

Vehicle Standards Bulletin 14

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

**SECTION LG
BRAKES**

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.

CONTENTS

	Page
1 Scope	4
1.1 Modifications Not Requiring Certification	4
1.2 Modifications Requiring Certification Under LG Approval Codes	4
2 General Requirements	4
2.1 Design	4
2.2 Drum or Disc Brake Substitution	5
2.3 Master Cylinder Substitution	6
2.4 Component Standards	6
2.5 Modification of Components	7
2.6 Fabrication	7
2.7 Installation	8
3 Australian Design Rules	9
4 Modifications without Certification	9
4.1 Optional Disc Brakes	9
4.2 Power Brakes	10
5 Certified Modifications (LG Approval Codes)	10
LG1 Brake System Conversion (Design)	11
Checklist	14
LG2 Brake System Conversion	15
Checklist	16

1 SCOPE

This Section outlines the minimum design, installation and fabrication requirements for the following light vehicle modifications involving braking systems.

1.1 MODIFICATIONS NOT REQUIRING CERTIFICATION

- Fitting a manufacturer's optional braking system for the particular make/model.
- Fitting of additional or substitute in-line brake boosters to pre-ADR 31/35 vehicles.

1.2 MODIFICATIONS REQUIRING CERTIFICATION UNDER LG APPROVAL CODES

- Fitting disc or drum brakes that are not a manufacturer's option;
- Substituting brake master cylinders;
- Fitting or modifying brake balance and pressure limiting devices
- Relocating the brake pedal position for left hand or right hand drive.

CERTIFIED MODIFICATIONS

NOTE: The main design installation and fabrication requirements for all of the above modifications are contained in sub-section 2 *General Requirements*.

2 GENERAL REQUIREMENTS

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

2.1 DESIGN

It is recommended that braking modifications be carried out using production components which themselves do not require modification.

The size and performance of the brake equipment must be suitably matched to the vehicle's weight and performance. The specifications of similar production vehicles can be used as a basis for comparison with the brake system of a modified vehicle. Such comparisons should include the following:

- Construction and dimensions of brakes; if disc, whether solid or vented, effective diameter, calliper piston area, pad area, or if drum, diameter, brake shoe width, brake lining area, slave cylinder piston area etc.
- Comparisons of vehicle weights and performance capabilities e.g. - power to weight ratio.

The aim of all brake system "up-grades" in early model passenger vehicles should be to at least meet the deceleration and brake fade standards specified in ADR 31, particularly in the case where an engine modification results in increased vehicle performance.

When the brake system of an early model vehicle is modified, a dual or split circuit brake system should be fitted. Disc brakes are highly recommended on the front and generally should be power assisted.

BRAKING PERFORMANCE

The brake system selected must provide the correct balance between front and rear. Proportioning valves such as the "Holden" unit or some after-market valves can be used to correct a small imbalance. Load sensing proportioning valves should be fitted at the rear on utilities and light commercial vehicles. The brake balance between wheels must not result in premature lock-up of front or rear wheels under braking (in particular, premature lock-up of the rear wheels must be avoided).

A comfortable and easily accessible range of positions of the brake pedal from the "off" position to the fully depressed position should be provided. Foot clearance around the brake pedal comparable with similar contemporary vehicles should also be provided.

For highly modified engines (e.g. high lift camshafts) which require a more open throttle position to maintain idle speed, it is recommended that a vacuum reserve tank be fitted together with a vacuum check valve to assist in maintaining the required low pressure in the brake booster.

Any alteration to a vehicle must not result in a reduction of service or emergency brake performance and must not impair the correct functioning of the secondary braking system and the original equipment failure warning systems.

2.2 DRUM OR DISC BRAKE SUBSTITUTION

STEERING KNUCKLES/UPRIGHTS/STRUTS

Steering knuckles, suspension uprights or McPherson struts with integral stub axles must not be modified to enable the fitting of hubs, disc rotors or calliper brackets.

