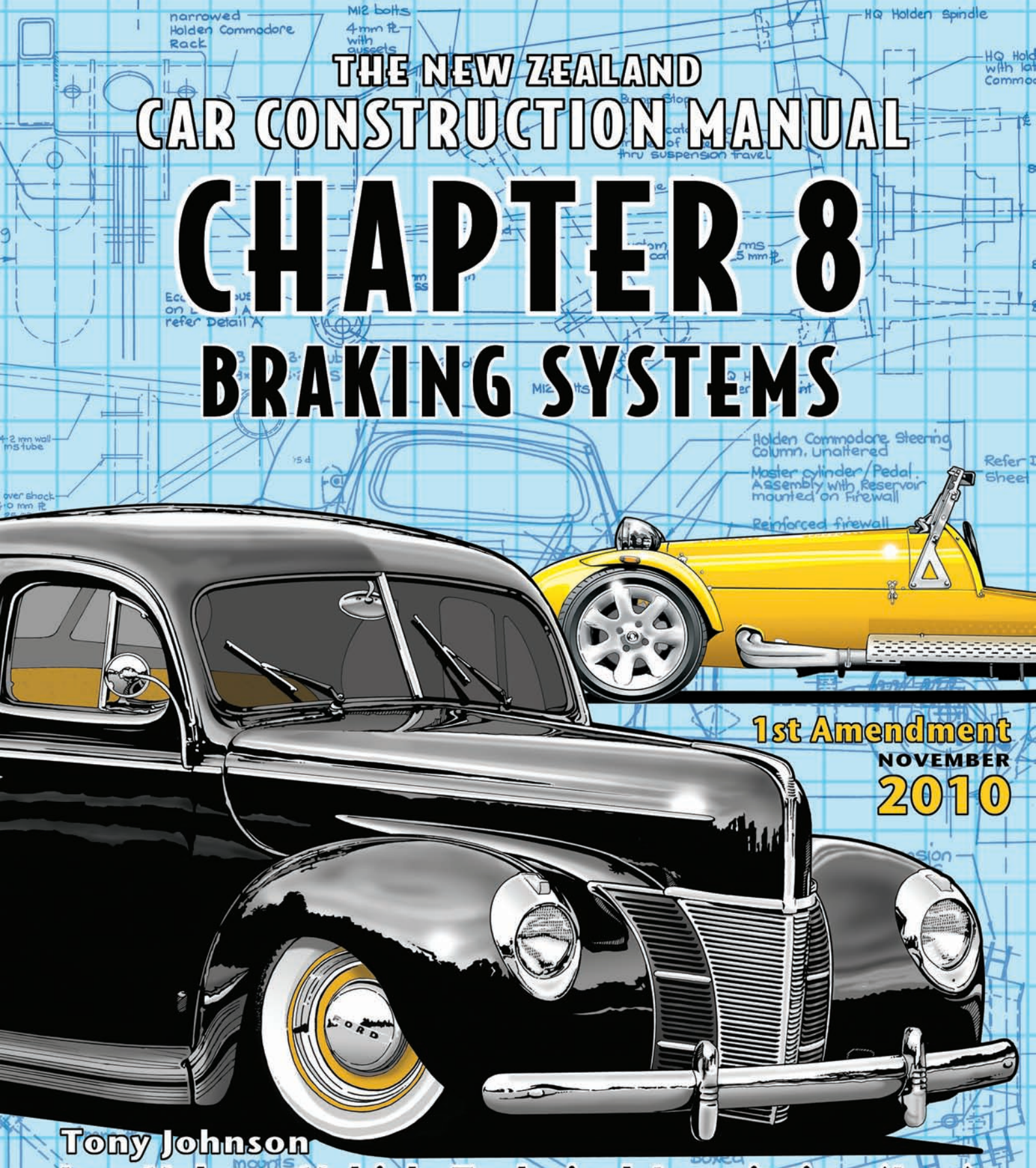
THE NEW ZEALAND CAR CONSTRUCTION MANUAL

CHAPTER 8

BRAKING SYSTEMS



1st Amendment
NOVEMBER
2010

Tony Johnson

Low Volume Vehicle Technical Association (Inc.)

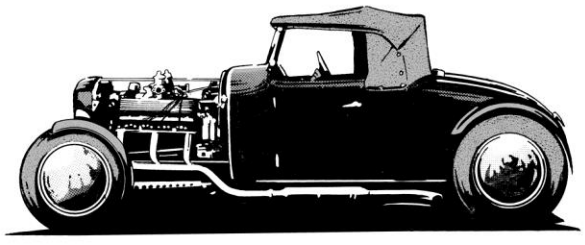
THE NEW ZEALAND
CAR
CONSTRUCTION MANUAL

Author: Tony Johnson

Publisher: The Low Volume Vehicle Technical Association Incorporated

First Published January 2007

1st Amendment November 2010



International Standards Book Number: ISBN 978-0-473-11935-5

PUBLISHER & OWNER

The New Zealand Car Construction Manual is published and owned by the Low Volume Vehicle Technical Association Incorporated (LVVTA). LVVTA is an incorporated society and was established in 1992, and represents approximately 50,000 motor vehicle enthusiasts throughout New Zealand.

The New Zealand Car Construction Manual was originally published by the New Zealand Hot Rod Association Incorporated (NZHRA), in January 2007.

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ACKNOWLEDGEMENT

The LVVTA wishes to acknowledge the New Zealand Hot Rod Association for its determination and vision in undertaking the original development of the New Zealand Car Construction Manual, and for demonstrating its on-going long-term commitment to all vehicle modifiers and builders by enabling this manual to become an integrated part of New Zealand's low volume vehicle certification system.

NZHRA, and its key personnel, have, and continue to since the inception of LVV certification, form the back-bone of the LVV certification system in New Zealand. LVVTA is very appreciative of NZHRA's on-going commitment and integrity.

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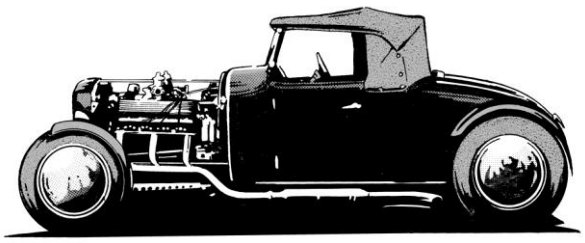

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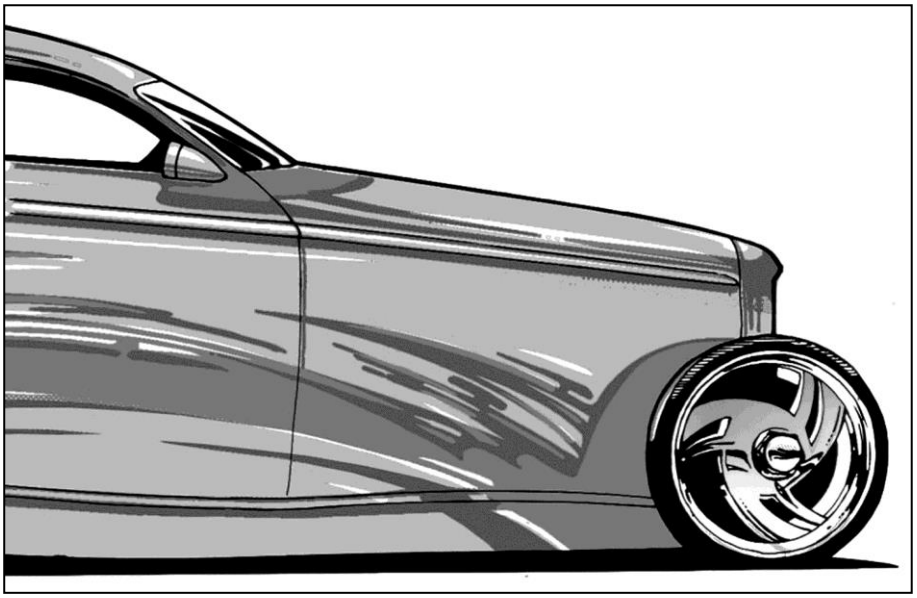
Chapter 8:

