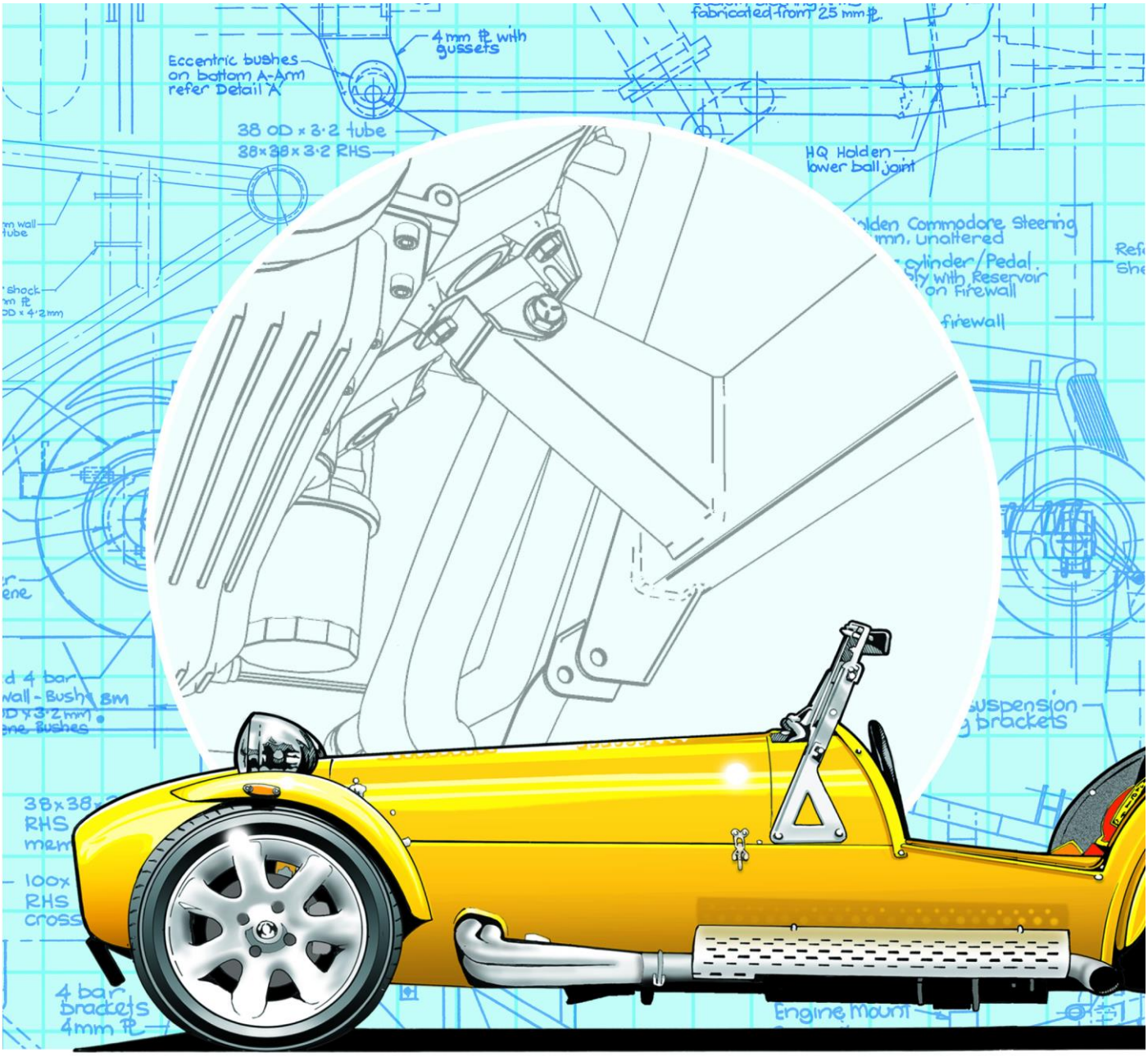
Low Volume Vehicle Technical Association (inc)

Helping New Zealanders Build & Modify Safe Vehicles

New Zealand Car Construction Manual

Chapter 9
Engine & Drive-train

3rd Amendment | Effective from 1 July 2021



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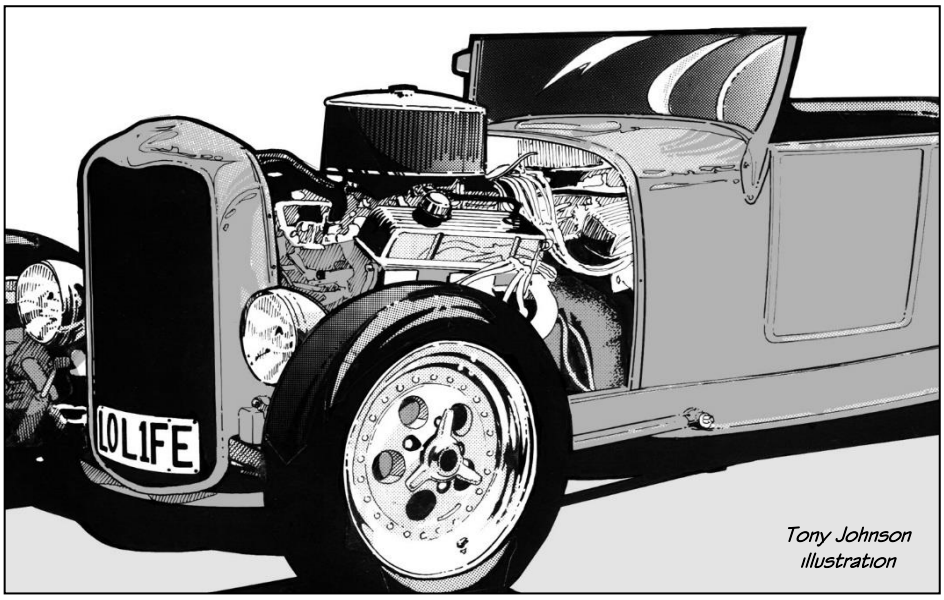

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The information in this NZ Car Construction Manual Chapter has stemmed from work undertaken by LVVTA founding member organisations that commenced prior to 1990 and has been progressively developed as an integral part of New Zealand Government safety rules and regulations by agreement and in consultation with the New Zealand Transport Agency.

As a result, the considerable experience in applied safety engineering built up by LVVTA and the specialist automotive groups over the past several decades can be of benefit to members of the New Zealand public who also wish to build or modify light motor vehicles.

LVVTA's contact details are below:

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Submissions should be made to submission@lvvta.org.nz, with the name of this Chapter in the Subject line.

Supporting Information:

This NZ Car Construction Manual Chapter is supported by a lot of other documents (referred to as 'supporting information' on the same subject, which could be very helpful to someone using this chapter.

This supporting information relating to this Chapter can be accessed from www.lvvta.org.nz/nzccm and is all free of charge.

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Credits:

The Low Volume Vehicle Technical Association (Inc.) acknowledges the following persons and organisations for their significant contribution toward the development of this NZ Car Construction Manual Chapter:

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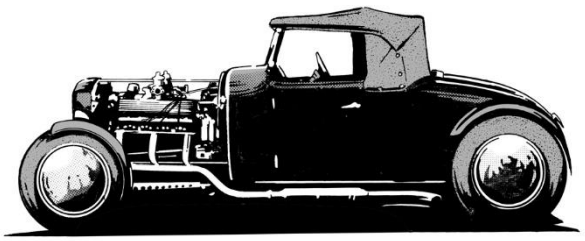
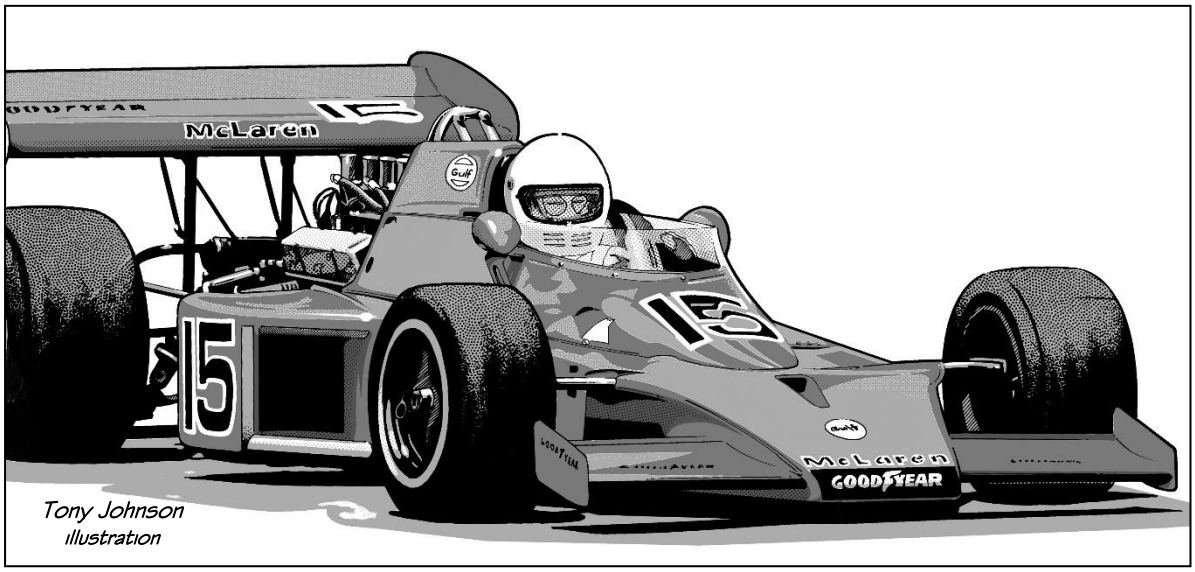
Normal type:	Provisions of the NZ Car Construction Manual for all vehicles.
Normal type in shaded box:	Special provisions of the NZ Car Construction Manual for vehicles built or modified before specified dates.
Script type:	Helpful hints, tips, explanations, clarifications, and interpretations.
Grey shaded text & grey vertical stroke in margin:	Latest amendments since previous version. Note that text which is high-lit in grey shows amendments that have been made since the document's previous version, and a grey vertical stroke to the left of the text denotes new or changed information which is important (rather than just a grammatical, formatting, or numbering change).



Chapter 9 Contents:



Tony Johnson illustration

CHAPTER 9: ENGINE & DRIVE-TRAIN

Introduction:

The purpose of this Chapter is to specify sound practical engineering principles and procedures relating to the conversion of engines and drive-trains to motor vehicles, to ensure that such conversions are as safe as practicable, having regard to their effect on inter-related vehicle components and systems, especially those relating to braking and steering control.

The engine and drive-train is the heart and soul of any hobby car, and the installation and attachment of the engine and drive-train components is full of pitfalls for the unwary or inexperienced enthusiast. Getting this part right not only has safety pay-offs, but will improve your vehicle in terms of noise, vibration, and harshness, and perhaps best of all, will help the long-term reliability of your ride.

Note that where a production vehicle is fitted with its original un-modified engine and drive-train components in their original location, the requirements in this chapter do not apply.

General safety requirements:

9.0 Requirements applicable to all vehicles

9.0.1

A low volume vehicle must:

(a) be designed and constructed using materials and components that are fit for their purpose; and

(b) be safe to be operated on the road.

9.0.1

This is from 2.3 of Part 2 of the LVV Code, which makes it clear that, regardless of what technical requirements are or are not in place, every vehicle certified to the LVV Code must be fit for its purpose, and must be safe.

9.0.2

A steering system on a motor vehicle, and associated systems and components that could directly or indirectly affect the directional control of the vehicle, must:

(a) be sound and in good condition and must provide the vehicle with safe, efficient, convenient, and sensitive control; and

(b) be strong, durable and fit for its purpose, taking into account whether adverse effects have resulted from a loss of integrity of any protective system used by a relevant component.

9.0.2

These are the applicable general safety requirements from the Land Transport Rule 32003/1 Steering Systems 2001, which are required as part of this Chapter, reproduced here in the interest of convenience.

Engine conversion requirements:

9.1 Engine mount design and construction

9.1.1

An engine mount fitted to a low volume vehicle must be designed and constructed in such a way that:

(a) it is able to withstand all fore and aft, side, rotational, and vertical loads and dynamic forces that may be imposed on it, taking into consideration engine weight and torque output; and

(b) its design will not impair the life of the flexible mount by stress.

9.1.2

Where a north-south configured engine is fitted to a low volume vehicle, and solid-mounted front and rear engine plates are fitted instead of conventional rubber mounts:

(a) the plates must be designed and constructed in such a way that they are able to withstand all fore and aft, rotational, and up/downward loads imposed on them; and

(b) the gearbox, if attached to a gearbox cross-member or other part of the vehicle structure, should also be rubber-mounted.

9.1.2

See the 'Useful Information' section at the back of this chapter for some hints on solid-mounted engines and gearboxes.

9.1.3

An engine mount fitted to a low volume vehicle must be designed and constructed in such a way that upon failure of either one or both of the engine mounts, the engine weight could not cause the steering system to become jammed or affected by engine weight, which may include either:

(a) an engine mount chassis or sub-frame bracket designed to prevent the engine from dropping; or

(b) a safety-type engine mount that features a through-bolt that prevents detachment of the mount upon separation of the rubber from the backing plate; or

(c) an engine mount safety-strap.

9.1.4

An engine mount fitted to a low volume vehicle used to attach an engine positioned to the rear of the vehicle occupants, must be designed to minimise forward movement of the engine as much as practicable during a frontal crash.

9.1.5

Where a non-original or custom manufactured engine cross-member is installed on a low volume vehicle, the cross-member must be:

(a) designed and constructed so as to withstand:

(i) the weight of the engine and gearbox it supports; and

(ii) any rotational or other dynamic loads it may be subjected to;

and

(b) attached to chassis rails using all applicable requirements contained in section 5.4 of 'Chapter 5 – Chassis Modification & Construction'.

9.1.6

When engine mounting to a low volume vehicle necessitates bolting through a boxed, RHS, or tubular chassis or sub-frame section, fasteners must pass through steel tubular reinforcing within the chassis or sub-frame section to prevent crushing.

9.2 Engine positioning

9.2.1

Where a north-south configured engine is fitted to a low volume vehicle, the engine must be positioned in such a way that the crankshaft centre-line either:

(a) in the case of a modified production vehicle, duplicates as closely as possible the original engine crankshaft centre-line, ensuring that the drive-shaft universal angles of the new drive-train match the original as closely as possible; or

(b) in the case of a scratch-built vehicle, is correctly aligned with the drive-shaft and differential; or

(c) in the case of an engine and gearbox that has to be offset from the centerline of the chassis, is correctly aligned with the drive-shaft and differential.

9.2.2

The engine in a low volume vehicle must be mounted in such a way that when maximum engine torque is applied, it cannot come into contact with any part of the engine compartment, or items within the engine compartment.

9.2.3

An engine in a low volume vehicle which is positioned above a beam-type axle assembly must be mounted in such a way that adequate clearance is still available between the engine and the axle assembly, when the suspension is under full compression.

9.2.3

This is especially important for 4WD off-road vehicles which have a substantial amount of suspension travel, and are subject to rough treatment.

9.3 Engine attachment

9.3.1

A flexible mount used in an engine conversion or installation in a low volume vehicle must be of a type and size that will withstand all loads imposed on it.

9.3.2

Attachment of an engine mount to the engine, and an engine mount to the chassis or sub-frame section of a low volume vehicle, must either:

(a) in the case of a modified production vehicle, incorporate fasteners of a quantity, size, type, and grade of equal or greater specification than that used by the original engine manufacturer; or

(b) in the case of a scratch-built vehicle, incorporate fasteners of a quantity, size, type, and grade suitable for:

(i) the weight of the engine; and

(ii) the rotational or other dynamic loads the engine is capable of applying.

9.3.3

All fasteners used in the process of mounting an engine to a chassis or sub-frame of a low volume vehicle must meet all fastening requirements specified from 18.2 to 18.6 inclusive in 'Chapter 18 - Attachment Systems'.

9.4 Engine compartment and floor modifications

9.4.1

Any part of a firewall, floor, gearbox tunnel, or other structural section of a low volume vehicle that has been cut or removed to provide room for engine conversion clearance, must be adequately re-strengthened.