CALLIPER BRACKETS

Calliper brackets must be designed to take into account all of the forces that occur during braking, including the bending stresses resulting from the offset between the centreline of the disc and the plane of the calliper bracket.

Calliper brackets must be mounted using all of the original disc brake calliper bracket mounting points or at least three of the original drum brake backing plate mounting points.

Tapped holes must have a depth at least equal to the diameter of the screw thread.

WHEEL RIM STUD/BOLT PATTERN

The number and size of fasteners, their pitch circle diameter and any nut/bolt taper angles must be the same for the attachment of all wheels on an axle. The wheel stud or bolt threads may be opposite handed on opposite ends of an axle. Where the rim attachment detail is different between axles, the design must prevent wheels from one axle being incorrectly fitted to the other axle.

WHEEL TRACK

Brake conversions can cause front or rear suspension track changes. The allowable track change (if any) is outlined in Code LS Suspension and Steering.

2.3 MASTER CYLINDER SUBSTITUTION

If other components of the braking system are also modified, the replacement master cylinder must be selected to ensure continued compliance with the requirements of the applicable ADR, including reservoir capacity and minimum pedal effort. Master cylinders must be sized to provide the correct braking effect to the front and rear wheels without excessive pedal travel.

PISTON DIAMETER

If all other components in the braking system are unmodified, a replacement master cylinder must have a piston diameter as near as possible to that of the original master cylinder.

STROKE

If all other components in the braking system are unmodified, a replacement master cylinder must have an effective stroke that enables an equivalent displacement of fluid in one stroke to that of the original master cylinder.

If all other components in the braking system are unmodified, a replacement master cylinder must have a stroke that gives full travel of the master cylinder piston(s) on full application of the brake pedal.

RESERVOIR CAPACITY

Master cylinder reservoirs must have sufficient capacity, adequate for the total displacement volume of all wheel (slave) cylinders and callipers. *Total displacement volume* includes the volume of brake fluid necessary to accommodate the variation in volume from new to fully worn brake pads or shoes.

MOUNTING

The firewall/master cylinder mounting must be adequately reinforced to achieve adequate mounting stiffness whenever replacement master cylinder/boosters are fitted. The strength of the mounting and of the brake pedal mechanism must be capable of withstanding a load of 1800 N applied to the brake pedal.

PEDALS

If a brake pedal is modified, the strength and detail of any welding must be checked to ensure that the pedal can withstand the maximum forces applied to the pedal.

2.4 COMPONENT STANDARDS

All components and devices in the 'Brake System' shall meet or exceed at least one appropriate recognised international, national or association standard, where such standards exist, or the relevant parts thereof. ("Recognised" can be taken as meaning AS, SAA, SAE, BS, JIS, ISO or DIN standards).

Hydraulic pipes must be made from steel Bundy tube complying with SAE J1047 or equivalent. All hydraulic pipes must be double flared in accordance with SAE J5336 or equivalent and appropriate flare connections must be used.

Hydraulic pipes must not be welded.

Hydraulic brake hoses must comply with SAE J1401 or equivalent.

2.5 MODIFICATION OF COMPONENTS

Where modification of components cannot be avoided, the following guidelines should be followed:

- Stub axles must not be machined to reduce the diameter of the spindle in order to fit the bearings of a replacement disc rotor. Rather, the disc rotor should be machined to accept suitable bearings providing such machining does not reduce the strength of the disc rotor;
- Welding of brake components, adaptors or brackets to steering knuckles, suspension uprights or struts is not allowed. These components must be attached using suitable fasteners together with appropriate adapters where necessary. Such modifications must not affect the structural integrity of the original components.
- Brake drums and disc rotors must not be machined beyond the limits recommended by the manufacturer for that application.

2.6 FABRICATION

All work must be performed in accordance with recognised engineering standards. Cutting, heating, welding or bending of 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.

ELECTROPLATING

To prevent cracks forming in the parent metal under chromium plating or from hydrogen embrittlement of steel components, electroplating of suspension and brake components including bolts is not allowed, unless a part of the original manufacturing process or unless specifically designed and approved under this Code or Code LS.

