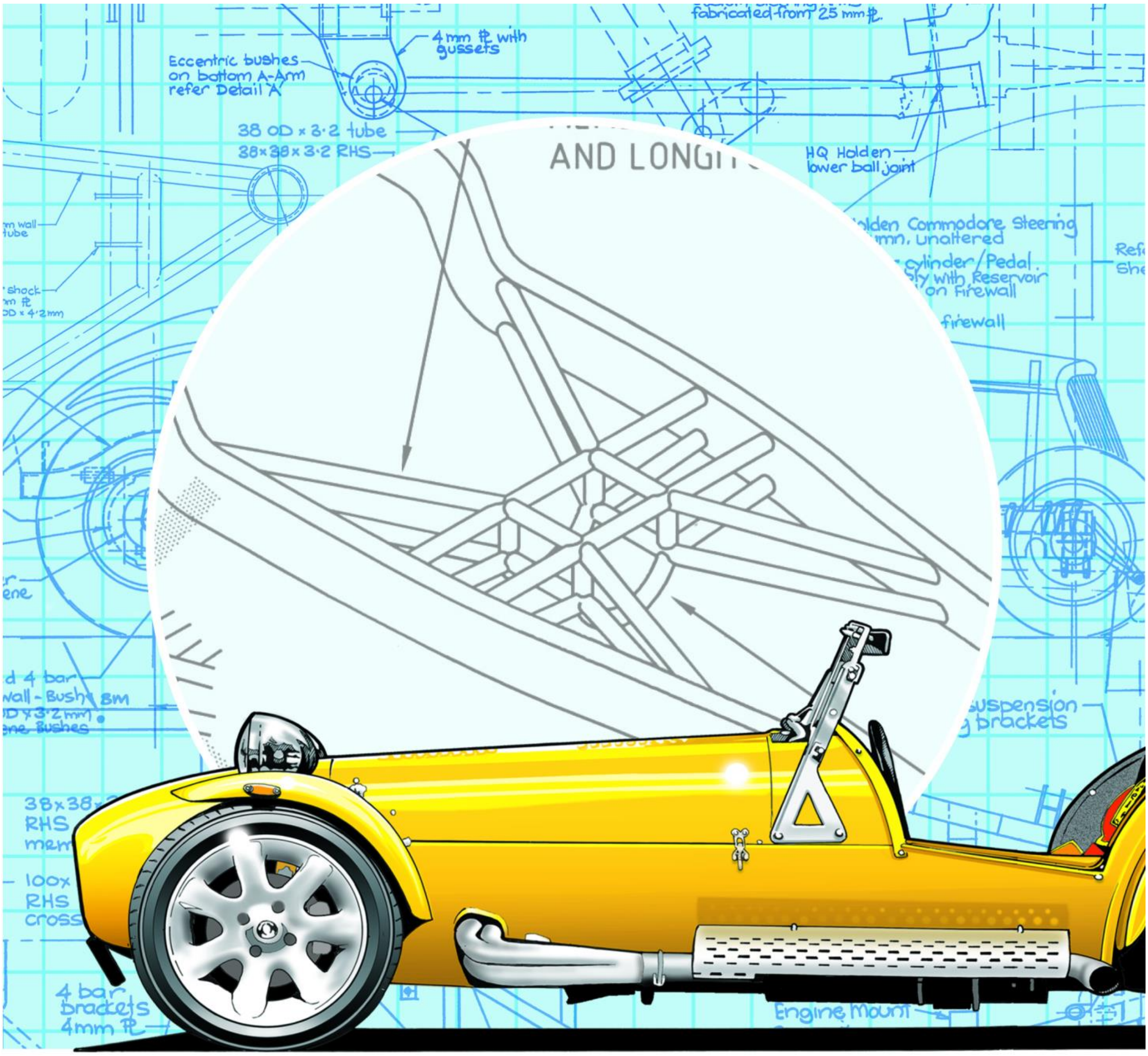
Helping New Zealanders Build & Modify Safe Vehicles

New Zealand Car Construction Manual

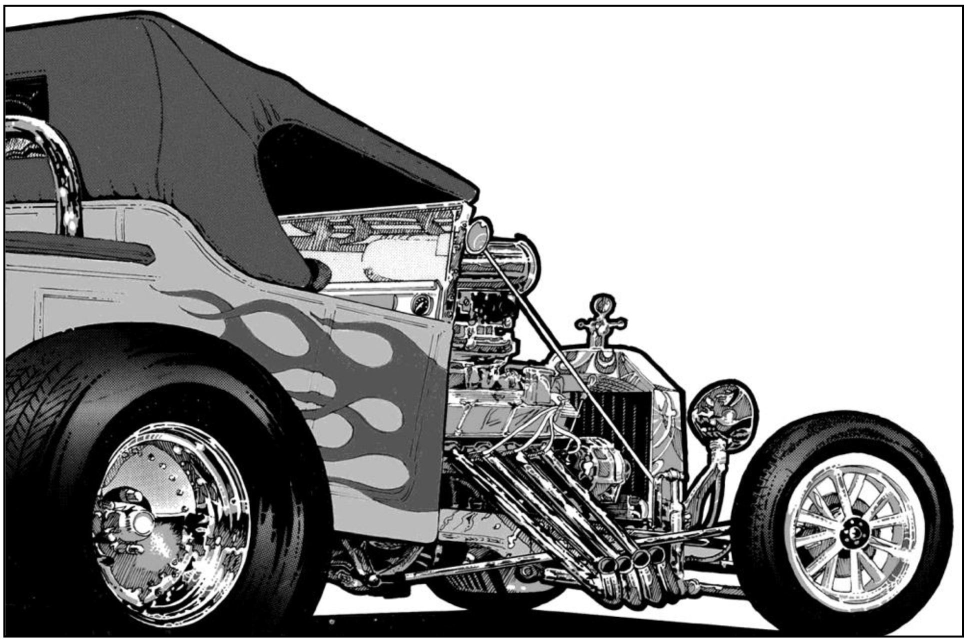
Chapter 5
Chassis Modification & Construction

2nd Amendment | Effective from 1 July 2021



Low Volume Vehicle Technical Association (inc)

Chapter 5
Chassis Modification & Construction



Tony Johnson illustration

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Signed in accordance with clause 1.3(5) of the Low Volume Vehicle Code of the LVVTA:	
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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.

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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.

