specified on all new critical mountings?		Y	N
11.3	Are fasteners specified at least equivalent to the original in strength and quantity?		Y	N
12	WELDING			
12.1	Are all welding details specified?	N/A	Y	N
13	DESIGN			
13.1	Does the design of the conversion comply with all of the requirements outlined in this LS Approval Code and VSB4?		Y	N

NOTE: If the answer to any question is **N (No)**, the design cannot be approved under Code LS3

Vehicle Make & Model

Description of Modification

.....

.....

Design Approval Number

Designed by (Signatory)

Company (if applicable)

Signed Date

FRONT SUSPENSION & STEERING CONVERSION

CODE LS4

SCOPE

The following is a summary of the modifications that may be approved under Code LS4 – Front Suspension and Steering Conversion.

Approvals that are **allowed** under this Code include:

1. Power steering conversions using components from different vehicle model(s);
2. Rack and pinion steering conversions;
3. Front suspension modification using different struts or uprights;
4. Conversions using a complete suspension and steering assembly from a different vehicle model;
5. Fitting of body lift kits up to 50mm;
6. Fitting wheels and tyres to vehicles with modified axles or suspension;
7. RH to LH steering and dual steering conversions.

Approvals that are **not allowed** under this Code include:

1. Modifications that do not have a Design Approval in accordance with the requirements of Code LS3;
2. LH to RH steering conversions;
3. Rear suspension modifications.

This section does not apply to L-group vehicles (e.g. motorcycles).

CHECKLIST

FRONT SUSPENSION & STEERING CONVERSION

APPROVAL CODE LS4

(N/A= Not Applicable, Y=Yes, N=No)

1	DESIGN			
1.1	Insert Design Approval No.....			
1.2	Has the vehicle been modified exactly in accordance with the plans and specifications issued under the LS3 Design Approval Number given above?		Y	N
2	WORKMANSHIP			
2.1	Is the quality of workmanship including welding to a satisfactory standard?	N/A	Y	N
2.2	Are replacement fasteners equivalent to or better than original in strength and quality?		Y	N
2.3	Are high tensile bolts and self-locking nuts used on all new critical joints and mountings?		Y	N
3	STEERING			
3.1	Steering Box Mounting			
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
3.2	Drag Link			
	If modified, does drag link comply with Code requirements?	N/A	Y	N
	Are weld X-ray and hardness results satisfactory?	N/A	Y	N
3.3	Steering Rack			
	If modified, does rack comply with Code requirements?	N/A	Y	N
3.4	Steering Geometry			
	Is turning circle in both directions acceptable?		Y	N
	Is the amount bump steer still within acceptable limits?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS4

(N/A= Not Applicable, Y=Yes, N=No)

3.5	Wheel Alignment			
	Have all wheels been aligned in accordance with the Design Approval specifications?	N/A	Y	N
4	SUSPENSION			
4.1	Cross-member Mounting			
	Is cross-member mounted in accordance with approved design?	N/A	Y	N
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
4.2	Ball Joints & Tie-rod Ends			
	Are all ball joint tapers compatible or modified in accordance with approved design requirements?	N/A	Y	N
5	LHD OR DUAL STEERING CONVERSION			
5.1	Does the conversion comply with all applicable requirements outlined in this LS Approval Code and VSB4?	N/A	Y	N

NOTE: If the answer to any question is **N (No)**, the modification cannot be approved under Code LS4

Make Model Year of Manufacture

Chassis No. or VIN

Description of Modification

.....

Vehicle Modified by

Vehicle Approved by (Signatory)

Company (if applicable)

Signed Date

REAR SUSPENSION MODIFICATION (DESIGN)

CODE LS5

SCOPE

The following is a summary of the modifications that may be approved under Code LS5 – Rear Suspension Conversion (Design).

Approvals that are **allowed** under this Code include:

4. Design of rear beam axle modifications including shortening, differential and axle substitution and revised location arms, rods, bearings, bushes and mountings.
5. Design of independent rear suspension modifications using different struts, trailing arms or uprights.
6. Design of a conversion using a complete suspension assembly from a different vehicle model.
7. Design of a complete rear suspension assembly using components from different vehicle model(s).
8. Design of body lift kits up to 50mm.
9. Alternative wheel and tyre specifications for vehicles with modified axles or suspension.