BRAKING SYSTEMS



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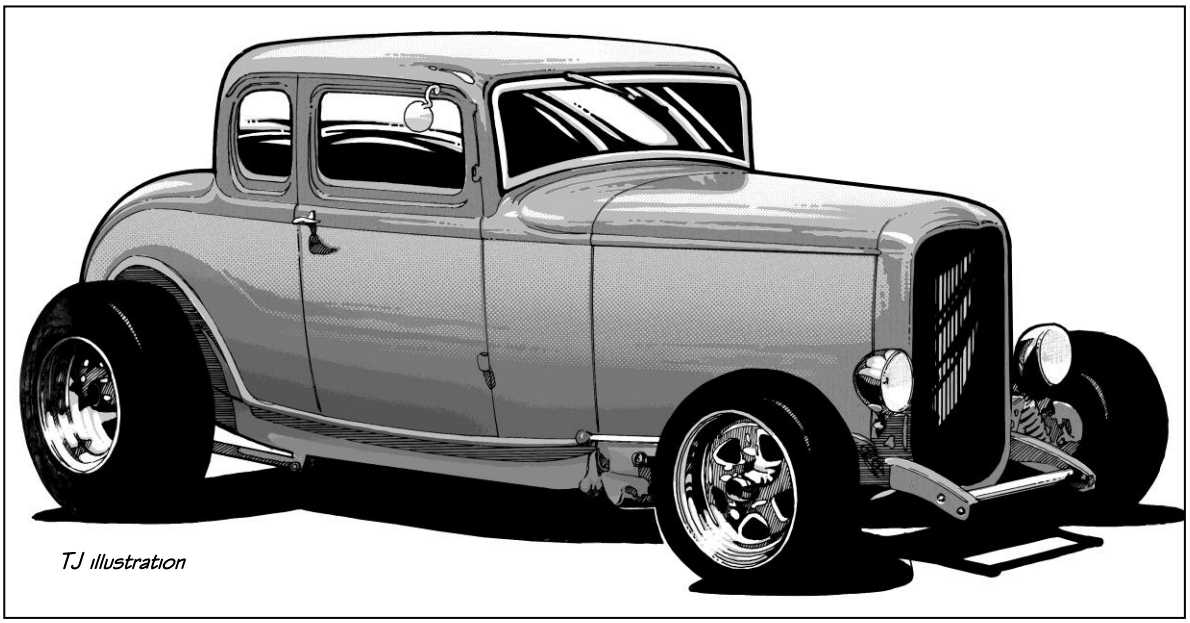
Chapter 8 Contents

Key: (for full key details, refer to 'Chapter 2 – About this Manual')

Normal type: Provisions of the NZ Car Construction Manual for all vehicles
Normal type in shaded box: Special provisions of the NZ Car Construction Manual for vehicles built or modified before specified dates
Italic type: *Extracts from any relevant LVVTA Low Volume Vehicle Standards*
Script type: Helpful hints, tips, explanations, clarifications, and interpretations
Shaded text & dotted vertical stroke in margin: Latest amendments since previous version



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CHAPTER 8: BRAKING SYSTEMS

Introduction:

The need for an efficient, reliable, and durable braking system is considered one of the two most important aspects of a hobby car's design and construction, along with the steering system. It is vital that the entire braking system is thoroughly thought out, and designed around the proposed weight and performance potential of the vehicle being built, before the purchase of any individual components begin. This will ensure that the braking system ultimately becomes a matched combination of components that will work in harmony, providing effective and well-balanced braking, both in one-off performance, and ability to resist brake-fade during repeated applications.

Note that where a production vehicle is fitted with its original braking system or braking system components in their original location, the requirements in this chapter do not apply.

Technical Requirements:

8.1 Brake system component compatibility

8.1.1

All components used within a braking system on a low volume vehicle must be purposely designed for automotive applications.

8.1.2

Brake components fitted to a low volume vehicle must be suitably matched for brake balance and bias, taking into account vehicle weight, engine set-back, and tyre size.

8.1.2

Tyre width can have a considerable effect on the front to rear brake balance, which is critical to optimising overall braking performance.

8.2 Disc and drum requirements

8.2.1

Brake disc and drum assemblies fitted to a low volume vehicle must be compatible with the weight and performance potential of the vehicle to which they are fitted, by incorporating:

(a) *braking surface swept area in accordance with the requirements specified in 8.2.2; and*

(b) *donor disc or drum material thickness that is not machined beyond the limitations specified by the brake component manufacturer.*

8.2.2

Brake disc and drum selection must be suitably matched to the performance potential of the low volume vehicle to which they are fitted, and Tables 8.1 and 8.2 should be used as a guide for appropriate component selection. (see Tables 8.1 and 8.2)

VEHICLE TYPE	VEHICLE WEIGHT RANGE	ENGINE HORSE POWER RANGE	POWER - WEIGHT RATIO (median)	FRONT DISC ROTOR SIZE (see Table 8.2 for typical sources)	FRONT CALIPER SIZE & TYPE (see Table 8.3 for typical sources)
▪ Lotus 7 replica ▪ Light-weight space-frame sports or classic/vintage special	500 - 800 kg (1100 - 1760 lb)	40 - 75	11.3	245 mm x 10 mm (S)	OEM small single-pot or OEM 2-pot
		75 - 150	5.8	250 mm x 12 mm (S)	OEM small single-pot or OEM 2-pot
		150 - 300	2.8	280 mm x 20 mm (V)	OEM medium single-pot or OEM 2-pot (75 mm [3"] pad)
		300 - 450	1.7	280 mm x 25 mm (V)	OEM medium single-pot or OEM 2-pot (75 mm [3"] pad)
▪ Heavy-weight space-frame sports special ▪ Medium-weight ladder-chassis sports car (MGTF replica) ▪ Light-weight hot rod (T-bucket, f-glass roadster) ▪ Small unit-construction sedan (Civic, Mazda 323)	800 - 1150 kg (1760 - 2530 lb)	75 - 150	8.7	250 mm x 12 mm (S)	OEM medium single-pot or OEM 2-pot (75 mm [3"] pad)
		150 - 300	4.3	280 mm x 20 mm (V)	OEM medium single-pot, OEM 2-pot (75 mm [3"] pad), or aftermarket small 4-pot
		300 - 450	2.6	280 mm x 25 mm (V)	OEM medium single-pot, OEM 2-pot (75 mm [3"] pad), or aftermarket small 4-pot
		450 - 600	1.8	300 mm x 28 mm (V)	Aftermarket medium size 4-pot (120 mm [4 ¾"] pad)

▪ Heavy-weight ladder-chassis sports car (Cobra) ▪ Medium-weight hot rod (steel coupe, pick-up) ▪ Large unit-construction sedan (Camaro, Falcon, Commodore) ▪ Large unit-construction Japanese (Skyline, GTO)	1150 - 1500 kg (2530 - 3300 lb)	150 - 300	5.8	280 mm x 20 mm (V) 280 mm x 25 mm (V)	Standard single-pot or OEM 2-pot sliding type
		300 - 450	3.5	300 mm x 28 mm (V)	OEM 2-pot sliding type or aftermarket medium 4-pot
		450 - 600	2.5	310 mm x 28 mm (V)	OEM 2-pot sliding type, OEM medium 4-pot, or aftermarket medium 4-pot
		600 - 750	1.9	330 mm x 30 mm (V)	OEM large 4-pot, or aftermarket medium 4-pot, or aftermarket large 4-pot
▪ Heavy-weight hot rod (30s & 40s sedan) ▪ Full size body/chassis car (50s & 60s USA sedan)	1500 - 2000 kg (3300 - 4400 lb)	150 - 300	7.7	280 mm x 25 mm (V)	OEM medium single-pot or OEM 2-pot sliding type
		300 - 450	4.6	300 mm x 28 mm (V)	OEM 2-pot sliding type or aftermarket medium 4-pot
		450 - 600	3.3	300 mm x 32 mm (V) 330 mm x 30 mm (V)	Aftermarket medium 4-pot, or OEM & aftermarket large 4-pot
		600 - 750	2.5	300 mm x 35 mm (V) 332 mm x 32 mm (V)	Aftermarket medium 4-pot, or OEM & aftermarket large 4-pot

Notes to accompany table 8.1:

- (S) denotes solid disc rotor, and (V) denotes ventilated disc rotor.
- Disc rotor and caliper sizes and types are those considered as ideal for the application, and while it is recommended that selections are made as closely as possible for the application, the table is only a guide. Despite the selection made, the one-off performance and cyclic brake-fade tests conducted during the certification process will determine what is acceptable. By following the table, you will optimize your chances of meeting the certification requirements.
- Table 8.3 should be referred to for assistance in brake caliper selection and sourcing.
- The emphasis on braking requirements is on the front brake components, as the front brakes do around 70% of the total stopping work. Therefore, it is recommended that:
  - in all but the most extreme combinations of performance and weight, solid discs will perform satisfactorily at the rear; and
  - rear disc rotor diameter should either be within approximately 15% of the front disc rotor diameter, or maintain the same front to rear relationship as found on the front disc rotor donor vehicle.
- An after-market cross-drilled and slotted sport disc rotor can be considered approximately as efficient as a non-cross-drilled and non-slotted disc rotor of the next diameter up.
- 330 mm (13") and larger diameter disc rotors will require 17", and possibly 18" wheels, to clear the calipers.