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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:

- CAD diagrams: Graham Walls
- Authorship & artwork: Tony Johnson
- Technical content: New Zealand Hot Rod Association (inc), LVVTA Technical Staff, LVVTA Technical Advisory Committee

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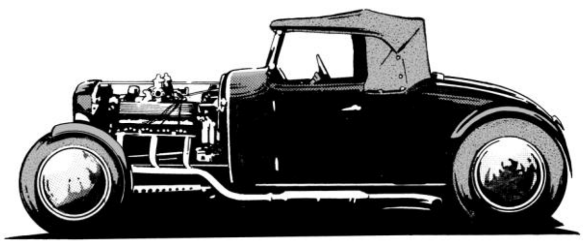
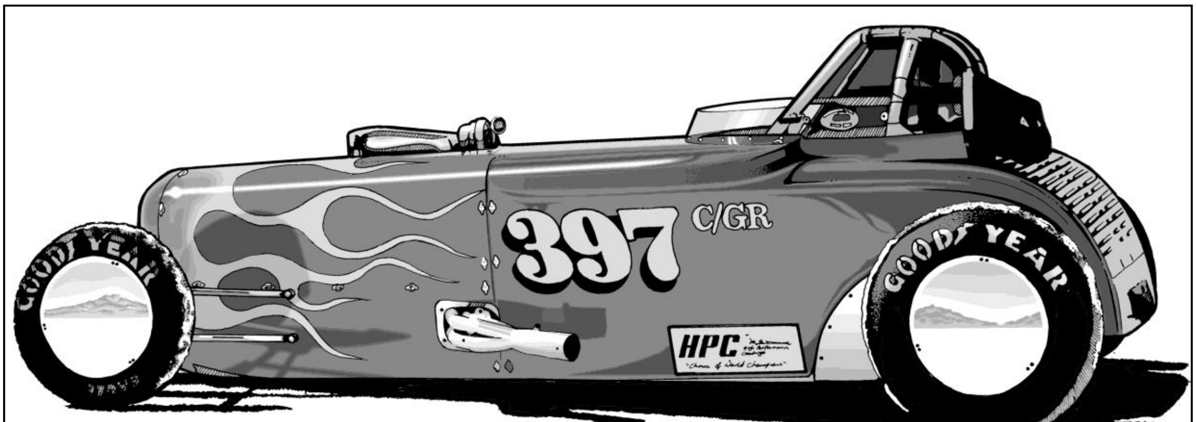
Normal type:	Provisions of the NZ Car Construction Manual for all vehicles.
Normal type in shaded box:	Special provisions of the NZ Car Construction Manual for vehicles built or modified before specified dates.
Script type:	*Helpful hints, tips, explanations, clarifications, and interpretations.*
Grey 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 5 Contents



Tony Johnson illustration

CHAPTER 5: CHASSIS MODIFICATION & CONSTRUCTION

Introduction:

In most cases, the traditional ladder-style or space-frame chassis is the foundation of the hobby motor car. The chassis supports the body and all of the major mechanical components, and keeps those components in their correct relative positions while the vehicle is subjected to the many stresses and loads imposed by acceleration, braking, cornering - and of course, our famous New Zealand roads.

Three basic types of chassis are covered here:

- high-volume manufacturers' chassis that are modified; and
- the 'ladder' or 'cruciform' chassis which is typically a mostly flat platform, incorporating channel or RHS (box) section side rails, linked by transverse and/or diagonal cross-members; and
- the 'space-frame' style which typically uses numerous predominantly straight small-diameter thin-wall tubes arranged in a triangulated manner to achieve high rigidity with minimal weight.

More complex motor vehicle foundations, such as the composite 'tub', whilst touched on here, is such a science that it is generally beyond the scope of this Car Construction Manual. Note that the requirements in this chapter do not apply to an unmodified production chassis.

General safety requirements:

5.0 Requirements applicable to all vehicles

5.0.1

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.

5.0.1

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.

5.0.2

The performance of a motor vehicle in relation to protecting occupants in a frontal impact collision must not be reduced below a safe tolerance of its state when manufactured or modified, by any factors, including corrosion, structural damage, material degradation, inadequate repair, the fitting of additional equipment, or the removal of equipment.

5.0.2

These are the applicable general safety requirements from the Land Transport Rule 32006 Frontal Impact 2001, which are required as part of this Chapter, reproduced here in the interest of convenience.

Production vehicle chassis modification requirements:

5.1 Production chassis joining

5.1.1

A production vehicle chassis in a low volume vehicle which incorporates any join, including as a result of a shortening process, or a lengthening process, must:

(a) be, where practicable, angle-cut to increase the weld area; and

(b) incorporate new material of the same type, specification, and wall thickness; and

(c) in order to avoid stress concentration points, be reinforced at the join by the attachment of a section or sections of material similar in specification to the chassis, that either:

(i) in the case of lengthened chassis or a chassis which has a wall thickness of less than 3 mm, extends beyond each side of the join by a distance of no less than twice the height of the chassis section being lengthened; or

(ii) in all other cases, meets the same joint reinforcement requirements specified for a custom ladder chassis in 5.10.1;

and

(d) be joined and reinforced by welding in accordance with the welding requirements specified in 'Chapter 18 - Attachment Systems'.

A chassis modified before 1992 is not required to comply with 5.1.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.1.1

This is typically to accommodate an increase in either passenger compartment area or load carrying capacity.

5.1.1(a)

60 degrees is generally considered the correct angle.

5.1.1(d)

This additional support could be provided by the use of flat plates on all three faces of a C-channel section, or a snug-fitting smaller channel-section positioned on the inside.

5.1.2

A production vehicle chassis designed and used for commercial activities in a low volume vehicle must not be extended or lengthened in order to enable the vehicle to carry a load beyond the gross vehicle mass specified by the original vehicle manufacturer, unless individually approved by LVVTA on a case-by-case basis.

5.1.3

Welding of any steels in a low volume vehicle which have an ultimate tensile strength exceeding 440 MPa must, in addition to meeting the welding requirements specified in 'Chapter 18 - Attachment Systems', incorporate a welding process that is compatible with the specific grade of steel.

5.2 Additional cross-members to production chassis

5.2.1

An additional cross-member fitted to a production vehicle chassis in a low volume vehicle must:

(a) be manufactured from material having dimensions appropriate for its application; and

(b) have a wall thickness of either:

(i) not less than the wall thickness of the main chassis rails; or

(ii) not less than 2.0 mm (5/64").

A chassis modified before 1992 is not required to comply with 5.2.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.2.2

A low volume vehicle fitted with a production vehicle chassis that was originally equipped with only transversely-mounted cross-members, must incorporate additional cross-members that are positioned diagonally to provide the chassis with some additional beaming and torsional support if either:

(a) the vehicle's performance characteristics have been significantly increased; or

(b) the vehicle has been converted from a beam-type front axle to an independent front suspension system.

5.1.3

Welding steels with a tensile strength of up to 440 MPa is generally an acceptable practice, provided that the method used is either MIG-welding or TIG-welding.

5.2

See the Useful Information section for more information about adding cross-members to a production chassis.

5.2.1

Additional cross-members can be RHS (rectangular hollow-section), channel, or tubular section.

5.2.2

Consideration should be given to 5.4.3, and also to 'Adding cross-members to production chassis' in the Useful Information section.

'Diagonally' does not necessarily mean spanning from one side of the chassis to the other, or that a full 'X' must be incorporated. A 'K'-member or other system can be used as long as the 'folding parallelogram' effect is somehow prevented.

In this context, 'beaming' means a longitudinal bending load (or 'sagging' throughout the length of the chassis), and 'torsion' means a rotational twisting load throughout the length of the chassis.

A chassis modified before 1992 is not required to comply with 5.2.2, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.2.3

Welding of any steels in a low volume vehicle which have an ultimate tensile strength exceeding 440 MPa must, in addition to meeting the welding requirements specified in 'Chapter 18 - Attachment Systems', incorporate a welding process that is compatible with the specific grade of steel.

5.2.3

Welding steels with a tensile strength of up to 440 MPa is generally an acceptable practice, provided that the method used is either MIG-welding or TIG-welding.