Approvals that are **not allowed** under this Code include:

10. Approval of the actual physical modification of particular vehicles (this is covered by Code LS6).
11. Design approvals for front suspension modifications (these are covered by Code LS3).

This section does not apply to L-group vehicles (e.g. motorcycles).

COMPLIANCE WITH APPLICABLE VEHICLE STANDARDS.

The modified vehicle must continue to comply with all applicable ADRs, AVSRs, VSBs, Acts and Regulations.

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

DETAIL	REQUIREMENTS
Braking System	ADR 7, 31, 35
Tyre Speed Rating	ADR 24
Ground Clearance	ADR 43

Section LS Tyres, Rims, Suspension & Steering

NOTE: To determine the ADRs that apply to the vehicle in question, refer to the Applicability Tables in Section LO. Vehicles manufactured after 1 January 1969 and prior to 1 July 1988 need to comply with the Second Edition ADRs whilst vehicles manufactured after this date need to comply with the Third Edition ADRs. Section LO has separate applicability tables for each edition.

The ADRs apply according to the vehicle's category and date of manufacture. It is the responsibility of the signatory to refer to the appropriate ADR applicable to the vehicle.

SPECIFIC REQUIREMENTS – REAR SUSPENSION

The following requirements must be met for all rear suspension modifications. Where a modification involves a change to the suspension system "design", the basic functional requirements for suspension modifications/conversions are provided as a guide to suitably qualified and experienced signatories when designing or certifying such modifications or conversions.

The approval should also comply with the general guidelines contained in both sub-section 2 *General Requirements* and *Specific Requirements* in Approval Code LS3 *Front Suspension and Steering Conversion – Design*.

Each design should be fully documented, with drawings, calculations, procedural details, test results, wheel alignment specifications and any other data necessary to fully describe the vehicle modifications and should have a unique design approval number. The design approval document should contain:

- Details of all drawings needed to fully describe the full extent of the modification;
- Details of any special modification techniques, procedures or adjustments;
- Details of any testing of components and performance (e.g. bump-steer plots) with related acceptance criteria.

It is recommended that rear suspension conversions utilise production components that do not require cutting, heating, bending or welding.

WATTS LINKAGE, PANHARD ROD

A Watts linkage or a Panhard rod can be used for sideways location of a rear axle and should be installed to comply with the following:

- It must locate sideways only and allow free movement of the axle in other directions;
- A Panhard rod should be mounted so that it is horizontal at the vehicle's normal ride height. This minimises lateral movement of the axle on full bump or rebound;
- Mounting brackets must not interfere with any other vehicle component through the full range of suspension movement.

TRACTION AIDS

Traction aids attached to a live rear axle near the spring mountings must comply with the following:

- The geometry of the system must be compatible with the geometry of the spring and not cause any binding with suspension movement;

- Parallel “ladder bars” which do not provide for body roll without a tendency to twist the axle are unacceptable for street use when used in conjunction with a torsionally rigid axle. A more suitable arrangement is the “4 link” suspension system;
- Under body clearances and ground clearance must be maintained and continue to meet regulation requirements.

CHECKLIST

REAR SUSPENSION MODIFICATION (DESIGN)

APPROVAL CODE LS5

(N/A= Not Applicable, Y=Yes, N=No)

1	REPLACEMENT REAR BEAM AXLE ASSEMBLY			
1.1	Rear axle Beam Selection			
	Is the axle assembly at least of equivalent capacity to original?		Y	N
1.3	Rear axle modifications			
	Are modifications as per Code of Practice guidelines?	N/A	Y	N
1.4	Rear Axle Mounting			
	Does location and angle of axle replicate original?	N/A	Y	N
	Is mounting of axle equivalent strength to original?	N/A	Y	N
	Does mounting allow vehicle to roll relative to axle?		Y	N
2	REPLACEMENT REAR SUSPENSION CROSSMEMBER AND SUSPENSION			
2.1	Cross member Mounting			
	Is mounting of cross member equivalent strength to original?		Y	N
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
2.2	Design Loadings			
	Do all components have adequate strength for the application?		Y	N
3	REPLACEMENT REAR SUSPENSION STRUTS OR UPRIGHTS			
3.1	Ball Joints & Tie-rod Ends			
	Are all ball joint tapers compatible or modified in accordance with Code of Practice requirements?	N/A	Y	N
3.2	Suspension geometry			
	If geometry is altered, is bump steer still within acceptable limits?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS5

