FRONT SUSPENSION AND STEERING MODIFICATION (DESIGN) CODE LS3

SCOPE

Code LS3 provides for the preparation of designs that may be approved by Registration Authorities for use by other signatories or modifiers. The designs under Code LS3 cover the design of modifications to the front suspension and steering.

Code LS3 does not apply to ADR category L-group vehicles and motor cycles.

DESIGNS COVERED UNDER CODE LS3

The following is a summary of the designs that may be prepared under Code LS3:

- Design of power steering conversions using components from different vehicle model(s);
- Design of rack and pinion steering conversions;
- Design of front suspension modifications using different struts or uprights;
- Design of conversions using a complete suspension and steering assembly from a different vehicle model;
- Alternative wheel and tyre specifications for vehicles with modified axles or suspension; and
- Design of RHD to LHD steering and dual steering conversions.

DESIGNS NOT COVERED UNDER CODE LS3

The following are designs that are not covered under Code LS3:

- Designs for vehicles originally equipped with ESC that have not been approved by the vehicle manufacturer or proven through testing;
- Designs that as a consequence of a single modification or a combination of modifications, result in a change of vehicle height exceeding 50mm (this is covered by Code LS7);
- Design of left to right hand drive steering conversions (these are covered by Code LS1);
- Certification of the actual vehicle modifications (this is covered by Code LS4); and
- Designs for rear suspension modifications (these are covered by Code LS5).

COMPLIANCE WITH APPLICABLE VEHICLE STANDARDS

Modified vehicles must continue to comply with the ADRs to which they were originally constructed, except as allowed for in the AVSR. These modified vehicles must also comply with the applicable in-service requirements of the AVSR. This is not an exhaustive list and other modifications may also affect ADR compliance.

Modified pre-ADR vehicles must continue to comply with the AVSR.

Compliance with the AVSR also means compliance with the equivalent regulations of a State or Territory of Australia.

Outlined in Table LS6 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

Table LS6 Summary of items that if modified, may detrimentally affect compliance with applicable ADRs

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

To determine the ADRs that apply to the vehicle in question, refer to the applicability tables in Section LO. Vehicles manufactured on or 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.

Alternatively, ADR applicability tables for individual vehicle categories may be referenced on the Department of Infrastructure and Transport *RVCS* website at the following address and under the section titled *ADR Applicability Tables*:

http://rvcs.dotars.gov.au/

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 LS 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 number. The design 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; and
- 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.

1 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:** 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 must be designed to ensure 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.

2 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; and
- ***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.

3 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 ±0.6g lateral; and
- 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; and
- the effect of steering system loads on the suspension components.

4 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 permitted) 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.

Section LZ *Appendices* provides further information and guidance on heat treatment and welding. The mandatory provisions of Section LZ must be complied with.

4.1 Standard Features

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

4.2 Machining of Input Shafts

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.

4.3 Machining of Any Components

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

4.4 All Splines

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

4.5 Threaded Bosses

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

4.6 Welding of Steering Components to Chassis

Steering components must not be welded to the chassis structure.

4.7 Re-machining of Ball Joint Tapered Stud Holes in Steering Arms

Re-machining of ball joint tapered stud holes in steering arms may be undertaken 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.

4.8 Tapered Adaptor Sleeves

Tapered adaptor sleeves may be used provided they are made of suitable steel, i.e. equivalent in strength and hardness to the stud to be mounted.

4.9 Mounting Surfaces

Mounting surfaces for steering components must designed and in a condition that ensures no stress inducing deflection of either mounting surface or steering component occurs when the attachment bolts are tightened.

4.10 Braces

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

4.11 Power Steering Conversions – Separate Ram Type

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; and
- 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.

4.12 Steering Linkage

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 may be done, provided that the processes are conducted under the controls described in this section; and
- 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.

4.13 Rack and Pinion Steering Gear

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. Steering racks must not be welded. 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;
- A rack shaft must not be shortened by cutting and re-welding;
- 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; and
- Mounting of the rack should replicate the original mounting configuration.

4.14 Chassis Mounted Steering Gear

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 a 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;
- Sector shafts must not be welded to change length or to alter spline details, and
- 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.

4.15 Pitman Arms

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.

4.16 Idler Arms

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.

4.17 Tie-rods

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.