9.4.2

An engine cooling fan or other rotating component within an engine compartment of a low volume vehicle which could be easily contacted and cause injury, must, if such a component would normally be provided with protective covering by a high-volume vehicle manufacturer, be fitted with some form of protective cover to minimise the likelihood of contact.

9.4.3

All flexible hoses and wiring which extend from the body or chassis or sub-frame structure to the engine and gearbox of a low volume vehicle must incorporate sufficient slack to allow for full engine rotational or other movement on its mounts.

9.4.4

An opening between the engine compartment, floor, or transmission tunnel, and the passenger compartment of a low volume vehicle, must be sealed to prevent exhaust gases, vapour, and liquids from entering the passenger compartment.

9.5 Engine weight

9.5.1

A low volume vehicle fitted with an engine that is substantially heavier than the original engine, and is of a configuration never intended by the original vehicle manufacturer for fitment to the vehicle in question, must incorporate:

(a) where necessary, a means of preventing the chassis or sub-frame rails from spreading apart as a result of the additional weight or torque loading of the new engine; and

(b) suspension components, including springs and shock absorbers up-rated as necessary to support the additional weight of the new engine; and

(c) an engine cross-member beam, if fitted, that either:

(i) is strong enough to withstand the additional weight or torque loading of the new engine; or

9.5.1

Consideration should be given to ensuring that the vehicle manufacturer's Gross Vehicle Mass (GVM), or individual axle ratings, haven't been exceeded as a result of the fitment of a much heavier engine.

9.5.1(a)

This applies in particular to the more traditional engine conversions such as a cast-iron V8 into a Holden Torana or Ford Cortina.

(ii) has been reinforced to provide the necessary additional strength;

and

(d) an increase to the wheel hub assembly's load-carrying capability by having either:

(i) the hub assembly replaced with one which has an increased number of studs, or an increase to the pitch circle diameter; or

(ii) the original wheel studs replaced by studs of a diameter equivalent to a production vehicle that has a similar engine weight and number of wheel studs.

9.5.1(b)

While springs and shock absorbers are the obvious suspension items, consideration should also be given to stub axles, suspension arms, and any other load-bearing items.

Engine equipment and system requirements:

9.6 Superchargers & engine protrusions

9.6.1

An engine fitted to a low volume vehicle which incorporates exposed forward-facing moving components positioned above the line of the engine hood, that could be easily contacted and cause injury, such as a mechanical supercharger, must incorporate some form of protective covering to reduce the likelihood of contact.

9.6.2

An engine fitted to a low volume vehicle with protrusions extending beyond the line of the engine hood must comply with:

(a) the external projection requirements specified within 'Chapter 13 - Body Modification and Construction' to ensure against the presence of unnecessarily sharp forward-facing surfaces; and

(b) the visibility requirements specified within 'Chapter 15 - Glazing and Vision' to ensure against the presence of forward-facing obstructions.

9.6.2

See Chapters 13 and 15 to make sure that air-cleaners, hood scoops, or other engine components meet the external projection and sight-line requirements.

9.6.3

Unless authorised by an LVV Authority Card specified under Annex 5 of the Low Volume Vehicle Code, a low volume vehicle must be fitted with a functional engine hood so as to minimise the likelihood of additional injury to pedestrians through contact with engine components.

9.6.3

Traditional hot rods based on 1934 or earlier vehicles may be eligible for an LVV Authority Card to allow for period-style cars to operate without an engine hood, providing specified safety criteria are met.

9.7 Nitrous oxide systems

9.7.1

A nitrous oxide injection system fitted to an engine in a low volume vehicle must:

(a) incorporate hoses and fittings which are purpose-designed for automotive applications; and

(b) have all hoses routed outside the occupant cell, and be installed in such a way that gas from a leaking hose or fitting cannot escape into the passenger compartment; and

(c) be fitted with a fail-safe arming switch to prevent unintentional activation of the system.

9.7.2

A bottle used within a nitrous oxide injection system fitted to a low volume vehicle must:

(a) have a current test mark applied by the cylinder manufacturer or an approved cylinder test facility; and

(b) be securely mounted, either:

(i) outside the passenger compartment; or

(ii) if mounted inside the passenger compartment, sealed and vented to the outside of the vehicle;

and

(c) be specifically designed and manufactured:

(i) for the carriage of nitrous oxide; and

(ii) as a high-pressure vessel, incorporating a high-pressure safety blow-off valve.

9.7.2

Ideally, a vehicle using NOS should incorporate some form of prominent labeling similar to that used on LPG and CNG-equipped vehicles, to warn emergency services of the NOS's presence.

9.8 Fuel systems

9.8.1

A low volume vehicle must comply with the relevant fuel system requirements specified in 'Chapter 10 - Fuel Systems'.

9.8.2

A low volume vehicle fitted with an alternative fuel system, including liquid petroleum gas or compressed natural gas, must comply with the requirements of the approved New Zealand standard for alternative fuel systems.

9.9 Oiling systems

9.9.1

A system fitted to a low volume vehicle used for the circulation of hot fluids which operate under pressure must incorporate:

(a) purpose-designed bulkhead fittings and bulkhead connections where the fluid is being circulated through the inside of the passenger compartment; and

(b) hoses which:

(i) meet an appropriate standard for the type, pressure, and temperature range of the fluids being circulated; and

(ii) are secured at intervals of not more than 300 mm; and

(iii) are positioned and protected such that the hoses cannot rupture as a result of rubbing or chafing against any hard objects or sharp edges, or by damage from occupants or cargo.

9.9.1

Typical systems will include engine oil dry-sump hoses, and hoses used for the cooling of power steering systems and transmissions.

Particular care must be taken with hoses and fittings associated with oiling systems if a rupture could cause high temperature fluids to spray occupants.

9.10 Accelerator systems

9.10.1

An accelerator system on a low volume vehicle must:

(a) be designed so as to ensure against being pulled or jammed in the open position in the event of an engine mount failure; and

(b) in the case of a low volume vehicle incorporating a modified or custom-built accelerator system, be fitted with a minimum of two return springs that work independently of each other; and

(c) have linkages that:

(i) move freely and give good return response without interference from any other part of the vehicle; and

(ii) are designed and positioned in such a way that they cannot jam over-centre;

and

(d) have an effective end stop for the accelerator pedal to prevent cable stretch at maximum travel.

9.10.1

The accelerator return springs should connect directly to the carburetor(s) rather than the accelerator linkage system.

The accelerator system must be set up so that the carburetor(s) return to the closed position in the event of either the accelerator return springs or the linkages or cable breaking.

9.10.2

An accelerator system fitted to a low volume vehicle that is either hydraulically or electrically actuated, must be designed in such a way that the accelerator system, in the event of a loss of hydraulic pressure or electrical power, will fail to the fully closed position.

9.11 Exhaust systems

9.11.1

An exhaust system fitted to a low volume vehicle must:

(a) be of a good design using materials suitable for the purpose; and

(b) terminate in a position where the outer end of the exhaust pipe directs exhaust fumes and heat away from, and beyond the perimeter of, the passenger compartment; and

(c) in the case of an exposed exhaust system which may be easily contacted from outside the vehicle:

(i) have a radius of no less than 3 mm (1/8") on any sections facing toward the front of the vehicle; and

(ii) have any sections contactable from the front of the vehicle or adjacent to points of occupant entry and exit adequately heat-shielded.

9.11

'Flame-throwers' are an operational issue rather than an LVV certification issue. Whilst they are not required to be considered as part of the LVV certification process, LVVTA recommends against their use.

9.11.1(c)(i)

This means that no exposed exhaust ends or openings may face forward toward the front of a vehicle.

9.11.2

An exhaust system fitted to a low volume vehicle must:

(a) be in good condition and free of leaks; and

(b) be securely attached to the vehicle, using a mounting system that enables all necessary engine movement without stressing the exhaust system; and

(c) along with the body of a low volume vehicle in the areas adjacent to the vehicle's exhaust system, be sufficiently sealed so as to prevent the entry of any exhaust gases into the passenger compartment, and

(d) be designed, constructed, and fitted in such a way that the exhaust system, or components within the exhaust system, cannot be removed, altered, or readily interfered with, without the use of hand tools; and

9.11.2(e)

Exhaust noise output is an operational issue, and not a safety one, however an LVV certifier should ensure that a vehicle undergoing low volume vehicle certification has an exhaust system that meets Warrant of Fitness requirements, and that provides sufficient silencing so as to prevent the emission of exhaust noise levels that are likely to be alarming to residents, pedestrians, and other road users.