Table 8.1 Disc rotor size application guide table

FRONT DISC ROTOR SIZE	TYPICAL DISC ROTOR DONOR VEHICLES & SOURCES
▪ 247 mm x 9.6 mm (9 23/32" x 3/8") (S)	Ford Zephyr Mk3, and very small Japanese makes
▪ 247 mm x 12.5 mm (9 23/32" x 1/2") (S)	Ford Escort Mk2, and Ford Cortina Mk3 Mk4 and Mk5
▪ 254 mm x 8.2 mm (10" x 5/16") (S)	Aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 280 mm x 20.6 mm (11" x 13/16") (V)	Honda and other common medium-sized Japanese makes
▪ 287 mm x 25.5 mm (11 5/16" x 1") (V)	XY – XF Ford Falcon

▪ 276 mm x 24.0 mm (10 7/8" x 5/16") (V)	HQ – HZ Holden
▪ 290 mm x 22.0 mm (11 27/64" x 7/8") (V)	VK – VS Holden Commodore
▪ 295 mm x 28.0 mm (11 39/64" x 1 7/64") (V)	VT – on Holden Commodore
▪ 300 mm x 21.0 mm (12" x 13/16") (V)	Aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 300 mm x 25.0 mm (12" x 1") (V)	Nissan Skyline and other larger Japanese makes, aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 310 mm x 30.0 mm (12 13/64" x 1 3/16") (V)	Aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 320 mm x 30.0 mm (12 39/64" x 1 3/16") (V)	Aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 328 mm x 28.0 mm (12 29/32" x 1 7/64") (V)	HSV Holden Commodore
▪ 332 mm x 32.0 mm (13 5/64" x 1 17/64") (V)	Aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 340 mm x 32.0 mm (13 25/64" x 1 17/64") (V)	Aftermarket brands such as Wilwood, Outlaw, AP etc
▪ 350 mm x 32.0 mm (14" x 1 17/64") (V)	Aftermarket brands such as Wilwood, Outlaw, AP etc

Table 8.2 Disc rotor source table

8.2.3

Brake disc caliper selection must be suitably matched to the performance potential of the low volume vehicle to which they are fitted, and Table 8.3 should be used as a guide for appropriate component selection. (see Table 8.3)

FRONT CALIPER TYPE	TYPICAL CALIPER DONOR VEHICLES & SOURCES
▪ OEM small single-pot	60 - 70 mm (2 23/64" – 2 49/64") pad; small non-performance Japanese makes
▪ OEM medium single-pot	100 mm (4") pad; Toyota Corolla, Honda Accord, Mitsubishi
▪ OEM large single-pot sliding type	Large pad; HQ-HZ Holden, XA-XF Falcon
▪ OEM small 2-pot	60 mm (2 23/64") pad; Cooper S, Datsun 1600, common modern small Japanese makes
▪ OEM medium 2-pot	75 mm (3") pad; Zephyr, Escort, Cortina, & other British makes, & Datsun Z-series
▪ OEM 2-pot sliding-type	Toyota Soarer, Subaru Legacy, Mitsubishi Diamante & Evo 1-4, some Honda Accord
▪ Aftermarket 2-pot	50 mm (2") pad; Wilwood and others, generally intended for rear
▪ OEM medium 4-pot	Subaru WRX STI, Mazda Series 4-on RX7, Nissan Skyline & 280 -300 Z-series
▪ OEM large 4-pot	R33 Nissan Skyline, Mitsubishi Evo 5-on, Porsche, late S2 XJ6 Jaguar
▪ Aftermarket small 4-pot	Wilwood Dynalite, Outlaw 2000
▪ Aftermarket medium 4-pot	Wilwood Superlite, Outlaw 3000
▪ Aftermarket large 4-pot	Wilwood Grand National, AP, Brembo, etc

Table 8.3 Brake caliper source table

8.2.4

Where a brake disc adaptation has taken place on a low volume vehicle, the adaptation must not incorporate:

(a) *any welding to any cast or forged suspension upright or stub axle, or steering arm; or*

(b) *any reduction of the spindle diameter by machining or any other means; or*

(c) *any alteration to the original radii incorporated within the spindle.*

8.2.4 does not apply to a low volume vehicle built or modified before 1992, provided that the original radii has been replicated during the machining process.

8.2.4(b)

The practice of machining a stub axle spindle to shorten the length of it is allowed.

8.2.5

Original equipment manufacturer or aftermarket brake rotors fitted to a low volume vehicle must not be drilled or modified in any other way, except where provided as part of the original specification by the brake rotor manufacturer.

8.3 Pedal assembly requirements

8.3.1

A custom-manufactured brake pedal fitted to a low volume vehicle must be manufactured from a material having a thickness of equal or greater strength than 8 mm (5/16") mild steel.

8.3.1 does not apply to a low volume vehicle built or modified before January 1992, provided that the pedal appears to be of sound design and in good condition.

8.3.1

A custom-manufactured brake pedal may be made from 5 mm (13/64") thickness material in cases where the pedal length is unusually short, such as in a typical Lotus 7 style vehicle.

If using aluminium for a brake pedal, the material thickness will need to be between 150% and 200% of the specified mild steel thickness.

Alternative pedal fabrication methods may be used in special applications (such as race-car type sheet-metal pedals) on a case-by-case basis, provided approval in writing is obtained from the LVVTA Technical Advisory Committee.

8.3.2

A brake pedal fitted to a low volume vehicle must operate without binding or interfering with any other components.

8.3.3

A brake pedal fitted to a low volume vehicle must:

(a) be positioned where a brake pedal could reasonably be expected to be located; and

(b) have no obstruction positioned between the brake pedal and the accelerator pedal; and

(c) have sufficient clear space around the brake pedal to enable the pedal to be safely accessed and operated; and

(d) be able to be comfortably operated; and

8.3.3(b)

A steering column is considered an obstruction if positioned between the brake and accelerator pedals.

8.3.3(d)

The ideally positioned brake pedal can be operated with the ball of the foot with the heel positioned on the floor.

(e) provide smooth progressive application of the braking system.

A low volume vehicle that was built or modified before 1992 incorporating a steering column positioned between the brake and accelerator pedals is not required to comply with sub-clause (b) of 8.3.3.

8.3.4

A brake pedal fitted to a low volume vehicle must be constructed from a single piece of material, except for:

(a) the footplate; or

(b) the attachment of a boss or sleeved end of a pendulum design that, upon the failure of the attaching weld, would still enable the pedal to actuate the master cylinder; (see Diagram 8.1) or

8.3.4

'Through-floor' brake pedals (where the master cylinder is beneath the vehicle floor) are allowed provided that they meet the same requirements specified in 8.3.4.