5.3 Production chassis 'C'-notch modifications

5.3.1

A suspension 'C'-notch fitted to a production chassis on a low volume vehicle must be made from material specifications that are appropriate for the type and size of the vehicle chassis.

5.3.1

A 'C'-notch can significantly weaken the rear chassis section to which it is attached, if not designed and installed correctly.

Bolt-in chassis C-notches should not be used unless fully-welded to the chassis, and both the C-notch and the chassis have been suitably reinforced.

5.3.2

The area of the chassis on a low volume vehicle at, and adjacent to, a 'C'-notch, must be suitably reinforced in order to reinstate the strength and rigidity lost in that area of the chassis as a result of the modification.

5.3.3

Welding of any steels in a low volume vehicle which have an ultimate tensile strength exceeding 440 MPa must, in addition to meeting the welding requirements specified in 'Chapter 18 - Attachment Systems', incorporate a welding process that is compatible with the specific grade of steel.

5.3.3

Welding steels with a tensile strength of up to 440 MPa is generally an acceptable practice, provided that the method used is either MIG-welding or TIG-welding.

5.4 Cross-member attachment to production chassis

5.4.1

Additional cross-members and mounting brackets fitted to a production vehicle chassis in a low volume vehicle, except for in the case of a cross-member or mounting bracket which is used only to support the weight of the component, must be attached to the chassis rails in such a way as to spread the transfer of their load to the web of the chassis rail by either:

(a) incorporating a reinforcing plate between the cross-member or bracket that spans the full height of the chassis rail (see Diagram 5.1); or

5.4.1

See 'Cross-member attachment to production chassis' in the 'Useful information' section for some situations where the requirements specified in 5.4.1 do not have to be met.

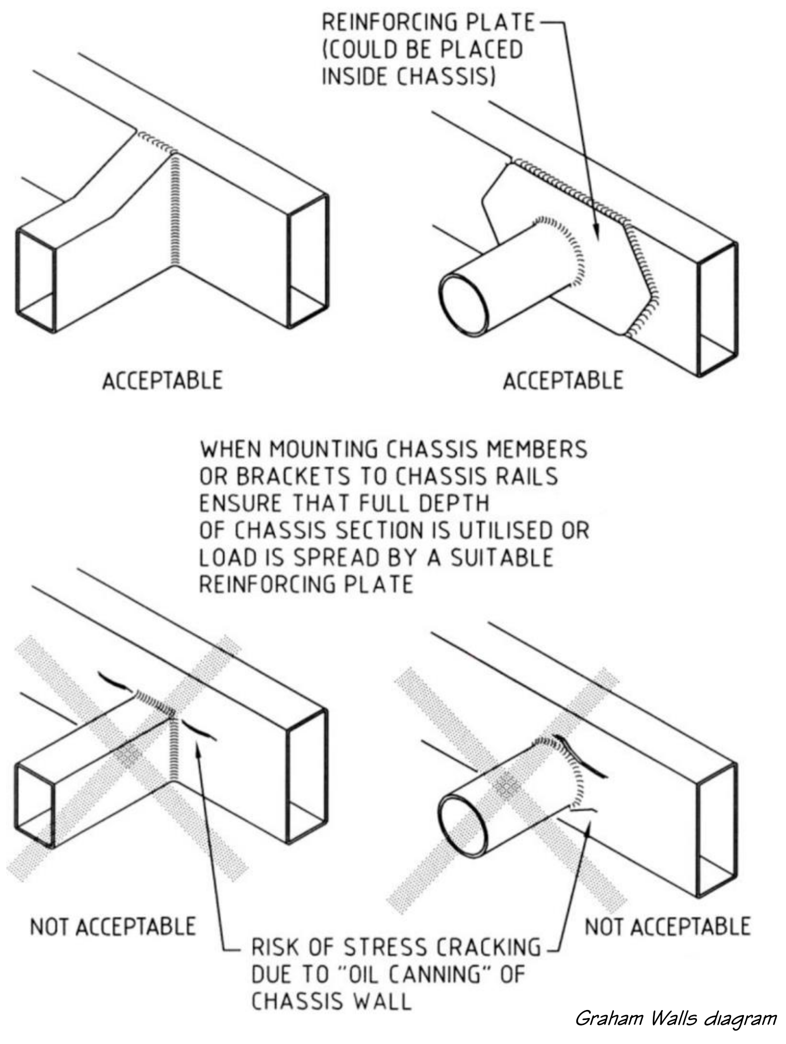
(b) spanning the full height of the chassis rail (see Diagram 5.1); or

(c) in the case of an open C-section chassis rail, attaching the cross-member or bracket to a section of bridging material that spans the full height of the chassis rail, and:

(i) is manufactured from a material of an appropriate specification for the application; and

(ii) has a substantial radius at each point where the bridging material meets the chassis rail to avoid stress points and consequential fatigue cracking (see Diagram 5.2).

A chassis modified before 1992 is not required to comply with 5.4.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.



Graham Walls diagram

Diagram 5.1 Cross-member to chassis rail attachment

5.4.1

C-section type chassis rails may be partially boxed at locations to suit mounting of cross-members, brackets, engine mounts, etc, or to stiffen or strengthen the chassis rails at specific locations, such as the area around where the engine is mounted.

Diagram 5.1

The style of twin-tubular cross-member system shown in Diagram 5.5 is also an acceptable method of spreading the load across the full height of the chassis rail web.

Moisture-trapping cavities (inside which dust, dirt, and water can collect and then rust) should be avoided where possible.

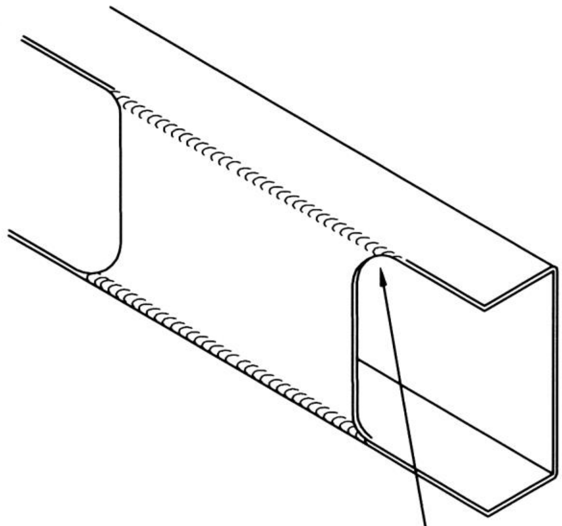


Diagram 5.2 Cross-member to chassis rail attachment (radius)

Diagram 5.2

See the requirement specified in 5.4.1(c)(ii).

Moisture-trapping cavities (inside which dust, dirt, and water can collect and then rust) should be avoided where possible.

5.4.2

An additional cross-member fitted to a production vehicle chassis in a low volume vehicle must be attached by means of either:

(a) welding, that meets the requirements specified in 18.7 and 18.8 of 'Chapter 18 - Attachment Systems'; or

(b) bolting, that meets the requirements specified in 18.2 to 18.6 of 'Chapter 18 - Attachment Systems'; or

(c) rivets of a size and type suitable for their application, which pass through holes that are drilled for a close-tolerance fit.