(e) be designed in such a way that the performance or operation of the exhaust system cannot be altered from inside the vehicle, or whilst the vehicle is in motion, unless the exhaust noise output is less than or similar to the noise output the vehicle (or a vehicle of a similar type) would have had when it was manufactured with its original exhaust system.

9.11.2(e)

A vehicle of a 'similar type' means a vehicle of similar age, vehicle size, body type, engine size and power output, and may be of a different make and model.

For information and legal requirements relating to exhaust noise output, refer to 'Chapter 11 – Emissions Systems'.

9.11.3

A component fitted to a low volume vehicle which may be susceptible to damage from exhaust heat, such as a fuel or brake pipe or hose, or rubber or fabric steering component, or plastic fuel tank, must either:

(a) be protected from any exhaust heat by the inter-positioning of a suitably fabricated and mounted heat-shield; or

(b) be provided with no less clearance from the exhaust system than that designed by the vehicle manufacturer; or

(c) be positioned so that there is a minimum clearance between the component and the exhaust system of:

(i) in the case of any part of the exhaust system other than a catalytic converter, 50 mm; or

(ii) in the case of a catalytic converter, 100 mm.

9.11.4

While a steel steering universal joint will not normally be damaged by exhaust heat, the grease contained inside the universal joint will be affected if there is not sufficient clearance between the joint and the exhaust, and this could prevent smooth steering joint operation.

9.11.4

A steel steering universal joint fitted to a low volume vehicle must be positioned so that there is a minimum clearance between the universal joint and any part of the exhaust system of 25 mm.

9.12 Braking systems

9.12.1

A low volume vehicle that has undergone an engine conversion that results in braking system modifications, or that may affect the performance of the braking system, must comply with the applicable requirements contained in the relevant braking design and construction requirements specified in 'Chapter 8 - Braking Systems'.

9.12.1

The braking performance of a vehicle may need to be improved in situations where the vehicle's performance has increased as a result of engine modifications or an engine conversion, in order to provide the braking efficiency necessary for the vehicle's increased performance. This is because of the reduced 'cool-down' time available to the vehicle's braking components between braking cycles resulting from the vehicle's increased performance.

9.13 Vacuum systems

9.13.1

A low volume vehicle that has been fitted with an engine which draws its vacuum from an alternator-mounted pump must have an alternator and drive system that:

(a) enables correct operation of the vacuum pump; and

(b) has correctly aligned drive pulleys; and

(c) incorporates drive-belts which are:

(i) in good condition; and

(ii) correctly adjusted; and

(iii) of the correct section type and width for the pulleys; and

(iv) of a purpose-designed heat and oil-resistant automotive type.

9.13.1

Vacuum hoses must be an approved type, as specified in section 8.6 of Chapter 8 – Braking Systems.

9.14 Electrical systems

9.14.1

A battery fitted to a low volume vehicle must:

(a) be secured by, or enclosed in, a device or structure, appropriate for the weight and load of the battery being used, to prevent it from shifting during braking, cornering, acceleration, or impact; and

(b) incorporate some method of preventing acid spills from entering the passenger compartment of the vehicle during a roll-over; and

(c) be sealed from the passenger compartment, and where charging and subsequent gas emission may occur while the vehicle is operating, ventilated to the vehicle exterior; and

(d) be safely wired and protected from short circuits.

9.14.1

Even if enclosed, a battery must not be able to move within the enclosure. If the enclosure is larger in any direction than the battery, the battery must also be secured.

Note also, that if a battery is secured within an enclosed container, provision must be made for the venting of the battery.

9.14.2

Where a battery, and fuel system components, such as a fuel tank or fuel pump, are located within the same compartment in a low volume vehicle, the battery and the fuel system components must be separated from each other by the enclosure of one or both within a secured fuel-resistant non-conductive container.

9.14.2

A motor-sport 'battery box' is ideal in this situation.

9.14.3

An earth lead of a size suitable for the application must be fitted to a low volume vehicle:

(a) in the case of a unitary construction vehicle, between the engine and body; and

(b) in the case of a vehicle with a separate body and chassis, between:

(i) the engine and chassis; and

(ii) the body and chassis.

9.14.4

Electrical wiring within the engine compartment of a low volume vehicle must:

(a) be tidily clipped and securely attached to the body or chassis or sub-frame structure; and

(b) positioned at a safe distance away from moving parts and exhaust heat.

9.14.4(a)

An approved alternative is for electrical wiring to pass through a well-secured tubular section, known as a 'service tube', provided that the wiring is suitably supported, and cannot rub or chafe.

9.14.5

Unless specifically designed for the purpose and fitment, an electrical system within a low volume vehicle must have electrical equipment such as pump motors and solenoids isolated from the fuel tank and system.

9.15 Steering system modifications

9.15.1

Where an engine conversion in a low volume vehicle results in the power steering system fitted to the vehicle being driven by a different means than that provided by the vehicle manufacturer, the pressure and supply delivery provided by the new engine or delivery system must be sufficient to safely operate the power steering system.

9.15.2

A low volume vehicle that has undergone an engine conversion that results in steering system modifications other than that specified in 9.15.1, or that may affect the performance of the steering system, must comply with the applicable requirements contained in 'Chapter 7 - Steering Systems'.

Gearbox conversion requirements:

9.16 Gearbox mount design and construction

9.16.1

Where a non-original or custom manufactured gearbox mount or cross-member is installed into a low volume vehicle, the cross-member must be:

(a) designed and constructed so as to withstand:

It should be noted that there is no legal requirement in New Zealand for a motor vehicle to have a reverse gear. Caution should be applied here however if any motor sport activities are planned; a reverse gear is required for most motor sport classes.

(i) the weight of the gearbox it supports; and

(ii) any rotational or other dynamic loads it may be subjected to;

and

(b) attached to chassis rails using all applicable requirements contained in section 5.4 of 'Chapter 5 – Chassis Modification & Construction'.

9.17 Gearbox attachment

9.17.1

9.17.1

See 5.20.2 of 'Chapter 5 - Chassis Modification and Construction' for details on correct crush-tube systems.

When gearbox mounting to a low volume vehicle necessitates bolting through a boxed, RHS, or tubular chassis or sub-frame section, fasteners must pass through steel tubular reinforcing within the chassis or sub-frame section to prevent crushing.

9.17.2

A flexible mount used within a gearbox conversion or installation in a low volume vehicle must be of a type and size that will withstand all loads imposed on it.

9.17.3

Attachment of a gearbox to a gearbox mount, a gearbox mount to a gearbox cross-member, and a gearbox cross-member to the chassis or sub-frame section of a low volume vehicle, if bolted, must:

(a) in the case of a modified production vehicle, incorporate fasteners of a quantity, size, type, and grade of equal or greater specification than that used by the original engine manufacturer; or

(b) in the case of a scratch-built vehicle, incorporate fasteners of a quantity, size, type, and grade suitable for:

(i) the weight of the gearbox; and

(ii) the rotational or other dynamic loads the engine is capable of applying.

9.17.4

A fastener used in the process of mounting a gearbox to a chassis or sub-frame of a low volume vehicle must meet all fastening requirements specified in 18.2 to 18.6 inclusive in 'Chapter 18 - Attachment Systems'.

9.18 Other gearbox requirements

9.18.1

Any part of a unitary-constructed low volume vehicle that has had any part of its chassis or subframe structure, floor, or gearbox tunnel material cut or removed for clearance or shifter installation, must be adequately re-strengthened.

9.18.2

A gear-shift mechanism in a low volume vehicle must:

(a) operate easily, smoothly, correctly, and logically; and

(b) operate without any binding, or interference caused by the shift mechanism touching any other components or part of the vehicle structure; and

(c) in the case of an automatic transmission, provide to the driver a visible and accurate indication of the selected gear; and

(d) be sealed, where the mechanism enters the passenger compartment, to prevent the entry of fumes.