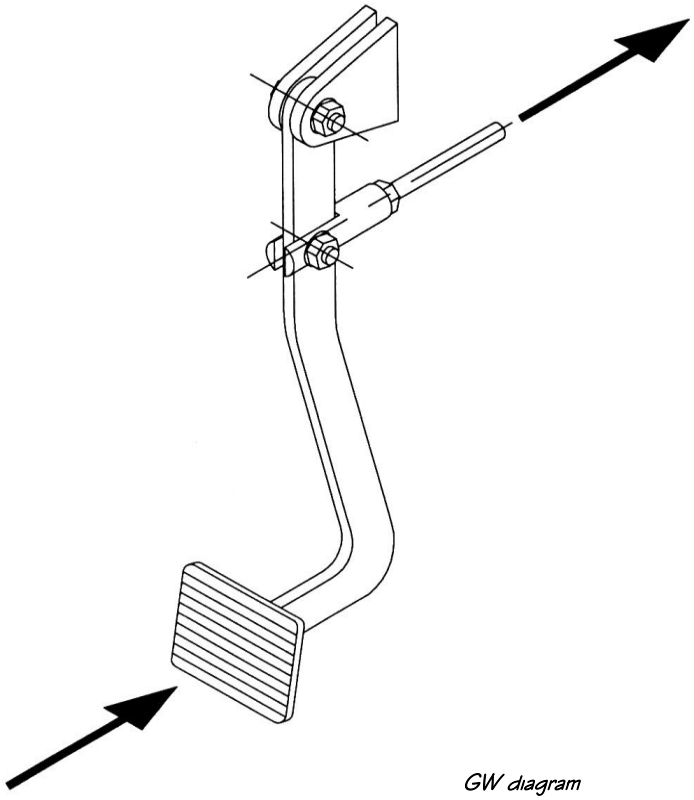


Diagram 8.1 Pendulum-design brake pedal assembly

(c) the attachment of an offset crank design only if accompanied by written approval from the Technical Advisory Committee of the Low Volume Vehicle Technical Association (Inc). (see Diagram 8.2)

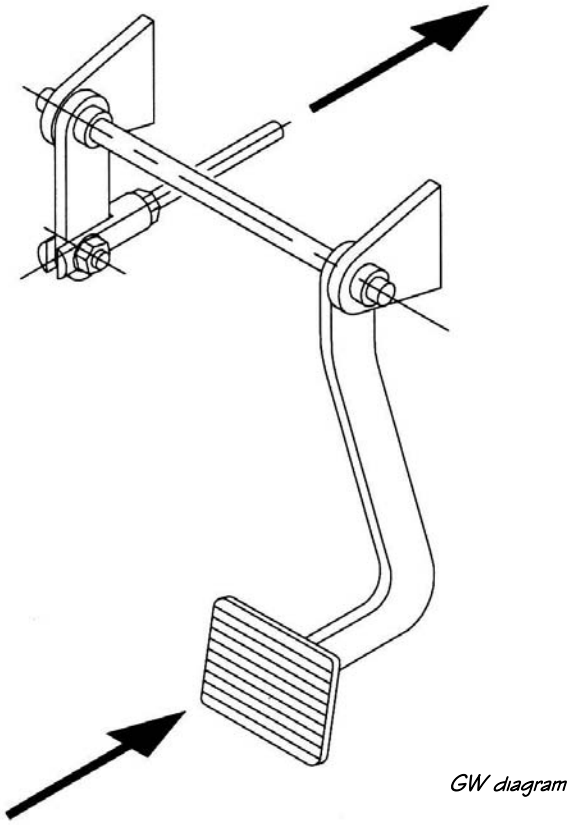


Diagram 8.2 Offset crank-design brake pedal assembly

8.3.4 does not apply to a low volume vehicle built or modified before 1992, provided that 8.15.1 is complied with.

8.3.5

A brake pedal assembly fitted to a low volume vehicle must incorporate:

(a) *an effective return spring; and*

(b) *a positive return stop; and*

(c) *an acceptable amount of free pedal movement before the braking system is actuated; and*

(d) positive retention of the pivot pin.

8.3.5(a)

An efficient return spring can include the spring incorporated within the booster (servo).

8.3.5(b)

A positive return stop is designed to prevent the push-rod from being able to fall out of the back of the master cylinder, and must be an independent pedal stop - not the washer and circlip within the master cylinder or booster.

8.3.6

A brake pedal push-rod fitted to a low volume vehicle must:

(a) be manufactured from material of a diameter appropriate to its length; and

(b) not incorporate any joins except for the attachment of end fittings; and

(c) not incorporate any welding, except in the case of an unmodified OE push-rod, which was carried out by the original high volume vehicle manufacturer.

8.3.6(c)

'High volume vehicle' means a production vehicle.

8.3.6 does not apply to a vehicle built or modified before 1992, provided that the non-destructive test requirements specified in 18.9.2 of 'Chapter 18 - Attachment Systems' are met.

8.3.7

A brake pedal push-rod fitted to a low volume vehicle must be positioned in such a way as to correctly align with the master cylinder or booster, and must not:

(a) incorporate any bends or changes of direction throughout its length; or

(b) travel through such an arc that excessive side-loading into the master cylinder or servo results; or

(c) operate in such a way that it binds or interferes with any other components.

8.3.8

A relocated or remounted brake pedal assembly must be located on a part of the structure of a low volume vehicle with sufficient strength and rigidity to securely attach and support the assembly during application of all normal and emergency braking loads.

8.3.9

A custom pedal box assembly fitted to a low volume vehicle must be:

(a) manufactured by a recognised aftermarket supplier of braking system components for motor-sport purposes; or

(b) designed so that a total failure of braking control cannot occur due to any individual component failure.

8.3.10

The braking system in a low volume vehicle must feature a brake pedal ratio that is designed to provide a comfortable operating balance between the length of travel and amount of force required to effect brake operation, which as a guide, should be:

(a) in the case of boosted brake systems;

(i) no less than 4:1; and

8.3.10

A 6:1 or 7:1 ratio is recommended for non-boosted systems, however, it is recognised that a particularly light vehicle built primarily for motor-sport purposes could get away with as little as a 4:1 non-boosted pedal ratio.

After-market pedal system manufacturers Wilwood and Tilton both supply a 6.25:1 system for non-boosted brake systems.

(ii) no more than 6:1;

or

(b) in the case of non-boosted brake systems;

(i) no less than 5:1; and

(ii) no more than 7:1.

8.3.11

An adjustable balance-bar assembly which actuates twin master cylinders in a low volume vehicle must:

(a) *be capable of being securely locked into position to prevent unintended changes in front to rear brake balance; and*

(b) *in the case of balance bar rods within a custom-built balance-bar assembly, be manufactured from a material of:*

(i) *appropriate strength; and*

(ii) *suitable diameter.*

8.3.12

A pedal assembly sourced from a high volume vehicle and fitted to a low volume vehicle must not be modified in any manner that could result in the weakening of the pedal.

8.4 Master cylinder requirements

8.4.1

A dual-circuit hydraulic master cylinder system must be fitted to:

(a) *all scratch-built low volume vehicles; and*

(b) *all modified production low volume vehicles which are fitted with any master cylinder other than that fitted by the original vehicle manufacturer.*

8.4.1 does not apply to a scratch-built vehicle built before 1992, or a production vehicle that has had a change in master cylinder before 1992.

8.4.2

A master cylinder reservoir fitted to a low volume vehicle must have a greater hydraulic fluid capacity than the combined total volume of all cylinders operating within the system.

8.3.12

'High volume vehicle' means a production vehicle.

8.4.1

A dual-circuit system must operate in such a way that a loss of fluid from one circuit (e.g. the front brakes), will not affect fluid supply to the other circuit (e.g. the rear brakes).

A dual-circuit system can be either one dual-circuit type master cylinder, or it can be two separate single-circuit master cylinders operated together by a balance bar assembly, with one cylinder operating the front brake circuit, and the other cylinder operating the rear circuit.

Note that a single reservoir can have two separate fluid chambers.

8.4.3

A relocated or remounted master cylinder must be located on a part of the structure of a low volume vehicle with sufficient strength and rigidity to securely attach the cylinder and support the cylinder during application of all normal and emergency braking loads.

8.4.4

When a master cylinder fitted to a low volume vehicle is at rest position, the master cylinder push-rod must have adequate clearance to ensure the release of fluid pressure.

8.4.4

Adequate clearance is considered to be approximately 1–2 mm (3/64" – 5/64").

8.4.5

A master cylinder and servo push-rod fitted to a low volume vehicle must be fitted with a dust-boot that is in good condition.

8.4.6

A master cylinder fitted to a low volume vehicle that was originally provided by the master cylinder manufacturer with rubber buffers at the servo end of the master cylinder, must continue to be fitted with rubber buffers.

8.4.6

The loss of these buffers is a common cause of sudden grabbing of the brake system.