2.7 INSTALLATION

CLEARANCE

All brake components shall clear other vehicle components such as wheels, suspension members and chassis members over the full range of steering and suspension travel. It is recommended that a clearance of at least 10 mm be provided at all such locations.

PROTECTION

Hydraulic brake pipes, hoses and cables must be mounted in protected areas where they are not likely to be struck or snagged by objects thrown up from the road or on other vehicle components. They must be protected from excessive heat and abrasion.

Pipes must be adequately supported. They must not be stretched or bent through too tight a radius over the full range of suspension and/or steering travel.

Brake hoses must not touch wheels or tyres and must not be located such that they are likely to be snagged by adjacent suspension components. Brake hoses shall be sufficiently clear of and/or shielded from hot exhaust components.

The vacuum pipe between the brake booster and engine must be routed to allow for engine movement and must be securely fastened at each end.

Power brake boosters must be securely mounted and where fitted under the floor must be very well protected from road debris by a shield or chassis cross member.

HANDBRAKE

Handbrake cables must not rub on the drive shaft under any condition of vehicle suspension movement.

Handbrake lever assemblies must not be mounted on un-reinforced wooden or particleboard floors.

HYDRAULIC PIPES

The use of copper tubing for hydraulic brake pipe is not allowed.

Joining hydraulic brake pipes by brazing, silver soldering, etc. is not allowed.

Threaded bosses used for braking component mounting must have full depth thread engagement of at least the bolt diameter.

SEALED OPENINGS

Any opening in the firewall (perhaps due to brake booster/master cylinder modifications) must be sealed to prevent entry of engine fumes into the vehicle cabin.

3 AUSTRALIAN DESIGN RULES

The Australian Design Rules (ADRs) most likely to be affected by a braking system substitution or modification are those relating to braking performance, brake hoses and brake lights.

However, some braking changes can affect compliance with other ADRs such as tyre and rim selection.

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

The applicable ADRs are individually listed on the Identification Plate of 2nd Edition ADR vehicles. For 3rd Edition ADR vehicles, the Identification Plate 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*).

The following is a list of ADRs that may be affected by modifications covered in this section:

ADR	Title & Comments
7, 7/..., 42/...	Brake Hoses
13, 13/...	Installation of lighting and light signalling devices (brake lights)
24, 24/...	Tyre & Rim Selection (speed rating)
31, 31/...	Hydraulic brake systems for passenger cars
35, 35/...	Commercial vehicle brake systems

4 MODIFICATIONS WITHOUT CERTIFICATION

The following modifications may be carried out without obtaining approval under an LG Approval Code, provided that the vehicle continues to comply with relevant Australian Design Rules and Australian Vehicle Standards Rules and provided that the vehicle meets the following general safety requirements.

4.1 OPTIONAL DISC BRAKES

The replacing of the front drum brakes with a disc brake system where the system was originally available as an option for the vehicle model is allowed, provided that:

- all associated equipment that was part of the manufacturer's disc brake "package" (which may include a different master cylinder, different rear wheel cylinders and proportioning valve) is fitted;
- the installation is in accordance with the manufacturer's specifications; and
- all components used are unmodified.

4.2 POWER BRAKES

The fitting of additional or substitute in-line brake boosters to pre-ADR 31 and pre-ADR 35 vehicles is allowable provided that they are installed in accordance with the requirements of the manufacturer of the replacement brake booster.

Power brake installations in ADR 31 and ADR 35 vehicles require certification under LG Approval Codes.

5 CERTIFIED MODIFICATIONS (LG APPROVAL CODES)

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

Each Code is supplemented with a checklist.

	LG Approval Code Directory	Page
LG1	Brake System Conversion (Design)	11
	Checklist	14
LG2	Brake System Conversion	15
	Checklist	16

BRAKE SYSTEM CONVERSION (DESIGN)

APPROVAL CODE LG1

SCOPE

The following is a summary of the designs that may be approved under Code LG1 – *Brake System Conversion (Design)*:

Design approvals are **allowed** under Code LG1 for:

- Fitting substitute disc brake or drum brake assemblies.
- Fitting substitute brake master cylinders.
- Fitting substitute or additional brake boosters.
- Fitting brake balance or pressure limiting devices.
- Transferring the position of the brake pedal for left hand or right hand drive.