4.18 Steering Arms

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

4.19 Draglink

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; and
- Sectioning and re-welding of the draglink must always be performed in accordance with the processes and controls described in this section.

4.20 Steering column Shaft Couplings

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 must ensure 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 must ensure that the resulting assembly has the torsional strength to withstand an applied torque of 200Nm; and
- The alignment of the coupling must be maintained to within the manufacturer's specification and phasing of the universal joints must be correct.

4.21 Intermediate Shafts

Intermediate shafts must be selected and installed as follows:

- Intermediate shafts designed for use only on power steering vehicles must not to 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 may be carried out 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;
- Intermediate shafts may be sectioned and welded, provided that the processes are conducted under the controls described in this section. The weld should be ground smooth. The joint may be supplemented with a fitted sleeve spanning the welded area and attached by plug welding and/or fillet welding at each end; and
- 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.

4.22 Steering Columns

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;
- Steering column shafts may be machined to accept revised splines;
- 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; and
- 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.

4.23 Change in Vehicle Height.

Where changes in vehicle height occur as a result of modifications, the requirements detailed under *Modified Components* above that are applicable to individual steering and suspension components continue to apply. Important items such as spline engagement, operating angles of drive shaft joints and in the case of CV joints, the range of axial movement, must remain within design limits for the full range of suspension travel. Also other components such as gear levers, brake hoses etc. may need to be extended depending on the nature of the lift.

Steering linkages must continue to operate efficiently and sufficient spline contact surface must be retained for the full range of suspension travel to ensure the safe operation of the vehicle. Otherwise an appropriate steering shaft extension must be used.

Following the completion of modifications the vehicle attitude must remain as per original specifications – i.e. 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 by the same amount.

Vehicles whose ride height is raised by more than 50mm must undergo a lane-change manoeuvre test in accordance with ISO 3888-1 *Passenger Cars – Test Track for a Severe Lane-Change Manoeuvre – Part 1: Double Lane-Change* to ensure its stability has not been compromised

This page is intentionally blank

CHECKLIST LS3
FRONT SUSPENSION AND STEERING MODIFICATION (DESIGN)
CODE LS3

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

1	**REPLACEMENT STEERING BOX OR RACK**			
1.1	**Steering Box/Rack Selection**			
	Is the specified RHD steering box/rack of equivalent capacity to the original?		Y	N
	Is the Pitman arm size/length and arc of travel equivalent to the original?	N/A	Y	N
	Does the 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 all modifications as per the *Specific Requirements* detailed in Code LS3?	N/A	Y	N
1.3	**Steering Box/Rack Mounting**			
	Does location and angle of steering box/rack replicate original?		Y	N
	Will the chassis rail be 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**			
	Will the original column coupling (or equivalent) be used?		Y	N
	Will the original steering box/rack coupling (or equivalent) be used?		Y	N
1.5	**Idler arm**			
	Does the design ensure that the mounting brackets will be adequately secured to chassis rail?	N/A	Y	N
	Does the design idler arm location and angle replicate the original?	N/A	Y	N
	Are mounting bolts replaceable?	N/A	Y	N

[Continued overleaf]

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

1.6	**Drag link**			
	Is the original drag link to be used without modification? or	N/A	Y	N
	Is the original drag link to be used without modification? or	N/A	Y	N
	Are the proposed modifications as per VSB 4 requirements?	N/A	Y	N
1.7	**Steering geometry**			
	Will the turning circle in both directions remain within legal limits?		Y	N
	Has the original geometry been replicated in the new configuration? or	N/A	Y	N
	If the geometry is to be altered, will the bump steer still be within specified limits?	N/A	Y	N
2	**REPLACEMENT FRONT SUSPENSION CROSS-MEMBER SUSPENSION AND STEERING**			
2.1	**Cross member Mounting**			
	Have the cross member mountings been designed to be at least equivalent in strength to the original mountings?	N/A	Y	N
	Will the chassis rail be 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 and Tie-rod Ends**			
	Are all ball joint tapers compatible or to be modified in accordance with Code LS3 requirements?	N/A	Y	N
3.2	**Steering geometry**			
	Will the turning circle in both directions remain within legal limits?		Y	N
	Has the original geometry been replicated in the new configuration? or	N/A	Y	N
	If the geometry is to be altered, will the bump steer still be within specified limits?	N/A	Y	N

[Continued overleaf]