8.5 Braking bias system requirements

8.5.1

A low volume vehicle may be fitted with one or more proportioning valves, provided that such valves are purposely designed for automotive applications.

8.5.2

A proportioning valve which is adjustable from inside a low volume vehicle must have the facility to be temporarily disabled or locked into a position of normal operation, to prevent unintended changes in front to rear brake balance occurring whilst the vehicle is being operated on public roads.

8.5.2

A motor-sport-type valve is acceptable provided the valve control lever or knob is removed, or protected by a hinged cover, for road use.

8.6 Vacuum servo system requirements

8.6.1

A vacuum servo system fitted to a low volume vehicle must provide and maintain sufficient vacuum to enable the braking system to operate safely at all engine speeds including idle.

8.6.1

A remote vacuum tank or accessory belt-driven vacuum pump may need to be fitted where the engine has a particularly high-lift camshaft, and as a result vacuum supply at low rpm is poor.

8.6.2

A remote vacuum servo fitted to a low volume vehicle, if exposed to or fitted near the road surface, must be protected by a chassis or sub-frame member, or purpose-designed shield, to prevent damage by irregular road surfaces or debris.

8.6.3

A vacuum brake hose fitted to a low volume vehicle must:

(a) *be of a type purposely designed for automotive applications; and*

(b) *incorporate a one-way check valve to prevent unintended loss of vacuum whilst the engine is not running; and*

(c) in the case of a hose that is not sourced from a high volume vehicle, meet one or more approved standards specified in Table 8.4. (see Table 8.4)

8.6.3

FMVSS 106 is the most common standard that an approved hose will comply with.

APPROVED STANDARD	ABBREVIATION
▪ Society of Automotive Engineers, SAE 40 R3L (light duty)	SAE 40 R3L
▪ Society of Automotive Engineers, SAE 40 R3H (heavy duty)	SAE 40 R3H
▪ Society of Automotive Engineers, SAE 40 M (heavy duty oil resistant)	SAE 40 M
▪ Society of Automotive Engineers, SAE J1403 (vacuum brake hose)	SAE J1403
▪ British Standard BSAU 109	BSAU 109
▪ Federal Motor Vehicle Safety Standard No. 106 (Brake hoses)	FMVSS 106 or DOT
▪ Japan Industrial Standard D2607	JIS D2607

Table 8.4 Vacuum brake hose approved standards table

8.7 Hydraulic brake pipe requirements

8.7.1

Hydraulic brake pipe fitted to a low volume vehicle must be:

(a) *of a type purposely designed for automotive applications; and*

(b) *manufactured from:*

(i) *steel bundy tubing; or*

(ii) *copper-nickel tubing.*

8.7.1(b)

Copper is considered by the industry as only being suitable for high corrosion applications such as boat trailers and stock trucks.

See the 'Useful Information' section at the back of this chapter for information on the use of stainless steel brake pipe.

A vehicle that was built or modified before 1992 that incorporates copper brake lines is not required to comply with 8.7.1(b), and may retain them, providing no sign of fatigue cracking is evident.

8.7.2

Hydraulic brake pipe fitted to a low volume vehicle must:

(a) *follow the shortest practical route; and*

(b) *be connected using double or ball flares; and*

(c) *be securely fastened to the vehicle structure at intervals:*

(i) *originally utilised by the vehicle manufacturer; or*

(ii) *no further apart than 300 mm (12").*

8.7.3

Hydraulic brake pipe fitted to a low volume vehicle must be mounted in such a position so as to be:

(a) *protected from being damaged by curbs, irregular road surfaces, or jacking equipment; and*

(b) *no closer than 100 mm (4") to any part of the vehicle's exhaust system, unless protected by a suitable heat-shield; and*

(c) *away from any moving components within the engine compartment; and*

(d) *able to be visually inspected without being removed; and*

(e) *protected from any chafing or abrasion where the hydraulic brake pipe passes through rigid sections.*

8.7.4

Hydraulic brake pipe which is mounted adjacent to any drive-shafts in a low volume vehicle that has been modified in such a way as to substantially increase power output, must either:

(a) *be re-directed away from the vicinity of the drive-shaft; or*

(b) *be protected from a drive-shaft failure by a 360-degree safety loop at each end of the drive-shaft, positioned within 150 mm (6") of each drive-shaft universal.*

8.7.5

Hydraulic brake pipe fitted to a low volume vehicle must not be electroplated, unless the electroplating is carried out as part of the manufacturing process by the brake pipe manufacturer.

8.7.2(b)

The low volume vehicle certifier, may, at his discretion, require the flares to be inspected, if he has reason to believe that they may not have been correctly flared.

8.7.2(c)

An approved alternative is for brake pipes to pass through a well-secured tubular section, known as a 'service tube', provided that the brake pipes are suitably supported, and cannot whip or flex.

8.7.3

This clause applies to scratch-built vehicles, or where the exhaust system or brake pipes have been changed or relocated.

8.7.3(b)

100 mm (4") is considered a minimum distance around headers, however this can reduce back to around 50 mm (2") further toward the rear of the system.

8.7.3(d)

Brake pipes may pass at 90 degrees through the width of a chassis rail or cross-member in order to run from one side of the vehicle to the other, but must not run lengthwise inside an enclosed chassis rail (eg RHS or boxed channel).

8.7.5

See note next page re electroplating.

8.8 Hydraulic brake hose requirements

8.8.1

A hydraulic brake hose fitted to a low volume vehicle must:

(a) *be of a type purposely designed for automotive applications; and*

(b) in the case of a hose that is not sourced from a high volume vehicle, meet one or more approved standards specified in Table 8.5. (see Table 8.5)

8.7.5

Electroplating is any process that involves 'electrolysis', which includes zinc, cadmium, gold, and silver. Stainless steel can be used if a high-quality finish is required, however it should be an annealed type, such as grade 304.

APPROVED STANDARD	ABBREVIATION
▪ Federal Motor Vehicle Safety Standard No. 106, (Brake hoses)	FMVSS 106 or DOT
▪ ISO 3996 (Brake hose assemblies for hydraulic braking systems used with non-petroleum-base brake fluid)	ISO 3996
▪ Society of Automotive Engineers, SAE J1401 (Hydraulic brake hose assemblies for use with non-petroleum-base hydraulic fluids)	SAE J1401
▪ Japanese Industrial Standard D2601 (Hydraulic Brake Hose for Automobiles)	JIS D2601
▪ Australian Design Rule 7/00 (Hydraulic Brake Hose)	ADR 7/00

Table 8.5 Hydraulic brake hose approved standards table (includes stainless-steel braided hoses)

8.8.2

Hydraulic brake hoses must not be used to replace rigid brake pipes on a low volume vehicle, except for where movement between vehicle parts makes this necessary.

8.8.3

Hydraulic brake hoses fitted to a low volume vehicle must be attached and located in such a way so as not to be able to:

(a) *come into contact with any moving parts such as wheels, tyres, brake or suspension components; and*

(b) *become caught or pinched between suspension spring coils, or the cover and body of the shock absorber.*

8.8.4

A hydraulic brake hose must be located and attached to a low volume vehicle in such a way that it is not fully extended, or under tension or excessive torsion at, or at any combination of, upward or downward suspension travel, or full steering lock.

8.8.1

Many aftermarket stainless-steel braided brake hoses don't comply with any approved standards for hydraulic brake hose, so be careful when purchasing them.

A 'high volume vehicle' is a production vehicle.

8.8.2

All brake pipes must, at the point where they connect to a brake hose, be rigidly supported.

8.9 Parking brake system requirements

8.9.1

A low volume vehicle, other than one of Class-LA, LB, LC, LD, or LE-1, must be fitted with a park brake system that operates on at least one axle.

8.9.2

A parking brake cable fitted to a low volume vehicle must be:

(a) *positioned or protected from being contacted by any moving parts of the vehicle; and*

(b) *securely fastened.*

8.9.3

A modification to a parking brake cable fitted to a low volume vehicle must be carried out by suitably experienced professionals, using components and attachment methods purposely designed for parking brake applications.

8.9.4

A low volume vehicle must not be fitted with a cardan-shaft parking brake system unless the vehicle is equipped with a dual circuit service brake system.

8.9.4 does not apply to a vehicle built, or fitted with a cardan-shaft parking brake system, before 1990.