Design approvals are **not allowed** under Code LG1 for:

- The actual physical modification of the vehicle (this is covered by Code LG2).
- Design of suspension modifications including substitute suspension uprights, struts and axles (this is covered by Code LS1).

Code LG1 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
Brake Hoses	ADR 7, 42
Brake Lights	ADR 13, ADR 60
Hydraulic Brake Systems	ADR 31, ADR 35
Brake Performance	Regulations

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 brake system conversions under Approval Code LG1.

The approval must also comply with the general guidelines contained in sub-section 2 *General Requirements*.

The completed vehicle must be evaluated under a range of road operating conditions to establish that braking performance progresses appropriately with the application of pedal force. Tests should examine the ability of the vehicle to meet the requirements of the relevant Regulations and applicable ADRs, where the performance cannot be justified by comparison or analytical methods.

1. Compliance of Pre-ADR (Post 1930) Vehicles

Tests should be conducted on fully laden vehicles and they should meet the following stopping distances and decelerations outlined in Table LG1.

The tests should be conducted on a smooth dry level road surface free from loose material.

The vehicle must not move outside a 3.7 metre wide straight path centred on the longitudinal axis of the vehicle when the brakes are initially applied.

Type Of Brakes	Gross Vehicle Mass	Stopping Distance from 35 km/hr has to be within	Min. Average Deceleration from any speed	Min. Peak Deceleration from any speed
Service Brakes	Under 2.5 tonnes GVM	12.5 metres	3.8 m/sec/sec	5.8 m/sec/sec
	2.5 tonnes GVM and over	16.5 metres	2.8 m/sec/sec	4.4 m/sec/sec
Emergency Brakes	Under 2.5 tonnes GVM	30 metres	1.6 m/sec/sec	1.9 m/sec/sec
	2.5 tonnes GVM and over	40.5 metres	1.1 m/sec/sec	1.5 m/sec/sec

Table LG1

The service brakes and emergency brakes should be capable of stopping the vehicle with one sustained application from a speed of 35 km/hr in no more than the respective distances listed in Table LG1.

The service brakes and emergency brakes should also be capable of stopping the vehicle with one sustained application from any speed at which the vehicle can travel, at no more than the respective average and peak deceleration rates listed in Table LG1.

The parking brake must be capable of holding the vehicle on a 12% gradient.

2. COMPLIANCE OF ADR VEHICLES

Vehicles originally manufactured to comply with ADR requirements must continue to comply.

A simplified brake test procedure has been developed for demonstrating compliance with the brake performance requirements of ADR 31 to enable approvals of brake system and brake modifications under Code LG. The test procedure is an alternative to the procedure specified in Table LG1 appended to Clause 31.3 of ADR 31/00 Hydraulic Brake Systems for Passenger Cars and does not exempt any other requirements of the Rule.

The following conditions, tests and procedures apply:

- The vehicle shall be tested in accordance with the requirements of ADR31/00 Clauses 31.3 and 31.4 (note Clauses 31.3.2 and 31.4.12 do not apply) and must meet the minimum performance standards outlined in Table LG2 below.
- The vehicle shall be loaded to its GVM i.e. 68kg per occupant + 7kg luggage per passenger & 90% maximum fuel load (plus all other items, fluids, spare tyre, etc), with the load distributed to emulate normal operating conditions.
- A least 5 pre-conditioning runs shall be carried out prior to commencing the test, to bed in and ensure that all brake components are at normal running temperatures.
- Initial vehicle speeds and stopping distances should be measured.
- No adjustments other than those permitted by the ADR may be carried out and no parts may be replaced after the commencement of the test.
- The vehicle's gearbox shall be as specified under the ADR for each test run.