9.18.2(c)

A proper device is required to show the selected gear position to the driver. Note that a gear pattern indicator (such as that typically engraved into a gear knob) is not sufficient in the case of an automatic transmission, as it does not indicate the gear that has been selected.

9.18.3

A low volume vehicle fitted with an automatic transmission must incorporate an operative inhibitor switch, to enable engine starting only in neutral and park positions.

Drive-shaft requirements:

9.19 Drive-shaft modification and construction

9.19.1

A drive-shaft fitted to a low volume vehicle must be manufactured from:

(a) tubing of a material specification appropriate for a drive-shaft; and

(b) of a diameter and wall thickness appropriate for the power, torque, and weight of the vehicle.

9.19.1

When replacing a 2-piece drive-shaft system with a single drive-shaft, the new longer drive-shaft must be made from tubing that has a significantly greater strength than the tubing from which the two shorter drive-shafts are made from.

9.19.2

A drive-shaft fitted to a low volume vehicle may be lengthened only if:

(a) either:

(i) the complete original drive-shaft tube is replaced by a complete new single piece of tubing, without any spigots or joined sections; or

(ii) where the drive-shaft yoke and drive-shaft tubing are of different diameters, a purpose-designed and manufactured concentric adapter (reducing or increasing bush) is used to adapt the drive-shaft yoke to the tubing;

and

(b) the main tubing material thickness is not reduced during any machining processes that are carried out; and

(c) in the case of a substantial increase in drive-shaft length or engine power output, the diameter of the drive-shaft is increased proportionately with the drive-shaft length or engine power output.

A drive-shaft lengthened before September 2002 is not required to comply with 9.19.2, provided that after thorough visual inspection, no fatigue cracking or fracturing is evident, and no obvious vibrations are detected during a road-test.

9.19.3

A modified, custom-manufactured, or non-original equipment drive-shaft fitted to a low volume vehicle must be manufactured or modified by a person or manufacturer who is a recognised industry specialist in the field of drive-shaft modification and manufacture.

9.19.4

In the case where it cannot be determined that a modified, custom-manufactured, or non-original equipment drive-shaft fitted to a low volume vehicle has been manufactured or modified by a person or manufacturer who is a recognised industry specialist in the field of drive-shaft modification and manufacture as required by 9.19.2, then the drive-shaft must either:

(a) be visually inspected and dynamically balanced by a person who is a recognised industry specialist in the field of drive-shaft modification and manufacture; or

(b) be assessed by an LVV Certifier and found to be satisfactory as a result of:

(i) a thorough visual inspection which has determined that the drive-shaft has no visible damage or defects, and has been built to a tradesman-like standard; and

9.19.2

The intention of these requirements is to prevent people from lengthening a drive-shaft tube with the addition of a welded extension, rather than using a correct length section of tubing.

A purpose-designed and manufactured concentric adaptor (reducing or increasing bush) is a recognised method only in the case where the diameters of the drive-shaft yoke and drive-shaft tubing differ.

9.19.4

Examples of situations where 9.19.4 would apply are:

- where a modified or custom-manufactured drive-shaft is fitted to a vehicle that has been imported from overseas, and for which no information about the drive-shaft exists; or
- where an LVV Certifier is inspecting a vehicle for recent modifications to which a modified or custom-manufactured drive-shaft was fitted some years previous to the recent modifications which have caused the vehicle to require LVV certification.

(ii) driving the vehicle during a 100 kph road-test and determining that there is an absence of any harmonic vibration from the drive-shaft.

9.19.5

A drive-shaft fitted to a low volume vehicle must maintain the majority of its drive-shaft yoke coupling depth engaged into the gearbox output shaft throughout the full range of suspension travel.

9.19.6

A drive-shaft fitted to a low volume vehicle may be fitted with a drive-shaft spacer between the drive-shaft and the differential flange, in order to increase the overall length of the drive-shaft, provided that:

(a) the spacer:

(i) is no more than 25 mm in thickness; and

(ii) is manufactured from a solid piece of suitable material; and

(iii) incorporates a correctly-machined hub-centric spigot which replicates the engagement of the original unmodified drive-shaft components;

and

(b) the vehicle to which the spacer is fitted has not undergone a significant power or torque increase.

9.20 Drive-shaft attachment

9.20.1

A drive-shaft fitted to a low volume vehicle must be attached such that interference is unlikely to occur between the underside of the body or any other components during full suspension travel.

9.20.2

Fasteners used in the attachment of a drive-shaft to a low volume vehicle must:

(a) in the case of a modified production vehicle, be of a quantity, size, type, and grade of equal or greater specification than that used by the original engine manufacturer; or

(b) in the case of a scratch-built vehicle, be of a quantity, size, type, and grade suitable for:

9.19.4

Where an LVV Certifier has any doubts or concerns during his assessment process in 9.19.4(b), he should refer the drive-shaft for an expert assessment as provided for in 9.19.4(a).

9.19.6

A drive-shaft spacer is sometimes used to correct a safety-related problem of insufficient spline engagement, which can occur as a result of raising the suspension system of a vehicle, commonly encountered in raised four-wheel drive vehicles.

(i) the weight of the drive-shaft; and

(ii) the loads the engine torque is capable of applying;

and

(c) where fasteners are not original equipment for the drive-shaft or the vehicle, meet all requirements specified in 18.2 to 18.6 inclusive in 'Chapter 18 - Attachment Systems'.

9.21 Drive-shaft universals

9.21.1

A drive-shaft universal fitted to a low volume vehicle must:

(a) be of a size appropriate for the torque loads that the engine is capable of applying; and

(b) not be able to bind throughout the full range of suspension travel; and

(c) be aligned in such a way as to not induce premature wear or cause vibration; and

(d) operate at angles that are within the universal manufacturer's specifications; and

(e) if not original universals in the original application, operate at a minimum of three degrees angle to prevent brinelling; and

(f) be positioned so that all universal angles and phasing are in alignment, unless exact factory misalignment is duplicated.

Drive-shaft safety-loop requirements:

9.22 When drive-shaft safety-loops are required

9.22.1

Unless 9.22.2 or 9.22.3 applies, a drive-shaft safety-loop must be fitted at the forward end of each section of drive-shaft transmitting power to the rear wheels on any low volume vehicle which is of a front-engine and either rear-wheel drive or four-wheel drive configuration, and which incorporates an open drive-line, if:

(a) the vehicle has had an engine conversion which has resulted in a significant increase in power or torque; or

(b) the vehicle has had its factory-fitted engine modified such that a significant increase in power or torque has resulted; or

9.21.1

These requirements relate to 'hooks' type joints used in front-engine rear-drive vehicles.

9.21.1(a)

For example, a 6-cylinder Ford falcon front yoke and universal joint will fit straight into many high-performance V8 conversions, but will not be up to the task expected of it.

9.21.1(d)

Generally, drive-shaft manufacturers recommend angles of not less than 1 degree, and not more than 5 degrees. Even when a drive-shaft safety-loop is fitted, 5 degrees should not be greatly exceeded.

9.21.1(f)

Universal phasing is a complex area, and often misunderstood even by many experienced car builders, which is one of the reasons it is a requirement to use an experienced drive-shaft specialist to make your drive-shaft.

9.22.1

Where a vehicle is required to have a drive-shaft safety-loop, and the vehicle has a two or three-piece drive-shaft, a drive-shaft safety-loop must be fitted to each drive-shaft section.

9.22.1(a) and (b)

A 'significant increase' in power or torque is 50%.

(c) the drive-shaft fitted to the vehicle, either:

(i) has been modified by welding; or

(ii) is an aftermarket drive-shaft, including one made from steel, carbon-fibre, aluminium, or a composite material.

See the 'Useful Information' section at the back of this chapter for further explanation on the importance of using drive-shaft safety-loops.

9.22.2

9.22.2

Provided that all drive-shaft components are identical between the variants of the vehicle, the requirements specified for a low volume vehicle to be fitted with a drive-shaft safety-loop in 9.22.1 do not apply where either:

Documented evidence must be provided by the vehicle manufacturer or the vehicle manufacturer's agent to verify that all drive-shaft components are identical between the variants of the make and model of vehicle.

(a) a same make and model variant engine conversion has occurred; or

(b) a same make and model variant turbocharger or supercharger conversion has occurred.