8.9.5

A low volume vehicle, other than one for which an LVV Authority Card is issued that specifies 'Hydraulic hand-brake', must not be fitted with a hydraulically-operated parking brake system.

8.9.6

A parking brake lever assembly must be located and attached to a part of the structure of a low volume vehicle that is sufficiently strong to securely attach the parking brake lever assembly.

8.9.7

A parking brake lever fitted to a low volume vehicle must be able to be operated by the driver whilst in a normal seated position.

8.9.1

This is aimed particularly at Morgan-style 3-wheelers, which have one wheel at the back, which the park brake usually operates against.

A cardan-shaft park brake system is deemed to operate on one axle.

8.9.4

This means a vehicle built after 1 November 1990 with a single-circuit service brake system must have a parking brake that will bring the vehicle to a controlled stop if the service brake fails. This is because a cardan-shaft parking brake system is likely to be damaged if applied whilst the vehicle is moving. Also if the cardan-shaft is fitted to the back of the gearbox, damage could occur to the gearbox as a result of application of the parking brake at speed, causing drive and engine braking to be lost.

Note that any scratch-built vehicle built after 1 January 1992 must be fitted with a dual-circuit braking system.

8.9.5

MotorSport New Zealand's LVV Authority Card enables, amongst other things, for a hydraulic hand-brake to be fitted into a road-going motor-sport competition vehicle.

8.10 Anti-lock braking system requirements

8.10.1

A modified production low volume vehicle originally fitted by the vehicle manufacturer with an anti-lock braking system may be converted to a non anti-lock braking system, provided that:

(a) *the vehicle is provided with a warning label permanently positioned so as to alert the driver that the vehicle is no longer equipped with an ABS system; and*

(b) *the vehicle has any warning lights originally installed by the vehicle manufacturer to indicate the presence of an ABS system removed or de-activated; and*

(c) *all parts of the braking system which are unique to ABS are removed and either:*

(i) *replaced with the relevant parts from a non-ABS fitted variant of the same make and model; or*

(ii) *the system is modified to a non-ABS configuration using purpose-built braking components;*

and

(d) *documentation in a form specified by the Low Volume Vehicle Technical Association (Inc), verifies that 8.10.1(c) has been complied with.*

8.10.2

A scratch-built low volume vehicle incorporating an anti-lock braking system must utilise a complete system from one make and model of donor vehicle, installed in the same way as originally installed into the donor vehicle by the original vehicle manufacturer.

8.11 Electronic traction-control system requirements

8.11.1

A modified production low volume vehicle originally fitted by the vehicle manufacturer with a traction control system operated by computer-aided service brake application must:

(a) not have any components within the system replaced or altered beyond the original manufacturer's specifications; and

(b) if disabled, not affect in any way the continued safe operation of the main service braking system.

8.11.2

An electronic or computer operated traction control system that is fitted to a scratch-built low volume vehicle must be either:

(a) a complete system from one make and model of donor high volume vehicle, and fitted in the same way as the system was originally installed in the donor high volume vehicle by the manufacturer; or

(b) a reputable brand of aftermarket traction control system.

8.11.2

A 'high volume vehicle' is a production vehicle.

8.11.2(b)

An example of a known high-quality traction control system manufacturer is the UK/USA brand 'Racelogic'

8.12 Manual traction-control system requirements

8.12.1

A manually-controlled individual wheel brake system, if fitted to a low volume vehicle, must:

(a) not compromise the safety and reliability of the original service braking system's operation; and

(b) incorporate purpose-built automotive brake system components; and

(c) incorporate a warning light that is clearly visible to the driver when the system is operable; and

(d) incorporate operating levers that:

(i) return to a neutral position when released; and

(ii) have the facility to be temporarily enclosed or disabled to prevent use whilst the vehicle is being operated on public roads; and

(iii) are mounted in such a way that does not obstruct normal operation of the vehicle; and

(iv) meet the requirements specified for interior impact in 'Chapter 16 - Interior Equipment'.

8.12.1

These are systems typically used in 4WD competition events (sometimes referred to as 'fiddle brakes'), and are designed to enable extremely tight maneuvering.

8.12.2

A manually-controlled individual wheel brake system, if fitted to a low volume vehicle, must incorporate for each master cylinder, a mechanical means to prevent dislodgement of the master cylinder piston, by either:

(a) a solid mechanical stop fitted to the brake lever; or

(b) a securely attached plate positioned against the master cylinder piston.

8.12.2

Many of these systems rely on circlips and the machined grooves into which the circlips lock, to prevent dislodgement of the master cylinder piston, which on its own is not enough to reliably resist the hydraulic fluid pressure.

8.13 Roll control and line-lock requirements

8.13.1

A roll-control or line-lock device fitted to a low volume vehicle must:

(a) be a purpose-built automotive brake system component and use purpose-built automotive brake parts; and

(b) be electrically operated; and

(c) incorporate a warning light which is visible to the driver, that shows when the device is in use; and

(d) only be operable by a momentary switch that automatically disengages the device when the roll-control or line-lock device is released; and

(e) have the facility to be temporarily enclosed or disabled to prevent use whilst the vehicle is being operated on public roads.

8.13.1

These are devices primarily designed for drag racing applications, to facilitate front brake-only application, to enable static burn-outs.

8.14 Brake component attachment requirements

8.14.1

All fasteners incorporated in braking system attachment, modification, or adaptation within a low volume vehicle, must meet all requirements specified from 18.2 to 18.6 inclusive in 'Chapter 18 - Attachment Systems'.

8.14.2

The attachment of the pedal assembly, master cylinder, and servo to a low volume vehicle, must remain securely attached, with minimal deflection to its mounting structure, using a force applied to the pedal of approximately 90 kg (198 lb).

8.14.2

Minimal deflection is generally considered to be no more than would be expected in a production vehicle. 90 kg (198 lb) is about the amount of force a lightly built person could apply to a brake pedal in the event of a panic-stop situation.

8.15 Welding of braking system components

8.15.1

All welding incorporated in braking system attachment, modification, or adaptation within a low volume vehicle, must meet all requirements specified in 18.9 'critical function welding requirements' in 'Chapter 18 - Attachment Systems'.

8.16 Other technical requirements

8.16.1

A service braking system and a parking braking system fitted to a low volume vehicle must comply with the applicable performance requirements specified in 'Chapter 19 - Vehicle Operation'.

8.16.1

This braking performance evaluation process involves a multi-cycle service brake test, which ensures that the vehicle's braking system is suitably matched to the mass and performance potential of the vehicle.

General Requirements:

8.17 General safety requirements

8.17.1

A low volume vehicle must be fitted with a brake for each wheel.

8.17.2

All low volume vehicles must comply with the following general safety requirements:

(a) *a brake must be easily adjustable to compensate for wear and must be maintained in good condition and efficient working order; and*

(b) *the friction surfaces of a brake must be within safe tolerance of their state when manufactured and must not be scored, damaged or weakened to the extent that the safety performance of the brake is adversely affected; and*

(c) *the run-out and thickness of a brake or brake disc must be within the service limits set by the vehicle manufacturer, or the brake manufacturer, and if these are not known, the thickness must not be less than 90% of the original thickness; and*

(d) *if a vehicle is fitted with a warning system that is part of, or associated with, the use of a brake component or system, that warning system must function correctly.*

8.17.2

These general safety requirements are from the General Safety Requirements of the Land Transport Rule; Light Vehicle Brakes 2002 (Rule 32014). All vehicles, whether modified or standard, have to comply with these regulations.

8.17.2(c)

This means that you can't use discs or drums if they have been machined several times. If in doubt, compare the thickness against a new disc or drum for the same make and model of vehicle.

Exclusions:

8.18 Rod or cable braking system exclusions

8.18.1

A low volume vehicle that is constructed entirely of components and systems produced no later than 1952 is not required to comply with 8.4 to 8.8 inclusive, and may be fitted with a mechanical rod or cable braking system, provided that:

(a) the vehicle being constructed is a faithful and authentic reproduction of the vehicle being replicated; and

(b) the performance potential of the vehicle is not greater than the vehicle being replicated; and

(c) the cable or rod is of an appropriate diameter for its length and application; and

(d) the system incorporates a balancing or compensating mechanism between the front and rear axles to ensure that even braking is achieved; and

(e) in the case of a cable system, the cable is:

(i) in good condition and shows no signs of fraying or deterioration; and

(ii) is well secured;

and

(f) the vehicle can be stopped within a distance of 7 m (23') from a speed of 30 kph (18 mph).