(N/A= Not Applicable, Y=Yes, N=No)

4	FASTENERS			
4.1	Are high tensile bolts specified on all new critical mountings?		Y	N
4.2	Are self-locking nuts specified on all new critical mountings?		Y	N
4.3	Are fasteners specified at least equivalent to the original in strength and quantity?		Y	N
5	WELDING			
5.1	Are all welding details specified?	N/A	Y	N
6	DESIGN			
6.1	Does the design of the conversion comply with all of the requirements outlined in this LS Approval Code?		Y	N

NOTE: If the answer to any question is **N (No)**, the design cannot be approved under Code LS5

Vehicle Make & Model

Description of Modification

.....

Design Approval Number

Designed by (Signatory)

Company (if applicable)

Signed Date

REAR SUSPENSION MODIFICATION

CODE LS6

SCOPE

The following is a summary of the modifications that may be approved under Code LS6 – Rear Suspension Conversion.

Approvals that are **allowed** under this Code include:

1. Rear beam axle modifications including shortening, differential and axle substitution and revised location arms, rods, bearings, bushes and mountings;
2. Independent rear suspension modifications using different struts, trailing arms or uprights;
3. Conversions using a complete suspension assembly from a different vehicle model;
4. Fabrication and installation of complete rear suspension assemblies using components from different vehicle model(s).
5. Fitting of body lift kits up to 50mm;

Approvals that are **not allowed** under this Code include:

6. Modifications that do not have a Design Approval in accordance with the requirements of Code LS5;
7. Steering conversions.

This section does not apply to L-group vehicles (e.g. motorcycles).

CHECKLIST

REAR SUSPENSION MODIFICATION

APPROVAL CODE LS6

(N/A= Not Applicable, Y=Yes, N=No)

1	DESIGN			
1.1	Insert Design Approval No.....			
1.2	Has the vehicle been modified exactly in accordance with the plans and specifications issued under the LS5 Design Approval Number given above?		Y	N
2	WORKMANSHIP			
2.1	Is the quality of workmanship including welding to a satisfactory standard?	N/A	Y	N
2.2	Are replacement fasteners equivalent to or better than original in strength and quality?		Y	N
2.3	Are high tensile bolts and self-locking nuts used on all new critical joints and mountings?		Y	N
3	REPLACEMENT REAR AXLE BEAM ASSEMBLY			
3.1	Axle Mounting			
	Does axle mounting allow vehicle roll relative to axle?	N/A	Y	N
3.2	Axle Modifications			
	If modified, does axle comply with Code requirements?	N/A	Y	N
4	SUSPENSION			
4.1	Cross-member Mounting			
	Is cross-member mounted in accordance with approved design?	N/A	Y	N
	Is chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
4.2	Ball Joints & Tie-rod Ends			
	Are all ball joint tapers compatible or modified in accordance with approved design requirements?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS6

(N/A= Not Applicable, Y=Yes, N=No)

4.3	Wheel Alignment			
	Have all wheels been aligned in accordance with the Design Approval specifications?	N/A	Y	N

NOTE: If the answer to any question is **N (No)**, the modification cannot be approved under Code LS6

Make Model Year of Manufacture

Chassis No. or VIN

Description of Modification

.....

Vehicle Modified by

Vehicle Approved by (Signatory)

Company (if applicable)

Signed Date

HIGH LIFT 50mm to 150mm (DESIGN)

CODE LS7

SCOPE

The following is a summary of the modifications that may be approved under Code LS7 – High Lift 50mm to 150mm (Design).

Approvals that are **allowed** under this Code include:

1. Design of modifications that result in the vehicle body being raised by more than 50mm from the original “as manufactured” height.
2. Design of front suspension modifications using different struts or uprights.
3. Design of independent rear suspension modifications using different struts, trailing arms or uprights.
4. Design of a conversion using a complete suspension assembly from a different vehicle model.
5. Design of a complete rear suspension assembly using components from different vehicle model(s).
6. Design of body lift kits.
7. Alternative wheel and tyre specifications for vehicles with modified axles or suspension.