9.22.3

The requirements specified in 9.22.1 for a low volume vehicle to be fitted with a drive-shaft safety-loop do not apply where either:

(a) a drive-shaft hanger bearing is positioned directly behind a drive-shaft universal, and the hanger bearing is designed in such a way that it will effectively contain a failed or disengaged drive-shaft; or

(b) a chassis or sub-frame member or section is positioned in such a way that it meets or exceeds the requirements for a drive-shaft safety-loop specified in 9.23 to 9.26.

9.23 Drive-shaft safety-loop design and construction

9.23.1

9.23(1)(c)(i)

Commercially-manufactured drive-shaft safety-loops are typically made from 5 mm thick flat-section material.

A drive-shaft safety-loop fitted to a low volume vehicle must:

(a) be as close to circular in shape as practicable; and

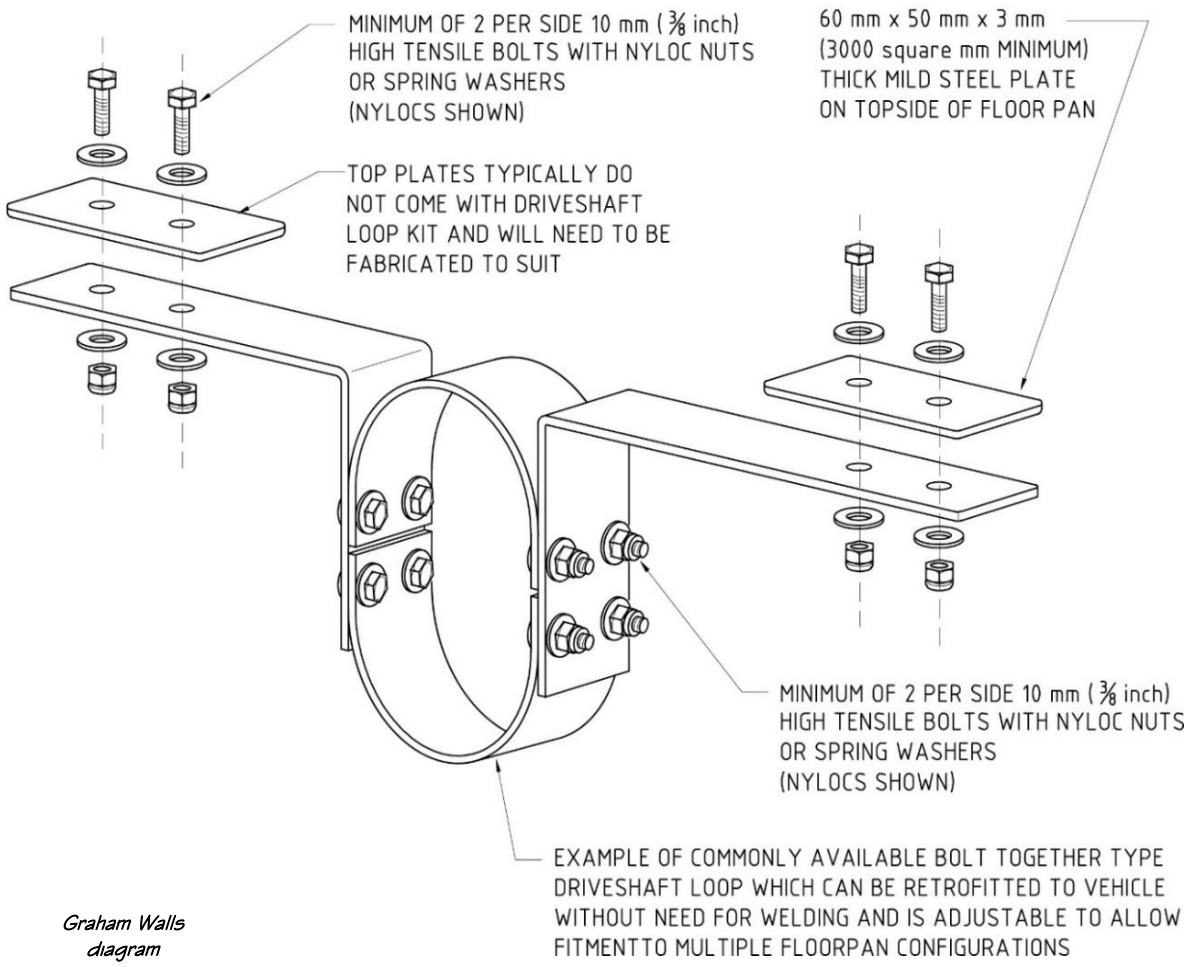
(b) provide a full 360-degree enclosure of the drive-shaft (see Diagrams 7.1 and 7.2); and

(c) be manufactured from a suitable material with a specification of, or equivalent to, not less than:

(i) in the case of flat-section material, 50 mm x 5 mm mild steel; or

(ii) in the case of tubular-section material, 22 mm x 3 mm mild steel.

If using a flat-section material, the 5 mm thick face of a 50 x 5 mm safety-loop must not face the drive-shaft, as the edge of the safety-loop could, upon contact, behave like a parting tool and cause a drive-shaft failure.



Graham Walls diagram

Diagram 7.1: Commonly-available bolt-together drive-shaft safety-loop

9.24 Drive-shaft safety-loop positioning

9.24.1

A drive-shaft safety-loop fitted to a low volume vehicle must be positioned:

(a) no more than 250 mm rearward of the front drive-shaft joint pivot centre; and

(b) as closely to the drive-shaft as can be practicably achieved, whilst taking into consideration:

(i) the drive-shaft's full range of articulation; and

(ii) the vehicle's range of suspension travel from full compression to full extension.

9.25.1(b)

Keeping the 'loop' section as close as practicable to the vehicle structure will prevent the safety-loop from pivoting forward or backwards, or from deflecting in any direction.

9.25.1(b)

Where the 'loop' section can't be positioned closely to the vehicle structure, additional support may be required to eliminate flexing or deflection of the loop.

9.25 Drive-shaft safety-loop attachment

9.25.1

A drive-shaft safety-loop fitted to a low volume vehicle must be attached to the vehicle structure:

(a) in not less than two places; and

(b) as closely to the 'loop' section of the drive-shaft safety-loop as practicably achievable (see Diagrams 7.1 and 7.2).

9.25.2

A drive-shaft safety-loop fitted to a low volume vehicle must either:

(a) be attached directly to, or incorporated within, a chassis or sub-frame rail or rigid cross-member, using, on each side of the drive-shaft safety-loop, two 10 mm (3/8") diameter fasteners, or one 14 mm (9/16") diameter fastener, of an appropriate grade; or

(b) where it is not practicable to attach a drive-shaft safety-loop to a chassis or sub-frame rail or rigid cross-member, be attached to the vehicle floor on each side of the drive-shaft safety-loop using:

(i) top plates mounted on top of the floor which are shaped as closely to square as can be practicably achieved, and which have a minimum mating area of 3000 square mm; and

(ii) two 10 mm (3/8") diameter adequately-spaced fasteners of an appropriate grade on each side of the drive-shaft safety-loop.

9.25.3

All top plates used in the attachment of a drive-shaft safety-loop to a low volume vehicle must:

(a) be oriented as closely as practicable to parallel to the longitudinal centreline of the vehicle; and

(b) have all corners rounded to a radius of not less than 5 mm (3/16"); and

(c) have all edges which contact the vehicle structure to which the top plate attaches rounded by the removal of not less than 0.1 mm of material.

2.25.2(a) and (b)(ii)

Refer to Chapter 18 – Attachment Systems for further information about fasteners.

2.25.2(b)(i)

The reference to 'as closely to square as can be practicably achieved' means that a top plate should, while achieving a total surface area of not less than 3000 square mm, be more 'square' than 'rectangular'. For example, a 60 mm x 50 mm top plate is closer to 'square' than a 100 mm x 30 mm plate, even though they both provide the same surface area.

9.25.3(a)

The reference to 'parallel to the longitudinal centreline of the vehicle' means that top plates should be oriented such that, when looking down on the vehicle floor from above, the plates are arranged in a 'square' or 'rectangular' shape rather than a 'diamond' shape. This orientation arrangement reduces the chances of impacts against the floor (caused by a failed or disengaged drive-shaft flailing within a drive-shaft safety-loop) being applied by the corners of the top plate, and creating a point-load, leading to tearing and failure of the floor.