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

4	**STEERING COLUMN**			
4.1	**Mounting**			
	Have support brackets been designed to be equivalent in strength to the original brackets?		Y	N
4.2	**Intermediate Shaft**			
	Will the modified shaft meet Code LS3 requirements?	N/A	Y	N
	If applicable, do the specified couplings and attachments meet the requirements of VSB 4?	N/A	Y	N
4.3	**Collapse Operation**			
	Does the specified column installation retain its designed collapse system?	N/A	Y	N
	Are the original telescopic sections to be left unmodified?	N/A	Y	N
5	**LHD STEERING CONVERSION USING LHD STEERING BOX OR RACK**			
5.1	**Drag link**			
	Is the original left hand drive drag link to be used without modification? or	N/A	Y	N
	Is the original right hand drive drag link to be used without modification? or	N/A	Y	N
	Does the designed modified drag link replicate the original?	N/A	Y	N
	Are modifications designed in accordance with the specific requirements of Code LS3?	N/A	Y	N
5.2	**Steering geometry**			
	Will the turning circle in both directions be 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 specified limits?	N/A	Y	N

[Continued overleaf]

(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 to be used designed for automotive steering application?		Y	N
	Are the input and output shafts splined?		Y	N
	Does the design allow for the gearboxes to be securely mounted and correctly aligned?		Y	N
6.2	**Couplings and Cross Shaft**			
	Is cross shaft articulated at both ends?		Y	N
	Does the design allow for the couplings to correctly mate with the 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 the selected chain drive unit designed for automotive steering application?		Y	N
7.2	Is the unit fully enclosed with provision for chain adjustment?		Y	N
7.3	Has at least duplex chain been specified with provision for adequate lubrication provided?		Y	N
7.4	Is the drive designed to withstand at least 200 Nm input torque?		Y	N
7.5	Are shaft connections to manufacturer's specification and/or are splines and cotter bolts sufficiently engaged?		Y	N
7.6	Does the design allow for the chain-drive unit and steering column to be adequately supported?		Y	N
8	**BRAKE MASTER CYLINDER RELOCATION**			
8.1	**Firewall Modifications**			
	Is the strength and stiffness of the left hand side firewall at least equivalent to the 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]

(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**			
	Has the system been checked or designed to be capable of transferring the design brake forces?	N/A	Y	N
	Will the deflection of the cross shaft at maximum torque remain within specified limits?	N/A	Y	N
9.2	**Bearings**			
	Are self-aligning bearings/bushes specified?	N/A	Y	N
	Are self-lubricated bearings/bushes specified?	N/A	Y	N
	Does the design allow for the cross shaft to be 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 specified?	N/A	Y	N
	Do bearing mountings have adequate stiffness?	N/A	Y	N
9.5	**Pivots**			
	Have the original pivot pins been specified? or	N/A	Y	N
	Are all new pins to be made of hardened steel or in self-lubricating bushes?	N/A	Y	N
	Have suitable retaining devices been specified for all pivot pins?	N/A	Y	N

[Continued overleaf]

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

10	**WINDSCREEN WIPERS**			
10.1	Does the wiper and wiper pattern design meet the requirements of VSB 4?	N/A	Y	N
11	**DESIGN INCLUDING WELDING AND FASTENERS**			
11.1	Does the design of the conversion comply with all of the requirements outlined in Code LS3 and VSB 4 as applicable?		Y	N
11.2	Has all work, that has been specified in the certification of the LS3 design, been determined in accordance with recognised engineering standards and the relevant Appendices of Section LZ *Appendices*?	N/A	Y	N
11.3	If the vehicle is to be raised, have all components affected by the lift such as gear levers, brake hoses etc. been designed to comply with Code LS3?	N/A	Y	N
11.4	If the vehicle is to be raised, have all items affected by the lift such as drive shaft joint operating angles, spline engagement and axial movement of CV joints been either checked or designed to be within design limits over the entire suspension travel?	N/A	Y	N
11.5	Will the vehicle been raised by no more than 50mm following the completion of all modifications including changes to tyre size?	N/A	Y	N
11.6	If the vehicle was originally equipped with ESC and if the modification affects the ESC has the ESC system been adjusted and tested and found to operate satisfactorily?	N/A	Y	N

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

[Continued overleaf]

CERTIFICATION DETAILS																	
Make						**Model**						**Year of Manufacture**					
VIN																	
Chassis Number (If applicable)																	
Brief Description of Modification/s																	
Vehicle Modified By																	
Certificate Number (If applicable)																	
Vehicle Certified By (*Print*)																	
Signatory's Employer (If applicable)																	
Signatory's Signature												**Date**					

FRONT SUSPENSION AND STEERING MODIFICATION CODE LS4

SCOPE

Code LS4 covers modifications to the front suspension and steering. The modifications may be carried out in conformity with designs approved by a Registration Authority under Code LS3.