No.	Tests And Procedures	Initial Vehicle Speed (km/h)	Min Average Deceleration (m/s ²)	Maximum Pedal Effort (N)
1.	Pre-test Instrumentation check	65 (max)	N/A	670
2.	First effectiveness test – all service brake systems	95-105	5.45	670
3.	Second effectiveness test – all service brake systems	45-55 95-105	5.45 5.75	670 670
4.	Partial Failure	95-105	2.55	670
5.	Brake Power Unit or Power Assist Unit Failure (as per ADR31/00 Clause 31.5.9)	95-105	2.55	670
6.	Spike stops	45-55	N/A	885 (min)
7.	Final effectiveness test – all service brake systems	95-105	5.45	670
8.	Parking Brake	N/A	30% (min. gradient)	400

Table LG2

CHECKLIST
BRAKE SYSTEM CONVERSION (DESIGN)
APPROVAL CODE LG1

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

1	COMPONENTS			
1.1	Are all components and equipment in the brake system specified to comply with relevant Standards outlined in sub-section 2 <i>General Requirements</i> ?		Y	N
2	CALLIPER BRACKETS			
2.1	Has the calliper bracket and mounting been correctly designed?	N/A	Y	N
3	MASTER CYLINDER			
3.1	Has the master cylinder and its mounting been correctly selected and specified?		Y	N
4	WORKMANSHIP			
4.1	Are the standards of installation and fabrication specified as required?		Y	N
5	ADR COMPLIANCE			
5.1	Does the design enable compliance with all applicable ADRs?		Y	N
6	TESTING			
6.1	Has all required testing been completed and results recorded?		Y	N

NOTE: If the answer to any question is **N (No)**, the design cannot be approved under Code LG1

Vehicle Make & Model

Description of Modification

.....

.....

Design Approval Number

Designed by (Signatory)

Signatory Employer (if applicable)

Signed Date

BRAKE SYSTEM CONVERSION

APPROVAL CODE LG2

SCOPE

The following is a summary of the modifications that may be approved under Code LG2 – *Brake System Conversion*.

Approvals are **allowed** under Code LG2 for:

- Fitting substitute disc brake or drum brake assemblies
- Fitting substitute brake master cylinders
- Fitting substitute or additional brake boosters
- Fitting brake balance or pressure limiting devices

Approvals are **not allowed** under Code LG2 for:

- Design of the brake system conversions (this is covered by Code LG1).
- Fitting substitute suspension components (these are covered by Code LS2).

Code LG2 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
Brake Hoses	ADR 7, 42
Brake Lights	ADR 13, ADR 60
Hydraulic Brake Systems	ADR 31, ADR 35
Brake Performance	Regulations

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

CHECKLIST
BRAKE SYSTEM CONVERSION
APPROVAL CODE LG2

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

1.	DESIGN			
1.1	Has the vehicle been modified exactly in accordance with the plans and specifications issued under: Design Approval No.....		Y	N
2.	WORKMANSHIP			
2.1	Has all work been performed in accordance with good recognised engineering standards?		Y	N
3.	WELDING			
3.1	Has all welding been carried out by qualified tradesperson?	N/A	Y	N
3.2	Does all welding comply with relevant Australian Standards?	N/A	Y	N
4.	FASTENERS			
4.1	Are high tensile bolts and self-locking nuts used on all new critical joints and mountings?	N/A	Y	N
4.2	Are all replacement fasteners equivalent to or better than original in strength and quality?	N/A	Y	N
5.	INSPECTION & TESTING			
5.1	Has an inspection been carried out on the installation and all modified components and found to be satisfactory?		Y	N
5.2	Has the vehicle been road tested and the braking system found to operate satisfactorily?		Y	N

NOTE: If the answer to any question is **N (No)**, the modification cannot be approved under Code LG2.

[Continued overleaf]

MakeModel Year of Manufacture

Chassis No. or VIN

Vehicle Modified by

Date of Inspection

Vehicle Approved By (Signatory)

Signatory Employer (if applicable)

Signed Date