9.25.3

When a top plate is used together with an under-floor plate, it is recommended that they be riveted together.

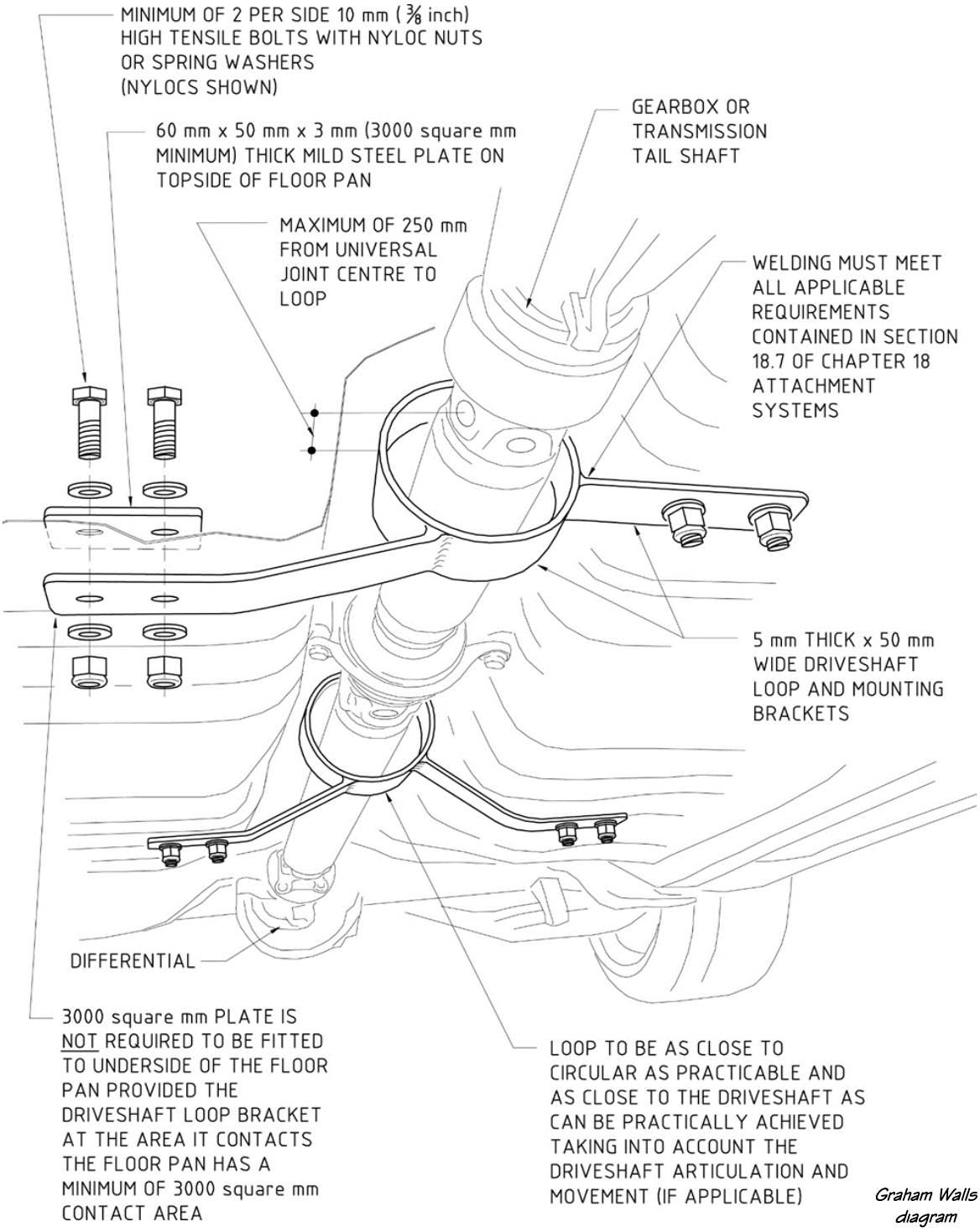


Diagram 7.2 Typical drive-shaft safety-loop installation

9.25.4

Where the mounting surface area of a drive-shaft safety-loop fitted to a low volume vehicle is less than 3000 square mm, an additional under-floor plate must be fitted to the underside of the floor (see Diagram 7.2).

9.25.4

A typical plate size that meets the 3000 square mm requirement is 50 x 60 x 3 mm.

9.25.5

The mounting surface area on the floor of a low volume vehicle to which a top or under-floor plate is attached, must be free from any compressible material, in order to enable the plate to seat firmly against the floor.

9.25.5

It is not necessary to remove thin, spray-on type coatings, such as underseal material, from the underside of the floor-pan beneath the plate or safety-loop surface.

9.26 Other drive-shaft safety-loop requirements

9.26.1

Where a hydraulic brake pipe fitted to a low volume vehicle is mounted adjacent to a drive-shaft which is required to be protected by a drive-shaft safety-loop, either:

(a) the drive-shaft safety-loop must be designed and attached so as to prevent the drive-shaft, upon its failure, from contacting the hydraulic brake pipe; or

(b) the hydraulic brake pipe must be re-directed away from the vicinity of the drive-shaft.

Axle housing requirements:

9.27 Axle housing and differential modification

9.27.1

Where an axle housing assembly conversion has taken place on a low volume vehicle, either:

(a) the vehicle's original suspension geometry and suspension locating mounting points must be duplicated on the replacement axle housing assembly, and at the chassis or sub-frame attachment points; or

(b) in the case of a changed suspension system configuration, the suspension must meet the relevant requirements specified in 'Chapter 6 - Suspension Systems'.

9.27.2

A differential fitted to a low volume vehicle must not be fitted with a permanently locked diff centre, spool, or mini-spool.

9.27.3

A differential fitted to a low volume vehicle that is of a type that, upon failure of an axle could result in the loss of a wheel, must be fitted with axles that are appropriate for the torque loads that the engine is capable of applying.

9.28 Axle housing attachment

9.28.1

Fasteners used in the attachment of an axle housing assembly to a low volume vehicle, must either:

(a) in the case of a modified production vehicle, be of a quantity, size, type, and grade of equal or greater specification than that used by the original differential manufacturer; or

(b) in the case of a scratch-built vehicle, be of a quantity, size, type, and grade suitable for:

(i) the weight of the differential; and

(ii) the loads the engine torque is capable of applying; and

(iii) if not original equipment for the axle housing or the vehicle, meet all fastening requirements specified from 18.2 to 18.6 inclusive in 'Chapter 18 - Attachment Systems'.

Other requirements:

9.29 Welding of drive-train components

9.29.1

Welding of any engine mounts, gearbox mounts or cross-members, differential housing modifications, or drive-shaft safety-loops on a low volume vehicle, must meet all relevant welding requirements specified in 18.7 and 18.8 of 'Chapter 18 - Attachment Systems'.

A drive-train component fitted to a low volume vehicle and modified before September 2002 is not required to comply with 9.29.1, provided that after thorough inspection, no fatigue cracking or fracturing is evident.

9.30 Four-wheel drive to two-wheel drive conversions

9.30.1

A vehicle that has been converted from four-wheel drive to permanent two-wheel drive must meet the requirements specified in 9.30.2 and 9.30.3 if the vehicle:

(a) does not have a selectable four-wheel drive system; and

(b) does not have a solid (live) front axle.

9.30.2

A vehicle specified in 9.30.1 must:

(a) retain and be correctly fitted with any original equipment drive-coupling or constant velocity joint which is relied upon to securely retain a wheel bearing or hub assembly; and

(b) where an original equipment inner constant velocity joint 'cup' remains in place where a half-shaft has been removed, or where a rear driveshaft is removed leaving an exposed tail-shaft spline or yoke, the cup or yoke must be either:

(i) securely attached by a method other than a 'C'-clip to prevent unexpected ejection of the joint, and the resultant escape of any transmission fluid; or

(ii) substituted by a properly machined plug to prevent unexpected ejection of the joint under high load or RPM conditions, and the escape of any transmission fluid.