Code LS4 does not apply to ADR category L-group vehicles and motor cycles.

MODIFICATIONS COVERED UNDER CODE LS4

The following is a summary of the modifications that may be performed under Code LS4:

- Power steering conversions using components from different vehicle model(s);
- Rack and pinion steering conversions;
- Front suspension modification using different struts or uprights;
- Conversions using a complete suspension and steering assembly from a different vehicle model;
- Fitting wheels and tyres to vehicles with modified axles or suspension; and
- RHD to LHD steering and dual steering conversions.

MODIFICATIONS NOT COVERED UNDER CODE LS4

Modifications not covered under this Code are listed below:

- LHD to RHD steering conversions;
- Rear suspension modifications; and
- Change of vehicle height exceeding 50mm as a consequence of a single modification or a combination of modifications, (this is covered by Code LS8).

CHECKLIST LS4
FRONT SUSPENSION AND STEERING MODIFICATION
CODE LS4

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

1	**DESIGN**			
1.1	Insert Design Number……(*the Design*)			
1.2	Has the vehicle been modified exactly in accordance with the plans and specifications issued under the LS3 Design Number given above?	N/A	Y	N
2	**WORKMANSHIP INCLUDING WELDING AND FASTENERS**			
2.1	Is all work, including welding, of satisfactory quality and has all work been performed in accordance with recognised engineering standards?	N/A	Y	N
2.2	Do all new or replaced fasteners comply with the applicable requirements of Section LZ *Appendices,* Appendix A *Fasteners*?		Y	N
2.3	Does the quality of welding comply with the applicable requirements of Section LZ *Appendices*, Appendix C *Heating and Welding of Steering Components*?		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 LS4 requirements?	N/A	Y	N
	Are weld X-ray and hardness results satisfactory?	N/A	Y	N
3.3	**Steering Rack**			
	If modified, does the rack comply with Code LS4 requirements?	N/A	Y	N
3.4	**Steering Geometry**			
	Is turning circle in both directions within specified and legal limits?		Y	N
	Is the amount bump steer still within specified limits?	N/A	Y	N

[Continued overleaf]

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

3.5	**Wheel Alignment**			
	Have all wheels been aligned in accordance with *the Design* specifications?	N/A	Y	N
4	**SUSPENSION**			
4.1	**Cross-member Mounting**			
	Is cross-member mounted in accordance with *the Design*?	N/A	Y	N
	Is the chassis rail reinforced and fitted with steel sleeves?	N/A	Y	N
4.2	**Ball Joints and Tie-rod Ends**			
	Are all ball joint tapers compatible or modified in accordance with certified *the 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 Code LS4 and VSB 4?	N/A	Y	N
6	**MODIFICATIONS RESULTING IN VEHICLE HEIGHT INCREASE**			
6.1	If the vehicle has been raised, have all components affected by the lift such as gear levers, brake hoses etc. been modified and fitted to comply with Code LS4?	N/A	Y	N
6.2	If the vehicle has been raised, have all items affected by the lift such as drive shaft joint operating angles, spline engagement and axial movement of CV joints been checked and found to be within design limits over the entire suspension travel?	N/A	Y	N
6.3	Has the vehicle been raised by no more than 50mm following the completion of all modifications including changes to tyre size?	N/A	Y	N
6.4	If the vehicle was originally equipped with ESC and if the modification affects the ESC, has the ESC system been adjusted and tested and found to operate satisfactorily?	N/A	Y	N

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

[Continued overleaf]

CERTIFICATION DETAILS																		
Make						**Model**						**Year of Manufacture**						
VIN																		
Chassis Number (If applicable)																		
Brief Description of Modification/s																		
Vehicle Modified By																		
Certificate Number (If applicable)																		
Vehicle Certified By (*Print*)																		
Signatory's Employer (If applicable)																		
Signatory's Signature												**Date**						