8.19 Two-wheeled braking system exclusions

8.19.1

A low volume vehicle that is constructed entirely of components and systems produced no later than 1927 is not required to comply with 8.17.1, and may be fitted with brakes that operate on two wheels, provided that:

(a) the vehicle being constructed is a faithful and authentic reproduction of the vehicle being replicated; and

(b) the performance potential of the vehicle being constructed is not greater than the vehicle being replicated; and

(c) the vehicle can be stopped within a distance of 7 (23') from a speed of 30 kph (18 mph).

Useful Information:

Disc brakes

Disc brakes have generally proven to provide superior braking performance over drum brakes. For purely performance reasons, a disc brake system is preferable over a drum brake system, especially at the front of a vehicle, where, through weight transfer, the majority of the braking effect occurs. The larger diameter the disc, (providing everything else matches) the better the braking performance.

A ventilated disc brake rotor won't necessarily provide substantially better braking in a one-off stopping situation than a solid rotor of the same diameter, but it will improve multiple stopping performance, because of the fact that the ventilation designed into the disc allows better dissipation of the heat between brake applications.

Freshly skimmed, or machined discs with a good quality aftermarket brake pad, will provide a noticeable improvement in braking performance, especially under repeated applications.

Drum brakes

It is generally accepted that properly sized disc brakes will give more consistent and reliable fade-resistant braking than drum brakes, and are therefore a preferred option, particularly for front brakes. However, there are many applications where hobby car builders want to use drums for authenticity of appearance, when building something like a '40s or '50s era hot rods, or vintage and sports replicas and specials. Provided the drum system used is of adequate size and in good condition, drum brakes can still be very efficient, and the braking performance requirements can still be achieved.

A typical application would be a light to medium weight roadster with moderate power, say under 250 horsepower in 1135 kg (2500 lbs) or less, using a complete '39-'48 Ford hydraulic drum brake system. The cylinder will require an upgrade to a dual-circuit unit, but would not necessarily need boosting unless specifically required. Correct front to rear balance can be achieved as needed by using smaller rear wheel cylinders (or sleeving the standard cylinders down), or by using a proportioning valve.

Many other drum systems can be used, such as those found in 1950s Ford F100 pick-ups, but should always be as large as possible, with around 254 mm (10") as a minimum diameter.

Using the same donor vehicle to supply the stub axle, backing plate, and drum assembly will generally prove to be the simplest system to set up with the best end results.

Disc and drum selection based on vehicle weight and performance

There are two major factors to consider when selecting the discs and/or drums for a vehicle; weight, and performance potential. Here's an overview of both factors:

- Vehicle weight is the major influence on brake component selection, in particular the disc rotors and/or drums for both front and rear. Kinetic energy, which is basically the vehicle's forward motion energy, increases in direct proportion to the vehicle weight. For example, a light-weight 650 kg (1430 lb) Lotus 7 style special has around 233,000 Nm (172,000 ft lb) of kinetic energy to stop from 96 kph (60 mph), whereas a 2000 kg (4400 lb) big-block Chev Impala has around 718,000 Nm (530,000 ft lb) of kinetic energy to stop from 96 kph (60 mph). It doesn't take Einstein to figure that the Impala is going to need around 3 times the disc or drum braking power to get the vehicle weight stopped in the same time as the Lotus special.

- The other major influence on the braking component selection is the performance potential of the vehicle. Take a mid-sixties Chev Impala with a stock 283 and drive it hard over a road with a lot of corners, and the old drum brakes (providing they're in good condition) will probably do all you need of them. Now double the horsepower by bolting in a trick 400 small-block (same weight) and do the same drive, and you'll be experiencing a great big dose of brake fade in no time. The reason – the braking system now has less time to cool down between applications because the speed is reached in less time, not to mention that the increased acceleration has increased the speeds you're braking from. This is why the vehicle's performance potential has to be considered when selecting your braking components.

Use the brake component application table to help you work out what is going to do the right job for the weight and performance potential of your project vehicle.

Brake pads

Where a modified production low volume vehicle retains its factory equipped braking system, and has been modified in such a way as to increase the performance of the vehicle, high performance brake pads incorporating a relatively high metal content should be fitted.

Higher metal content within brake pads generally provides better heat dissipation and improved braking performance. Caution, though, is needed with your high performance brake pad selection; - don't go too far toward the highest (race-quality) metal-content pad, as these rely on several applications to build up sufficient heat for them to provide their optimum performance. This can be hazardous in an on-road situation – especially if the driver is not prepared for the poor braking performance provided by a high metal-content pad that is cold.

Pedal ratios

Pedal ratio is the relationship between the distances from the pedal pivot and the footplate, and the pedal pivot and the master cylinder. For example, a pedal that has 300 mm (12") between the pivot and the footplate, and 50 mm (2") between the pivot and the master cylinder, gives a pedal ratio of 6:1. The higher the pedal ratio, the more travel; the lower the pedal ratio, the less travel.

Master cylinders

In some applications when drum brakes are used all round, a residual pressure valve may be needed at the front of the master cylinder to provide some residual pressure against the wheel cylinders.

Where dual-circuit master cylinders are used in conjunction with non self-adjusting drum brakes, the master cylinder stroke should be checked with brakes fully de-adjusted to ensure that the master cylinder has sufficient stroke to prevent bottoming out.

This is because dual-circuit master cylinders sometimes have a shorter stroke than single-circuit master cylinders, and may not have sufficient stroke to prevent bottoming out if older drum brakes run out of adjustment.

Master cylinder bore diameter

The larger the bore diameter of a master cylinder, the less force it will apply to the system with the same amount of pedal force applied. If you want to increase the force to the system from the master cylinder, use a smaller master cylinder bore diameter. Generally, a lightweight hobby car can get sufficient braking force without a servo by using a 25 mm (1") or smaller master cylinder bore diameter.

Think of a 25 mm (1") diameter master cylinder applying 45 kg (100 lb) of force to a wheel cylinder or caliper;

- if the wheel cylinder is 12 mm (½") diameter, the resultant force out the other side will be 11 kg (25 lb);
- if the wheel cylinder is 25 mm (1") diameter, the resultant force out the other side will be 45 kg (100 lb);
- if the wheel cylinder is 50 mm (2") diameter, the resultant force out the other side will be 181 kg (400 lb). (see Diagram 8.3 Pedal pressures and cylinder forces)