Approvals that are **not allowed** under this Code include:

8. Approval of the actual physical modification of particular vehicles (this is covered by Code LS8).
9. Design approvals for modifications that raise the vehicle body more than 150mm from the original “as manufactured” height (lifting vehicles beyond 150mm is outside of the scope of this Code of Practice).
10. Design approvals for modifications that raise the vehicle body more than 50mm from the original “as manufactured” height on vehicles that have had the wheel track reduced from the “as manufactured” width. Modifications to these vehicles will only be considered on an individual application basis.

This section does not apply to L-group vehicles (e.g. motorcycles).

COMPLIANCE WITH APPLICABLE VEHICLE STANDARDS.

The modified vehicle must continue to comply with all applicable ADRs, AVSRs, VSBs, Acts and Regulations.

Section LS Tyres, Rims, Suspension & Steering

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

DETAIL	REQUIREMENTS
Installation of Lighting	ADR 13, 45, 46
Braking System	ADR 7, 31, 35
Speedometer	ADR 18
Tyre Speed Rating	ADR 24
Ground Clearance	ADR 43

NOTE: To determine the ADRs that apply to the vehicle in question, refer to the Applicability Tables in Section LO. Vehicles manufactured after 1 January 1969 and prior to 1 July 1988 need to comply with the Second Edition ADRs whilst vehicles manufactured after this date need to comply with the Third Edition ADRs. Section LO has separate applicability tables for each edition.

The ADRs apply according to the vehicle's category and date of manufacture. It is the responsibility of the signatory to refer to the appropriate ADR applicable to the vehicle.

SPECIFIC REQUIREMENTS – BODY LIFTS BETWEEN 50MM & 150MM

The following requirements must be met for all vehicle body "high" lift modifications. Where a modification involves a change to the suspension system "design", the basic functional requirements for suspension modifications/conversions are provided as a guide to suitably qualified and experienced signatories when designing or certifying such modifications or conversions.

The approval should also comply with the general guidelines contained in sub-section 2 *General Requirements, Specific Requirements* in Approval Code LS3 *Front Suspension and Steering Conversion – Design* and *Specific Requirements* in Approval Code LS5 *Rear Suspension Modification – Design*.

Each design should be fully documented, with drawings, calculations, procedural details, test results, wheel alignment specifications and any other data necessary to fully describe the vehicle modifications and should have a unique design approval number. The design approval document should contain:

- Details of all drawings needed to fully describe the full extent of the modification;
- Details of any special modification techniques, procedures or adjustments;
- Details of any testing of components and performance (e.g. bump-steer plots) with related acceptance criteria.

SUSPENSION MODIFICATIONS

The available suspension travel must remain at least equivalent to that originally available prior to modifying the system.

The available suspension rebound following the addition of increased length coil springs and longer travel shock absorbers must be at least equivalent to the original rebound travel.

The rebound must be limited by either the shock absorber maximum travel (providing the component is designed for this type of loading), the technique used by the original manufacturer's design or by the addition of adequately sized straps.

At full rebound the coil springs shall still be securely attached to the vehicle by not having reached their free length.

All linkages and brake lines etc must be adequately designed for the increased movement.

BODY BLOCKS

Body blocks between the vehicle body and the chassis must comply with the following:

- The material must be of similar strength and durability as the original components;
- All assemblies and piping that spans between the body and the chassis must be suitable for the increased distance;
- The increase in height from these blocks must be less than 51mm.

WHEELS AND TYRES

The overall tyre diameter can be increased by up to 26mm (four wheel drive vehicles only).

Tyres fitted to off-road passenger and commercial vehicles must not be more than 50% wider than the vehicle manufacturer's widest optional tyre. Tyres fitted to passenger vehicles must not be more than 30% wider than the vehicle manufacturer's widest optional tyre.

The rim width must match the recommendations for the tyre fitted.

The tables of original tyres with the maximum allowable tyre and rim sizes in Clause 4.2 *Non-Standard Tyres and Rims* are applicable.

The wheel track of off-road and four wheel drive vehicles must not be increased by more than 25mm beyond the maximum specified by the vehicle manufacturer for the particular model, except for vehicles fitted with front and rear beam axles, where a maximum wheel track increase of 50mm is allowed. The wheel track of passenger vehicles must not be increased by more than 25mm beyond the maximum specified by the vehicle manufacturer for the particular model.

The wheels must be contained within the bodywork or mudguards (including "flares") when the wheels are in the straight-ahead position. Adequate clearance must be available between the tyres and the vehicle bodywork.