5.4.3

A production vehicle chassis used in a low volume vehicle designed and used for commercial activities, that has one or more chassis cross-members replaced, or is fitted with additional chassis cross-members, must have the replacement or additional cross-members attached to the chassis by a method that (see Diagram 5.3):

(a) replicates the method in which the original cross-members are attached; and

(b) duplicates the parts of the chassis rail to which the original cross-members are attached; and

5.4.3

This generally applies where a light truck was originally designed with open C-section chassis rails, with cross-members attached by rivets, and attached at the top and bottom flanges of the C-section to enable chassis flex, in which case additional members should not be welded into place but attached by the same method and in the same parts of the chassis, to avoid localised stiffening and fracturing of the chassis.

(c) does not restrict or inhibit the working characteristics of the original chassis design.

A chassis modified before 1992 is not required to comply with 5.4.3, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

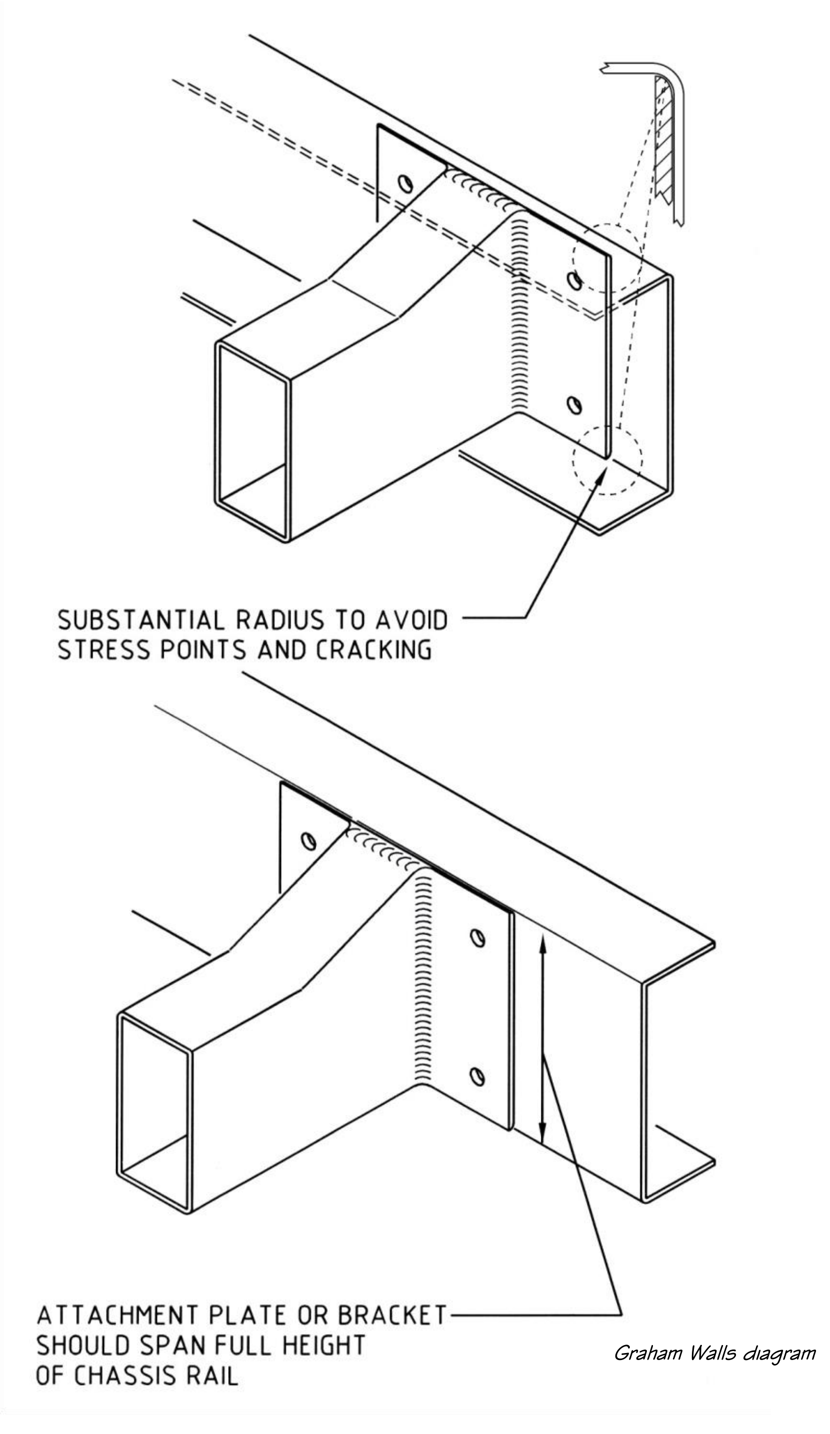


Diagram 5.3 Cross-member to C-section chassis attachment

Diagram 5.3

The radius referred to in the top diagram is to ensure that all of the edges (top, bottom, and sides) of the plate facing the chassis rail are chamfered to minimise edge loading or chafing. A chamfer or radius on the plate also ensures that the plate sits flat against the chassis rail sections, and prevents the plate edge creating a mis-match against the internal radius.

5.4.4 (see next page)

Welding steels with a tensile strength of up to 440 MPa is generally an acceptable practice, provided that the method used is either MIG-welding or TIG-welding.

5.4.4

Welding of any steels in a low volume vehicle which have an ultimate tensile strength exceeding 440 MPa must, in addition to meeting the welding requirements specified in 'Chapter 18 - Attachment Systems', incorporate a welding process that is compatible with the specific grade of steel.

5.5 Production chassis torsional stiffness

5.5.1

A production chassis in a low volume vehicle that is fitted with a non-standard body must be properly assessed to ensure that the combination of the chassis and non-factory body exhibits not less than the same amount of torsional strength as the donor vehicle from which the body is sourced.

A chassis built before 1992 is not required to comply with 5.5.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.6 Production chassis frontal impact

5.6.1

A modified production chassis in a low volume vehicle must not:

(a) be modified in any way that, in the event of a frontal impact, could:

(i) result in increased deformation of the passenger compartment; or

(ii) increase the likelihood of penetration of the engine or transmission into the passenger compartment;

or

(b) feature any modifications that could affect the vehicle's frontal impact performance, including any crumple zone or other energy-absorbing measure incorporated by the vehicle manufacturer.

A vehicle which was manufactured before 1 March 1999 is not required to comply with 5.6.

5.4.4

See side-bar on previous page.

5.5.1

See 'Torsional Strength' and 'Torsional Testing' in the 'Useful Information' section.

5.6.1

This means that you can't do anything to stiffen a chassis between the front axle centre-line and the front of the vehicle, and should avoid wherever possible any stiffening between the front axle centre-line back to the firewall. Production vehicles are designed to deform under impact to absorb energy, thereby reducing the deceleration rate of the occupants, and this protection system must not be compromised, particularly by the addition of any longitudinally-positioned bars that could stiffen the front of the vehicle, such as roll-cage or roll-bar sections, suspension reinforcement bars, or other components that provide longitudinal stiffening forward of the front axle centre-line.

See also 'Exclusions' section for situations where compliance with 5.6.1 is not required.

See also 'Frontal impact performance of production vehicles' in the 'Useful Information' section.