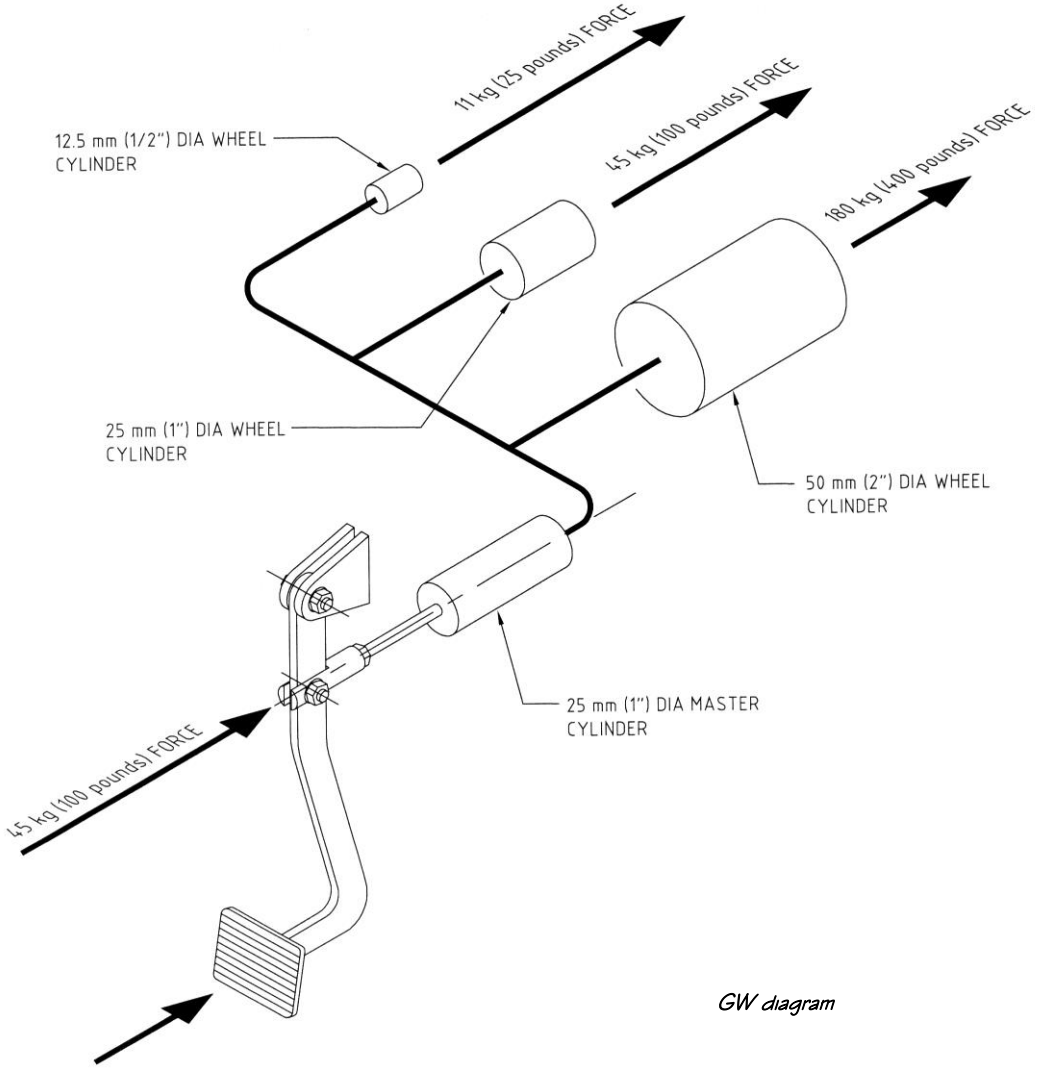


Diagram 8.3 Pedal pressures and cylinder forces

If you can't get enough pressure to all, or one end of your braking system, you can increase the pressure without changing your discs or drums by changing to either a:

- higher pedal ratio; or
- larger wheel cylinder or caliper piston diameter; or
- smaller master cylinder bore diameter.

A master cylinder with a small bore diameter gives a pedal that feels softer and travels further, and a master cylinder with a large bore diameter gives a pedal that feels harder and travels less.

The larger the tyre diameter, the greater the braking effort, and therefore the more pressure, that will be required.

Booster clearance problems

Limited under-floor room on some hobby cars can provide problems finding space for the booster if one is required. Because most hobby cars are relatively light, a nice compact 180 mm (7") booster off something like a 1970s Corolla will provide all the additional pressure needed, it will adapt well to a typical master cylinder like the HQ Holden type, and will solve your space problems.

Stainless steel brake pipe

The reason that stainless steel brake pipe is not listed in 8.7.1 as an approved material, is that because it is so hard, it isn't possible to create an approved double flare as can be achieved with steel bundy or copper-nickel material. However, it is recognised that the owners of some top-level show cars want to use stainless steel as a brake pipe material. Stainless steel may be used provided that the flaring of the pipe is carried out by a person who is professionally engaged in the car construction industry, and in whom the TAC has absolute confidence. The constructor or LVV Certifier should contact the TAC for specific advice if the owner proposes to use stainless steel brake pipe tubing.

Ford 9" disc brake adaptations on a budget

Disc brake adaptations can be carried out to a 9" Ford diff on a budget, by using the front calipers off an early front-wheel drive Subaru (with hand-brake mechanism incorporated) onto Toyota Hi-Ace rotors – the Hi-Ace rotors are a good size for the rear of even a relatively heavy vehicle, and have the bonus of incorporating the same stud pattern as the Ford.

Proportioning valves

Proportioning valves are often required to achieve the ideal balance between front to rear braking. The ideal situation is for the front brakes to lock up slightly before the rear – the opposite situation can be harder to control, particularly on a cambered surface or when steering is combined with the emergency braking.

Larger 'Pro-street' types of tyres, due to their larger road contact area, can be subject to aquaplaning on wet road surfaces, and therefore rear brake lock-up can occur before it would with the same braking system applied to 'normal' sized rear tyres. Therefore, take these types of tyres into account when planning and setting up your braking system, and incorporate a good compromise between the different effects of dry and wet road conditions.

Proportioning valves can be:

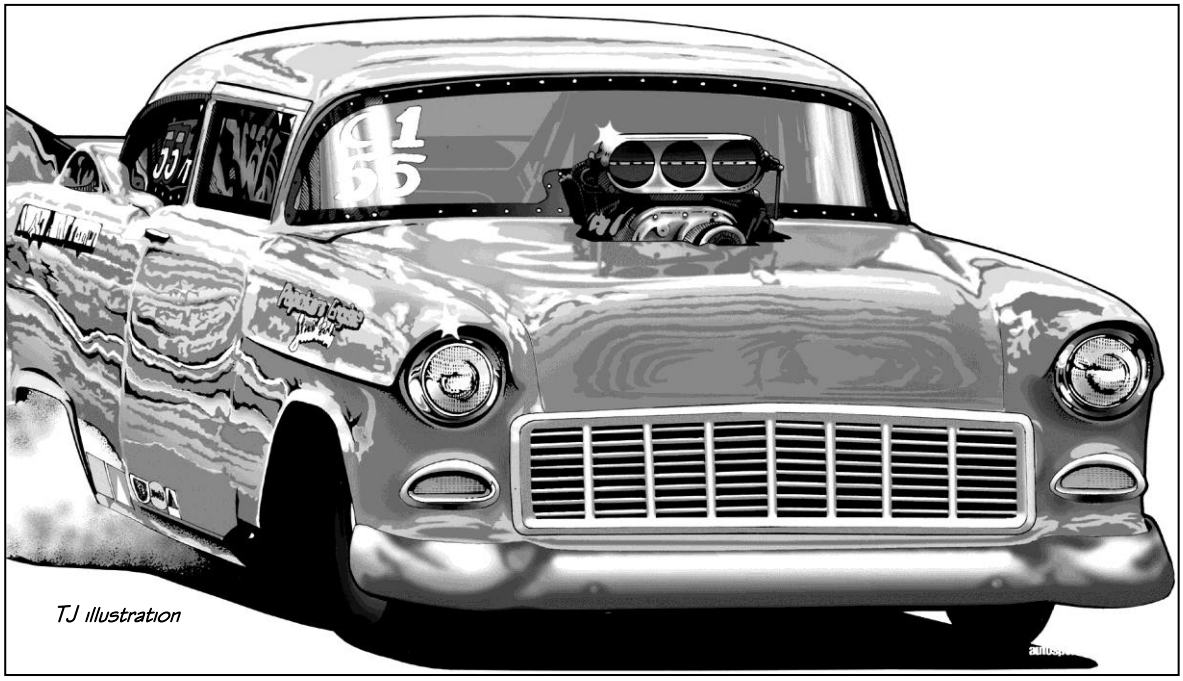
- fitted within the master cylinder; or
- stepped bore sizes for the two circuits within the master cylinder; or
- an independent proportioning valve positioned in the brake pipe between the master cylinder and the brakes.

Independent proportioning valves can be fixed, which means to constantly limit the pressure to one or other of the circuits, or they can be adjustable.

Adjustable proportioning valves are typically aftermarket items, and are usually fitted to the rear brake line to limit the pressure to the rear, as premature rear lock-up is the most common braking system imbalance. The pressure can be reduced by anywhere between 0 and 60%.

Setting up an adjustable proportioning valve can require a lot of brake testing (find some gravel or a wet surface to make life easier) to achieve the right balance, and sometimes a combination of a fixed proportioning valve and an adjustable proportioning valve is needed to get a system bang-on. Likely vehicle loading should be taken into account when setting up a proportioning valve, such as the number of seating positions available.

Be aware that even when using an entire OEM system from a production vehicle in a scratch-built hobby car, a braking imbalance could still result, requiring a proportioning valve to get it right. This is because other factors such as front to rear axle weight ratios, engine location, and rear tyre sizes, can all have an effect on braking bias.



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