Speedometer accuracy must be maintained for the selected tyre and rim combination to within the degree of accuracy specified in ADR 18 where applicable.

BRAKES

Modifications to any of the brake circuitry should meet the requirements of Section LG *Brakes*.

The braking performance of the vehicle should also meet the requirements of Section LG *Brakes*.

VEHICLE DYNAMICS

These modifications, where the centre of mass (centre of gravity) of an existing vehicle is increased, can have a significant influence on the cornering / swerving characteristics of the completed vehicle. The maximum height (up to 150mm) that a particular vehicle can be raised is governed by the ability to safely negotiate and fully comply with the "Lane Change Test" as outlined in Section LT (Code LT2).

VEHICLE LIGHTING

The dipped beam headlights shall comply with the ADR requirements with respect to position and illuminated pattern. For vehicles complying with ADR 13/00 the top of the headlamp lens shall not be greater than 1200mm from the ground when measured on a level surface.

CHECKLIST

HIGH LIFT 50mm to 150mm (DESIGN)

APPROVAL CODE LS7

(N/A= Not Applicable, Y=Yes, N=No)

1	SUSPENSION MODIFICATIONS			
1.1	Front Suspension and Steering			
	Do the front suspension system modifications comply with all of the relevant requirements of LS3?	N/A	Y	N
1.2	Rear Suspension			
	Do the rear suspension system modifications comply with all of the relevant requirements of LS5?	N/A	Y	N
1.3	Suspension travel			
	Is the suspension travel the same as original? Sometimes more is OK At least two thirds in each direction	N/A	Y	N
	Is the suspension rebound the same as original?	N/A	Y	N
	Is adequate rebound limiting provided?	N/A	Y	N
	Are the coil springs still under compression at full travel?	N/A	Y	N
	Are all linkages and brake lines adequate for the increased movement?	N/A	Y	N
2	BODY BLOCKS			
2.1	Mounting			
	Are the replacement body blocks suitably designed to carry the load as per the vehicle's GVM?	N/A	Y	N
	Do the blocks lift the body less than 75mm?	N/A	Y	N
2.2	Design			
	Are all assemblies spanning the body and chassis suitably modified to allow for the increased distance?	N/A	Y	N
	Are the body lift blocks suitably braced to the chassis or bodywork so as to prevent excess bending loads being placed on components?		Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS7

(N/A= Not Applicable, Y=Yes, N=No)

3	WHEELS AND TYRES			
3.1	Wheels			
	Are all wheels in accordance with the Code of Practice requirements?	N/A	Y	N
	Is the increase in overall diameter less than 50mm for 4 wheel drive vehicles or 15mm for passenger vehicles?	N/A	Y	N
3.2	Speedometer			
	Has the speedometer accuracy been verified?	N/A	Y	N
4	VEHICLE DYNAMICS			
4.1	Lane Change Test (Code LT2)			
	Is the vehicle capable of completing the lane change test?		Y	N
	Was the driver satisfied that the vehicle was safe to drive?		Y	N
5	HIGH LIFT			
5.1	Maximum Increase in Vehicle Height			
	Is the total increase in vehicle height less than 150mm?		Y	N
	Is the top of the dipped beam headlight less than 1200mm?		Y	N
	Does the dipped beam headlight pattern and position comply?		Y	N
6	BRAKES			
6.1	Do the brake modifications comply with Code LG?	N/A	Y	N
6.2	Do the brakes meet the Code LG performance requirements?	N/A	Y	N
7	FASTENERS			
7.1	Are high tensile bolts specified on all new critical mountings?		Y	N
7.2	Are self-locking nuts specified on all new critical mountings?		Y	N
7.3	Are fasteners specified at least equivalent to the original in strength and quantity?		Y	N
8	WELDING			
8.1	Are all welding details specified?	N/A	Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS7

(N/A= Not Applicable, Y=Yes, N=No)

9	DESIGN			
9.1	Does the design of the modification comply with all of the requirements outlined in this LS Approval Code?		Y	N

NOTE: If the answer to any question is **N (No)**, the design cannot be approved under Code LS7

Vehicle Make & Model

Description of Modification

.....

.....

.....

Design Approval Number

Designed by (Signatory)

Company (if applicable)

Signed Date

HIGH LIFT 50mm to 150mm MODIFICATION

CODE LS8

SCOPE

The following is a summary of the modifications that may be approved under Code LS8 – High Lift 50mm to 150mm Modification.