Custom ladder chassis construction requirements:

5.7 Custom ladder chassis basic design

5.7.1

The design of a custom ladder chassis in a low volume vehicle must either:

(a) follow generally accepted time-proven design and construction methods and material specifications applicable to the project in question; or

(b) have been approved in writing through the process specified in 'Chapter 4 - Build Approval Process', by the Technical Advisory Committee of the Low Volume Vehicle Technical Association (Inc).

5.7.2

The section and wall thickness of material used for the construction of a custom ladder chassis in a low volume vehicle must be suitable for the vehicle's size, weight, and performance.

5.8 Custom ladder chassis main rail design

5.8.1

The main rails of a custom ladder chassis in a low volume vehicle must be manufactured from either:

(a) a material specification of not less than:

(i) in the case of RHS, 75 mm x 50 mm x 3 mm (3" x 2" x 1/8"); or

(ii) in the case of tubular section, 75 mm x 2 mm (3" x 5/64");

or

(b) a combination of materials that have been approved in writing through the process specified in 'Chapter 4 - Build Approval Process', by the Technical Advisory Committee of the Low Volume Vehicle Technical Association (Inc).

A chassis built before 1992 is not required to comply with 5.8.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.7.1

Wherever ladder chassis are referred to, this includes cruciform and perimeter-type chassis also.

5.7.1(b)

The Technical Advisory Committee may require engineering calculations or torsional testing to be carried out if a proposed chassis design is well away from traditional types. As a generalisation, the build approval process is not a mandatory requirement, however it can provide good assurance to the constructor that his or her ideas are sound, thereby reducing the chances of major problems during the certification inspection.

5.8.1

This minimum material specification does not apply to the area of the chassis in front of the forward-most front suspension attachment points. A 'suspension pick-up point', for the purpose of this requirement, means a primary suspension component used to locate the hub assembly.

5.8.1(a)

This specification is a minimum, intended more for a light-weight vehicle. See the 'Ladder Chassis Material Specifications' part of the 'Useful Information' section.

5.8.2

The main rails of a channel-section custom ladder chassis in a low volume vehicle must either:

(a) be fully boxed; or

(b) at locations where high loads could be transmitted to the chassis from the engine mounting, suspension pick-up points, or cross-member attachment points:

(i) be partially boxed in the loaded areas; or

(ii) be reinforced in the loaded areas in accordance with the requirements specified in 5.9.1.

A chassis built before 1992 is not required to comply with 5.8.2, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.9 Custom ladder chassis cross-member attachment

5.9.1

Cross-members and mounting brackets must be attached to the main rails of a custom ladder chassis in a low volume vehicle in such a way as to spread the transfer of their load to the web of the chassis rail by either:

(a) spanning the full height of the chassis rail (see Diagram 5.1); or

(b) incorporating a reinforcing plate between the cross-member or bracket that spans the full height of the chassis rail (see Diagram 5.1); or

(c) in the case of an open C-section custom ladder chassis rail, attaching the cross-member or bracket to a section of bridging material that spans the full height of the chassis rail, that (see Diagram 5.2):

(i) is manufactured from a material of an appropriate specification for the application; and

(ii) has a substantial radius at each point where the bridging material meets the chassis rail to avoid stress points and consequential fatigue cracking.

A chassis built before 1992 is not required to comply with 5.9.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.8.2

Unboxed C-section type chassis rails are particularly weak under torsional loads (twisting), so for high-performance applications, full-boxing is ideal, but at the very least C-section rails should be partially-boxed at locations to suit mounting of cross-members and engine mounts, to stiffen or strengthen the chassis rails at specific locations, such as where the engine is mounted.

See also 'Ladder chassis material specifications' in 'Useful Information' section.

Note that all chassis welds must comply with the requirements specified in 18.9.1 of 'Chapter 18 – Attachment Systems', which specifies that a weld cannot be ground, dressed, smoothed, or covered with filler.

For a commercial vehicle with a C-section chassis, refer to sidebar note 5.4.3.

5.10 Custom ladder chassis join reinforcement

5.10.1

Where sections of a custom ladder chassis in a low volume vehicle positioned between the front and rear axles or suspension pick-up points are joined by welding, some additional form of reinforcement or gusseting must be provided at each section join, which:

(a) must not be less than 3 mm thickness, or not less than the thickness of the chassis rail web; and

(b) may be either:

(i) capping plates on the top and bottom of the chassis rails (see Diagram 5.4); or

(ii) fish-plates positioned on one side of the chassis rail, which can be either the outside or the inside of the chassis rail (see Diagram 5.4); or

(iii) a cross-member or permanent roll-cage section positioned in such a way that it overlaps the join, and assists in load distribution (see Diagram 5.4).

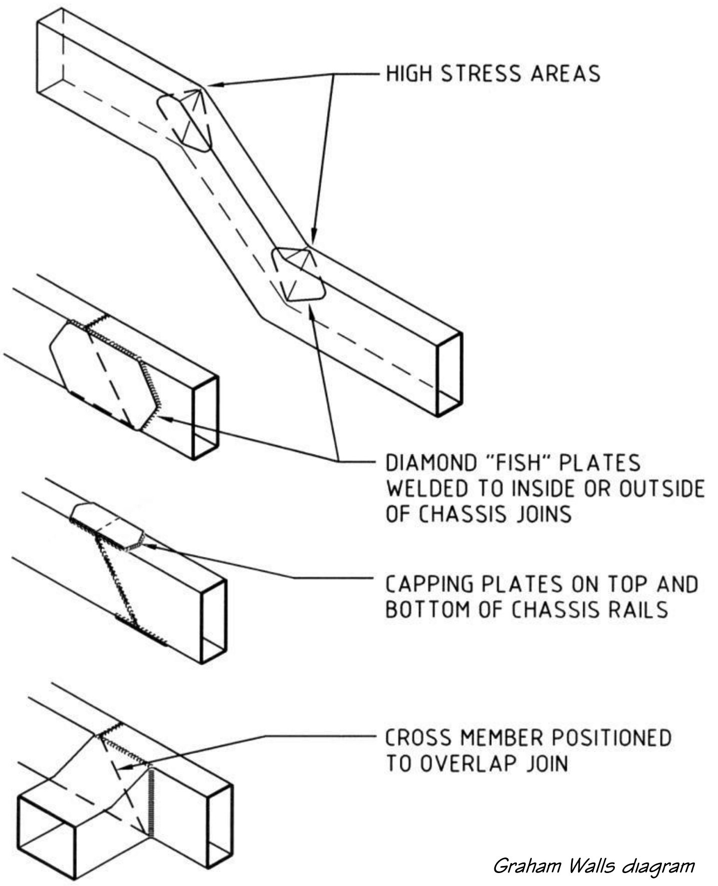


Diagram 5.4 Chassis joint reinforcement

5.10.1

Chassis joins should, where possible, be angle-cut to increase the length of weld area.

5.10.1(a) & (b)

Plates specified in 5.10.1(a) or (b) may be fitted on the inside of the chassis rails if a clean look is desired, provided that the LVV Certifier has either inspected the plate installation prior to the boxing being carried out, or can confirm the presence of the plates from the outside of the chassis section (from heat marks) before the rail sections are cleaned up and coated.

Diagram 5.4

All fish-plates and capping plates should incorporate some 'diamond' shape, or curvature, into them, so as to avoid stress concentrations.