9.30.2

If a drive-coupling or constant velocity joint is modified (by machining off the CV 'cup') the coupling or joint must retain the unmodified OEM joint main shaft, with the clamping, threaded, splined and stepped sections and locking nut.

9.30.3

A vehicle specified in 9.30.1 must, in addition to the technical requirements specified in 9.30.2:

(a) retain any anti-locking braking system components required by the vehicle's anti-lock braking system to continue to operate correctly; and

(b) when compared to a same make and model unmodified vehicle, exhibit safe handling characteristics during normal road use; and

(c) meet the three-cycle or five-cycle brake performance test requirements of LVV Standard 35-00 (Braking Systems), tested both with and without the anti-lock braking system active, without exhibiting any adverse front-to-rear brake balance characteristics; and

(d) have a warning label supplied by the LVV Certifier attached to the vehicle in a position clearly visible to the driver, that makes a driver aware that the vehicle may handle differently to when it was manufactured in its original four-wheel drive configuration.

9.30.3(c)

In the case of a late-model vehicle fitted with Electronic Brake Distribution (EBD) or other similar system, the ABS must not be deactivated.

Exclusions:

No exclusions apply to this chapter.

Useful information:

Drive-shaft safety-loops

A drive-shaft spins at an extremely high speed, causing a drive-shaft to contain enormous rotational forces.

In the event of a front drive-shaft yoke failure, a flailing drive-shaft can easily penetrate through the vehicle floor injuring vehicle occupants, or impact the road surface below which can cause a loss of directional control or even a roll-over. There have been serious injuries and even fatalities on New Zealand roads over the years, as a result of failed or disengaged drive-shafts.

Drive-shaft safety-loops ensure that in the event of drive-shaft yoke failure, or drive-shaft disengagement (such as through a rear radius rod failure), the massive energy of the disengaged and rotating drive-shaft is contained. For this reason, a drive-shaft safety-loop and its attachment systems must be well-engineered.

All drive-shaft joints, including constant velocity joints, regardless of their construction type, must be treated in the same way as universal joints when determining whether a drive-shaft safety-loop is required to be fitted.

While a carbon-fibre drive-shaft may be much lighter than a traditional steel drive-shaft, it must have a drive-shaft safety-loop as it can still fail. The drive-shaft may contain aluminium or similar materials as part of the composite construction so there is still enough potential for rotational forces to cause major damage, loss of control, or occupant injury.

Solid-mounted engines & gearboxes

There are a few things to remember with solid-mounted engines and gearboxes. Firstly, whilst it's not a safety issue, you'll get a lot more NVH (noise/vibration/harshness) coming through the car with a solid-mounted engine.

Secondly, the most common view on this subject is that if you are solid-mounting the engine at its factory mounting points, the gearbox could be solid-mounted or rubber-mounted. If however you are solid-mounting the engine with a front and mid plate, the gearbox should always be supported by a rubber mount.

Thirdly, opinions differ on this one, but some say that you shouldn't rely on solid mounts where they're only at the front of the engine and rear of the gearbox. In some cases, there won't be enough support at the back of the engine/front of the gearbox. Some experts believe that it's a good insurance policy to use a mid-plate as well in this case.

Terms & definitions for Chapter 9 Engine & Drive-train:

Aftermarket	means a component or system made by a manufacturer, other than a high-volume motor vehicle manufacturer, who produces components or systems on a production-run basis for the mass-market.
Alternator	means a device mechanically driven by the engine that provides an electrical supply to maintain the battery's charge.
Automatic transmission	means a type of gearbox, or transmission, that automatically varies the ratios between the input shaft and the output shaft to suit engine speeds automatically, without the driver having to physically select the gears.

Boxed	means to add a capping plate to convert a c-section or channel chassis rail or cross-member to a fully enclosed section like a RHS.
Brinelling	means premature wear of drive-shaft universal bearings due to a lack of rotary movement.
Carbon Fibre Composite	is a strong and light material, usually consisting of a plastic which contains fibres of carbon. A carbon-fibre drive-shaft may also include aluminium in the design.
Capped	means to add a capping plate to convert a c-section or channel-section chassis rail or cross-member to a fully enclosed section like a RHS.
Chassis	means the supporting frame or platform of a motor vehicle to which the major mechanical components and body attach.
Crush-tube	means a section of non-compressible material that is positioned within a cavity, through which a fastener passes, to prevent collapsing of the material surrounding the cavity, and consequential loosening of the fastener.
Cross-member	means a section of material positioned between or connecting the main chassis rails or sections to provide support to the chassis or body, or for the attachment of related components and systems.
Custom	means a service provided, or a component or system manufactured, by an individual person or a company who is not a high-volume motor vehicle manufacturer or aftermarket manufacturer.
Differential	means the mechanical assembly used for transferring the engine and gearbox power output to the driving wheels.
Doubler plate	means a pair of plates that clamp together on either side of a part of a vehicle structure, commonly used as a seat anchorage or a seatbelt anchorage system.
Drive-shaft	means the assembly which transfers the power output from the gearbox to the differential.
Drive-shaft joint	means a device such as a universal joint or a constant-velocity (CV) joint positioned at each end of the drive-shaft, or between multiple drive-shafts, to enable the power transfer to take place from the rigidly-mounted gearbox to the differential operating on an upward and downward plane whilst the suspension operates throughout its range of travel.
Drive-shaft safety-loop	means a safety device designed to contain the drive-shaft in the event of a drive-shaft universal failure, to prevent the drive-shaft from contacting the vehicle floor or the road surface.
Engine hood	means a body panel which is hinged, lift-off, or removeable with hand tools, that gives access to the engine compartment of a vehicle, also known as a bonnet.
Engine mounts	means the devices that fasten the engine onto the chassis or sub-frame section.

Engine plates	means an alternative method of fastening the engine onto the chassis or sub-frame section through the use of a rigid plate system positioned vertically at the front and the rear of an engine, instead of the more common flexible engine mounts.
Fan-belt	means flexible drive-belts, which operate the engine-cooling fan, water, pump, alternator, and other accessory motors from the engine crankshaft pulley.
Gearbox	means the mechanical assembly used to convert engine speed to road speed through the use of a number of different gear ratios.
Gear-shift	means the device by which the different gear ratios in the gearbox are selected.
Gearbox tunnel	means the floor of a motor vehicle surrounding the area where the gearbox is positioned.
Locked differential	means a differential that drives both left and right-side axles simultaneously without the usual mechanical slippage designed into production motor vehicles to provide safe and comfortable cornering.
Longitudinal	means in the fore-aft direction, running on or parallel to the centre-line of the vehicle.
LVV Certifier	means a person appointed by the New Zealand Transport Agency to inspect and approve modified and scratch-built vehicles, under the Low Volume Vehicle Code.
Monocoque	means a type of vehicle construction that incorporates the vehicle body and chassis frame in one unit, as opposed to having a separate and removable chassis.
mm	is an abbreviation for millimetres.
Nitrous oxide	means a liquid chemical composition of one part of nitrogen and two parts of oxygen, which when introduced with the fuel mixture entering an internal combustion engine, converts to a gas and may increase the oxygen content in the combustion chamber producing a momentary increase in power output.
Nyloc	means a type of vibration-proof locking nut that incorporates a nylon section, which enables the nut to lock itself against the corresponding bolt.
OE	is an abbreviation for original equipment.
Original equipment	means components that were part of a mass-produced vehicle's equipment at the time of its manufacture.
RHS	is an abbreviation for rectangular hollow section, which is a configuration of steel section commonly used in the manufacture of chassis and other motor vehicle component fabrication.
Spool	means a device which when fitted, has the effect of a locked differential.
Square mm	means an area measured by multiplying the height by the width. For example, a rectangle 80 mm high and 50 mm wide has an area of 4000 square mm.

RPM	is an abbreviation for revolutions per minute, a measurement of engine speed.
Sub-frame	means a structural part of a unit-construction vehicle to which the major mechanical components attach.
Supercharged	means a mechanical device driven by the crankshaft pulley of an engine which forces an air/fuel mixture into the engine to provide increased levels of power output.
Torque	means rotating effort produced by applying a force to a lever arm about a pivot.
Unitary construction	means a type of vehicle construction that incorporates the vehicle body and chassis frame in one unit, as opposed to having a separate and removable chassis.