Approvals that are **allowed** under this Code include:

1. Modifications that result in the vehicle body being raised by more than 50mm from the original “as manufactured” height.
2. Front suspension modifications using different struts or uprights.
3. Independent rear suspension modifications using different struts, trailing arms or uprights.
4. Conversion using a complete suspension assembly from a different vehicle model.
5. Fitment of a complete rear suspension assembly using components from different vehicle model(s).
6. Installation of body lift kits.
7. Fitment of alternative wheel and tyre specifications for vehicles with modified axles or suspension.

Approvals that are **not allowed** under this Code include:

1. Design approval of the modification of particular vehicles (this is covered by Code LS7).
2. Modifications that do not have a Design Approval in accordance with the requirements of Code LS7.
3. Modifications that raise the vehicle body more than 150mm from the original “as manufactured” height (lifting vehicles beyond 150mm is outside of the scope of this Code of Practice).
4. Modifications that raise the vehicle body more than 50mm from the original “as manufactured” height on vehicles that have had the wheel track reduced from the “as manufactured” width. Modifications to these vehicles will only be considered on an individual application basis.

This section does not apply to L-group vehicles (e.g. motorcycles).

CHECKLIST

HIGH LIFT 50mm to 150mm MODIFICATION

APPROVAL CODE LS8

(N/A= Not Applicable, Y=Yes, N=No)

1	DESIGN			
1.1	Insert Design Approval No.....			
1.2	Has the vehicle been modified exactly in accordance with the plans and specifications issued under the LS7 Design Approval Number given above?		Y	N
2	VEHICLE CONDITION PRIOR TO MODIFICATION			
2.1	Is the front suspension serviceable?		Y	N
2.2	Is the steering box serviceable?		Y	N
2.3	Is the steering linkage serviceable?		Y	N
2.4	Is the chassis serviceable?		Y	N
3	WORKMANSHIP			
3.1	Is the quality of workmanship including welding to a satisfactory standard?	N/A	Y	N
3.2	Are replacement fasteners equivalent to or better than original in strength and quality?		Y	N
3.3	Are high tensile bolts and self-locking nuts used on all new critical joints and mountings?		Y	N
4	MODIFICATION DETAILS			
4.1	What was the original height of the vehicle body prior to any modification? _____			
4.2	What is the height of the vehicle body following completion of all lift modifications _____			
4.3	Is the difference in height less than 150mm?		Y	N

[Continued overleaf]

Section LS Tyres, Rims, Suspension & Steering

Form No: LS8

(N/A= Not Applicable, Y=Yes, N=No)

4.4	What is the maximum size tyre offered by the manufacturer for this vehicle? _____			
4.5	What size tyre has been fitted? _____			
4.6	Is the difference less than 50mm?		Y	N
4.7	If the vehicle body has been lifted relative to the chassis, Is the overall body lift less than 75mm?		Y	N
4.8	If the suspension has been modified to provide an increase in vehicle body height, is this increase more than 50mm?	N/A	Y	N
5	LANE CHANGE TEST			
5.1	Has the vehicle undergone a lane change test as per Code LT2?		Y	N
5.2	Did the vehicle pass the test satisfactorily?		Y	N
5.3	Was the driver satisfied that the vehicle was safe to drive?		Y	N
5.4	Is a copy of the lane change test results form attached as required by Code LT2?		Y	N
6	VEHICLE CONDITION AFTER MODIFICATION			
6.1	Is the front suspension serviceable?		Y	N
6.2	Is the steering box serviceable?		Y	N
6.3	Is the steering linkage serviceable?		Y	N
6.4	Is the chassis serviceable?		Y	N
6.5	Is the dipped beam headlight height less than 1200mm?		Y	N
6.6	Have the headlights been adjusted?		Y	N
6.7	Have all brake tests been satisfactorily completed?	N/A	Y	N
6.8	Is the combined height increase less than 150mm?		Y	N

NOTE: If the answer to any question is **N (No)**, the modification cannot be approved under Code LS8

Section LS Tyres, Rims, Suspension & Steering

Form No: LS8

Make Model Year of Manufacture

Chassis No. or VIN

Description of Modification

.....

Vehicle Modified by

Vehicle Approved by (Signatory)

Company (if applicable)

Signed Date