A chassis built before 1992 is not required to comply with 5.10.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.11 Custom ladder chassis torsional stiffness

5.11.1

A custom ladder chassis in a low volume vehicle must incorporate cross-members that are designed and positioned in such a way as to provide the chassis with sufficient resistance to torsional twisting movement (see Diagram 5.5).

5.11.1

The type of cross-member arrangement should be suitable for the application, taking into account the type of suspension, vehicle weight, and engine horsepower.

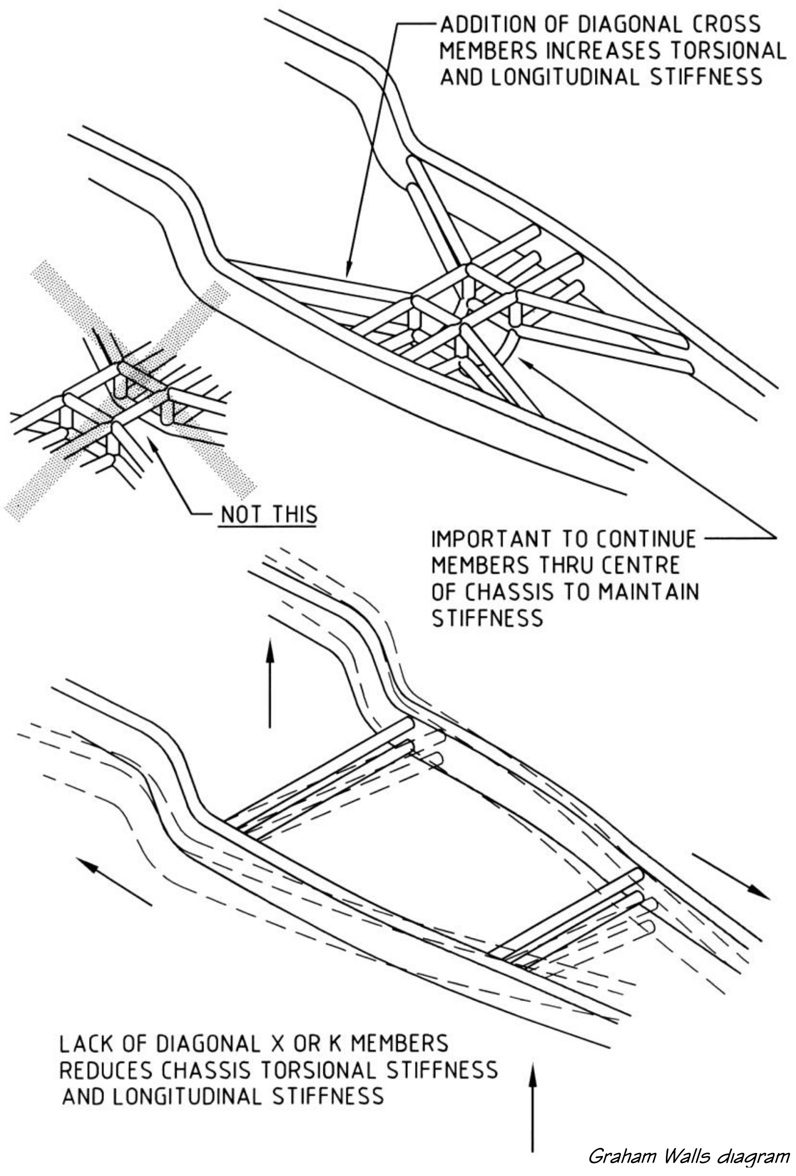


Diagram 5.5 Chassis rail torsional stiffness

A chassis built before 1992 is not required to comply with 5.11.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.12 Custom ladder chassis frontal impact

5.12.1

A custom ladder chassis in a low volume vehicle must be constructed in such a way as to:

(a) minimise the likelihood of penetration of the engine, transmission, suspension, body structure or parts into the passenger compartment as a result of a frontal impact; and

(b) ensure that the section of the vehicle forward of the passenger compartment will progressively absorb impact energy without significant deformation of the passenger compartment, either by:

(i) featuring design characteristics forward of the passenger compartment comparable with that expected of same-era mass-produced vehicles; or

(ii) following relevant design and construction principles specified in 5.12.2.

A custom ladder chassis which was constructed before 1 March 1999 is not required to comply with 5.12.1

5.12.2

In addition to 5.12.1, a custom ladder chassis in a low volume vehicle must feature a purpose-designed reduction in longitudinal stiffness, in the area of the chassis in front of the forward-most front suspension attachment point, by a method which may include:

(a) the use of a chassis material which has a lesser wall thickness than the primary chassis rail sections; or

(b) the use of a chassis material which has less rigidity than the primary chassis rail sections; or

(c) the positioning of a change in direction of the chassis rails, which has the effect of tapering the chassis rail sections inward or outward from the direct longitudinal direction; or

(d) the incorporation of failure or deformation points, through appropriately positioned holes, slots, or cut-aways.

5.12.1

Production vehicles are designed to deform under impact to absorb energy, thereby reducing the deceleration rate of the occupants. This principle must be applied as far as is practicable to custom chassis and scratch-built vehicles. This means that a chassis must not be designed to be any stiffer than it needs to be between the firewall and the front of the vehicle, particularly between the front axle centre-line and the forward-most part of the vehicle, other than fulfilling the functions required of it, such as supporting the various components and body section attached to it. This could be achieved through the use of channel section at the front of an RHS chassis.

See 'Exclusions' section for situations where compliance with 5.12.1 is not required.

5.12.1(b)(i)

This means, basically, that if an original Model-A Ford chassis is made from 3 mm (1/8") wall material, use a lighter material at the forward section of the reproduction chassis, or alternatively, don't 'box' this area of the chassis (leave as a 'C-section').

5.12.2

Stiffness reduction forward of the suspension is to avoid affecting a vehicle's safe operation.

A custom ladder chassis which was constructed before 1 March 1999 is not required to comply with 5.12.2

Custom space-frame chassis construction requirements:

5.13 Custom space-frame chassis basic design

5.13.1

The design of a custom space-frame chassis in a low volume vehicle must either:

(a) follow generally accepted time-proven design and construction methods and material specifications applicable to the project in question; or

(b) have been approved in writing through the process specified in 'Chapter 4 - Build Approval Process', by the Technical Advisory Committee of the Low Volume Vehicle Technical Association (Inc).

5.14 Custom space-frame chassis design requirements

5.14.1

The diameter and wall thickness of tubing used for the construction of a custom space-frame chassis in a low volume vehicle must:

(a) be suitable for the size, weight, and performance potential of the vehicle; and

(b) be manufactured from a material specification of either:

(i) not less than 1.6 mm (1/16") in wall thickness for any major chassis component; or

(ii) a combination of materials that have been approved in writing through the process specified in 'Chapter 4 - Build Approval Process', by the Technical Advisory Committee of the Low Volume Vehicle Technical Association (Inc).

A chassis built before 1992 is not required to comply with 5.14.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.12.2

A 'forward-most front suspension attachment point', for the purpose of this requirement, means a primary suspension component which is used to locate the hub assembly.

5.13

A typical example of a space-frame chassis is that found on a Lotus 7 sports car.

5.13.1(b)

The Technical Advisory Committee may require engineering calculations or torsional testing to be carried out if a proposed chassis design is well away from traditional types. Although the build approval process is not a mandatory requirement for a time-proven design, the process can provide good assurance to the constructor that his or her ideas are sound, thereby reducing the chances of major problems or disappointments at certification time.

5.14.1(b)(i)

This minimum material specification does not apply to the area of the chassis in front of the forward-most front suspension attachment points.

5.14.2

A custom space-frame chassis in a low volume vehicle must incorporate sufficient depth between the top and bottom main frame rails to provide the necessary frame rigidity in order to resist the applied combined torsional and beaming loads.

5.14.3

A custom space-frame chassis in a low volume vehicle must incorporate triangulated bracing within all load-bearing sections of the chassis except for:

(a) the areas forward of the front suspension, and rearward of the rear suspension; and

(b) where physical constraints prevent the placement of triangulated bracing, in which case the same rigidity is required to be achieved in such areas through the use of an alternative method of bracing.

A chassis built before 1992 is not required to comply with 5.14.3, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.15 Custom space-frame chassis component attachment

5.15.1

Brackets and anchorage points used to attach components to a custom space-frame chassis in a low volume vehicle that could substantially load the chassis, such as suspension, engine, steering, brakes, and seatbelt anchorages must be attached (see Diagram 5.6):

(a) either:

(i) at points where no less than two chassis tubes intersect; and

(ii) where sufficient gusseting is incorporated to maximise the area of frame throughout which the loads applied by the components are spread;

or

(b) at a location where it can be proven that the chassis has sufficient strength to support the loadings that could be transmitted to it without failure or deformation.

5.14.2

'Torsional' in this context means rotational twisting loads throughout the length of the chassis, and 'beaming' means bending loads (sagging) on the horizontal plane throughout the length of the chassis.

The material specification of the main frame rails must be increased accordingly if the depth between the rails is decreased, such as where the rails run below opening doors, if opening doors are incorporated within the vehicle design.

5.14.3(b)

An example of an alternative method of bracing is a diaphragm panel attached across the opening by bonding and riveting.

5.15.1(b)

'Proven' could include comparisons with equivalent proven designs, or through confirmation established by an engineering calculation process by a suitably experienced heavy vehicle certifier.

A chassis built before 1992 is not required to comply with 5.15.1, provided that after thorough inspection, no fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.15.2

Component attachment brackets welded to the chassis tubes within a custom space-frame chassis in a low volume vehicle, must be welded in such a way as to:

(a) reduce the effect of the stress concentration point; and

(b) ensure that a site for corrosion is not created between the bracket and the tube.

A chassis built before 1992 is not required to comply with 5.15.2, provided that after thorough inspection, no corrosion is evident. Specific investigation for corrosion must be carried out, with removal of paint if necessary to assist the inspection process.

5.15.2(b)

A continuous weld around the bracket is a common way of avoiding a corrosion site.

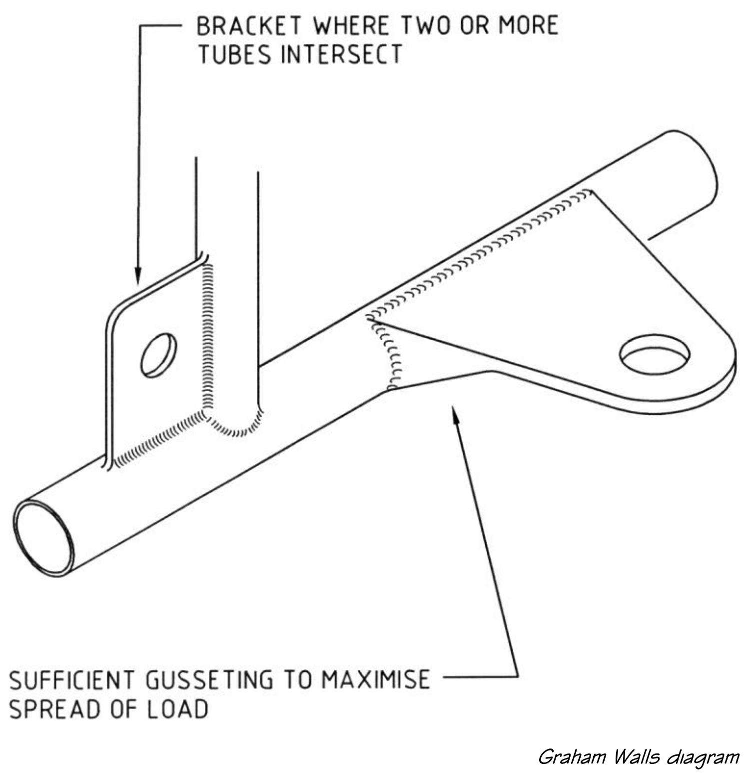


Diagram 5.6 Custom space-frame component attachment

5.16.1 (next page)

The type of chassis tube placement and cross-member arrangement should be suitable for the application, taking into account the type of suspension, vehicle weight, and engine horsepower.

5.16 Custom space-frame chassis torsional stiffness

5.16.1

A custom space-frame chassis in a low volume vehicle must incorporate chassis tubes that are designed and positioned in such a way as to provide the chassis with sufficient resistance to torsional twisting movement.

A chassis built before 1992 is not required to comply with 5.16.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.17 Custom space-frame chassis frontal impact

5.17.1

A custom space-frame chassis in a low volume vehicle must be constructed in such a way as to:

(a) minimise the likelihood of penetration of the engine, transmission, suspension, body structure or parts into the passenger compartment as a result of a frontal impact; and:

(b) ensure that the section of the vehicle forward of the passenger compartment will progressively absorb impact energy without significant deformation of the passenger compartment, either by:

(i) featuring design characteristics forward of the passenger compartment comparable with that expected of same-era mass-produced vehicles; or

(ii) following relevant design and construction principles specified in 5.17.2.

A custom space-frame chassis which was constructed before 1 March 1999 is not required to comply with 5.17.1.

5.17.2

A scratch-built custom space-frame chassis in a low volume vehicle must, in addition to 5.17.1, feature a purpose-designed reduction in longitudinal stiffness, in the area of the chassis at the front of the forward-most suspension attachment point, which may include:

(a) the use of a chassis material which has a lesser wall thickness than the primary chassis rail sections; or

5.16.1

See the side-bar note on previous page.

5.17.1

Production vehicles are designed to deform under impact to absorb energy, thereby reducing the deceleration rate of the occupants. This principle must be applied as far as is practicable to custom chassis and scratch-built vehicles. This means that a chassis must not be designed to be any stiffer than it needs to be between the firewall and the front of the vehicle, particularly between the front axle centre-line and the forward-most part of the vehicle, other than fulfilling the functions required of it, such as supporting the various components and body section attached to it.

See 'Exclusions' section for situations where compliance with 5.17.1 is not required.

5.17.2

Stiffness reduction forward of the suspension is to avoid affecting a vehicle's safe operation.

A 'forward-most front suspension attachment point', for the purpose of this requirement, means a primary suspension component which is used to locate the hub assembly.

(b) the use of a chassis material which has less rigidity than the primary chassis rail sections; or

(c) the positioning of a change in direction of the chassis rails, which has the effect of tapering the chassis rail sections inward or outward from the direct longitudinal direction; or

(d) the incorporation of failure or deformation points, through appropriately positioned holes, slots, or cut-aways.

A custom space-frame chassis which was constructed before 1 March 1999 is not required to comply with 5.17.2.

Composite chassis construction requirements:

5.18 Composite chassis basic design

5.18.1

A composite chassis, or section of a composite chassis, in a low volume vehicle, to which steering, suspension, braking, seats, seatbelts, or other highly-loaded or critical components attach, must be proven to have equal or greater strength and load-carrying capacity to a chassis using conventional chassis design and materials, taking into consideration the vehicle's weight, performance characteristics, and intended use.

5.18.2

The design of a composite chassis, or section of a composite chassis, in a low volume vehicle, must have been approved in writing through the process specified in 'Chapter 4 – Build Approval Process' by the Technical Advisory Committee of the Low Volume Vehicle Technical Association (Inc), who may at their discretion, require the involvement of outside expertise.

5.19 Composite chassis strength

5.19.1

The outer surface of a composite chassis, or section of a composite chassis, in a low volume vehicle, must be of sufficient strength and rigidity to resist penetration of foreign matter such as road debris during normal use.

5.19.2

A composite chassis, or section of a composite chassis, in a low volume vehicle, that uses ultra-high modulus carbon, must incorporate an extra level of protection by either:

5.17.2(b)

This could be achieved through the use of smaller diameter or thinner wall thickness tubing.

5.18

Composite materials can include fibre-glass, carbon-fibre, aluminium sandwich panel, or any other combination of structural materials.

The requirements specified here for a composite chassis also apply to any highly-loaded sections of a composite body. Also, any highly-loaded sections of a monocoque or unitary-constructed vehicle must be treated in the same way.

5.18.1 & 5.18.2

'Proven' and 'outside expertise' could include, as directed by the TAC, comparisons with equivalent proven designs, confirmation established by an engineering calculation process by a suitably experienced transport engineer, pull-testing, torsional testing, core sample testing, or any appropriate combinations thereof.

5.19.1

This is especially relevant to the floor area. Such resistance should be at least equivalent to a normal panel steel floor-pan in a production vehicle.

(a) the use of a protective impact-resistant outer-coating, such as an aramid-ply; or

(b) the partial incorporation of a tough material such as a hybrid weave to act as a fail-safe; or

(c) including a sacrificial portion of the chassis or chassis section that will clearly fail first, with such a failure unable to cause any loss of braking or directional control of the vehicle.

5.19.2

'Ultra-high modulus carbon is known as 'UHMC'. Impact damage referred to here could include road debris.

5.19.2(a)

'Aramid-ply' is the generic name for what we know as 'Kevlar'.

5.20 Composite chassis torsional stiffness

5.20.1

A composite chassis in a low volume vehicle must be designed and constructed in such a way as to provide the chassis with sufficient resistance to torsional twisting movement.

A chassis built before 1992 is not required to comply with 5.20.1, provided that after thorough inspection, no twisting, bending, bowing, or fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.20.1

The torsional stiffness of a composite chassis will require assessment and approval by the Technical Advisory Committee of the Low Volume Vehicle Technical Association.

5.21 Composite chassis frontal impact

5.21.1

A composite chassis in a low volume vehicle must be constructed in such a way as to:

(a) minimise the likelihood of penetration of the engine, transmission, suspension, body structure or parts into the passenger compartment as a result of a frontal impact; and:

(b) ensure that the section of the vehicle forward of the passenger compartment will progressively absorb impact energy without significant deformation of the passenger compartment.

A composite chassis which was constructed before 1 March 1999 is not required to comply with 5.21.1.

5.21.1

The frontal impact performance design of a composite chassis will require assessment and approval by the Technical Advisory Committee of the Low Volume Vehicle Technical Association.

5.22 Composite chassis sealing

5.22.1

All edges within a composite chassis, or section of a composite chassis, in a low volume vehicle, must be fully sealed with a resin or other durable substance to prevent entry of moisture into the material.

5.22.1

Some composite materials are susceptible to osmosis, and must be properly sealed to prevent moisture from getting into the material structure. These materials can also be damaged if moisture becomes trapped in the material and freezes.

5.23 Composite chassis inspection

5.23.1

Resin or adhesive used during the moulding or connections of a composite chassis, or section of a composite chassis, in a low volume vehicle, must be shown to be fully bonded and cured, by retaining and providing to the LVV Certifier, either:

(a) core sample cut-outs of the main structure; or

(b) representative samples of each composite material used in the manufacture of the main structure, made identically and simultaneously with the main composite mouldings or structures.

A chassis built before 1992 is not required to comply with 5.23.1, provided that after thorough inspection, no delamination is evident. Specific investigation for delamination must be carried out, with removal of paint if necessary to assist the inspection process.

5.23.1

Signs of delamination can often be identified through a simple 'tap-test'; - using the edge of a coin, a sharp 'tap' sound suggests a sound bond, whereas a dull 'thud' is an indicator of delamination.

5.23.1(b)

The requirement for representative samples includes any connection of any composite materials.

Additional requirements for all chassis modification & construction:

5.24 Chassis reinforcement

5.24.1

A chassis bracket designed for the attachment of a critical steering or braking component in a low volume vehicle, where the attachment relies on a weld, must incorporate some form of additional reinforcement or gusseting.

A chassis built before 1992 is not required to comply with 5.24.1, provided that after thorough inspection, no fatigue cracking or fracturing is evident. Specific investigation for fatigue cracking must be carried out, with removal of paint if necessary to assist the inspection process.

5.25 Engine and drive-train attachment

5.25.1

The engine and drive-train fitted to a low volume vehicle must be attached to the chassis in accordance with the requirements specified in 'Chapter 9 - Engine & Drive-train'.

5.26 Cross-member, bracket, and component attachment

5.26.1

A suspension or steering attachment point must be positioned on a modified or custom chassis in a low volume vehicle in such a way that any irregularities within the chassis caused by distortion during the chassis modification or manufacturing process, and could result in adverse suspension or steering geometry, are compensated for.

5.26.2

A fastener which attaches structural sections, brackets, or mechanical components to RHS, channel, or tubular chassis rails or cross-members in a low volume vehicle, must pass through a tubular steel reinforcing crush-tube that:

(a) is manufactured of a material with a wall thickness of not less than the material used for the main chassis rails or cross-members, however in no circumstances less than 3 mm; and

(b) is of an inside diameter that provides a close tolerance fit for the fastener; and

(c) is inserted within the chassis rail or cross-member through a hole that provides a close tolerance fit for the reinforcing crush-tube, on the face of the chassis rail or cross-member opposite to that which the component is positioned against; and

(d) is fully welded to the face of the chassis rail or cross-member opposite to that which the component is positioned against (see Diagram 5.7).

5.26.1

If a chassis twists through heat during welding, exactly symmetrical placement of brackets may be 'out of square', and cause the suspension or steering geometry to be out when the vehicle is completed.

5.26.2

A crush-tube prevents crushing and collapsing of the chassis or cross-member section, which in turn prevents the fastening system from loosening.

5.27 Drive-shaft safety-loops

5.27.1

A drive-shaft safety-loop must be fitted to those low volume vehicles specified in 'Chapter 9 - Engine & Drive-train'.

5.27.2

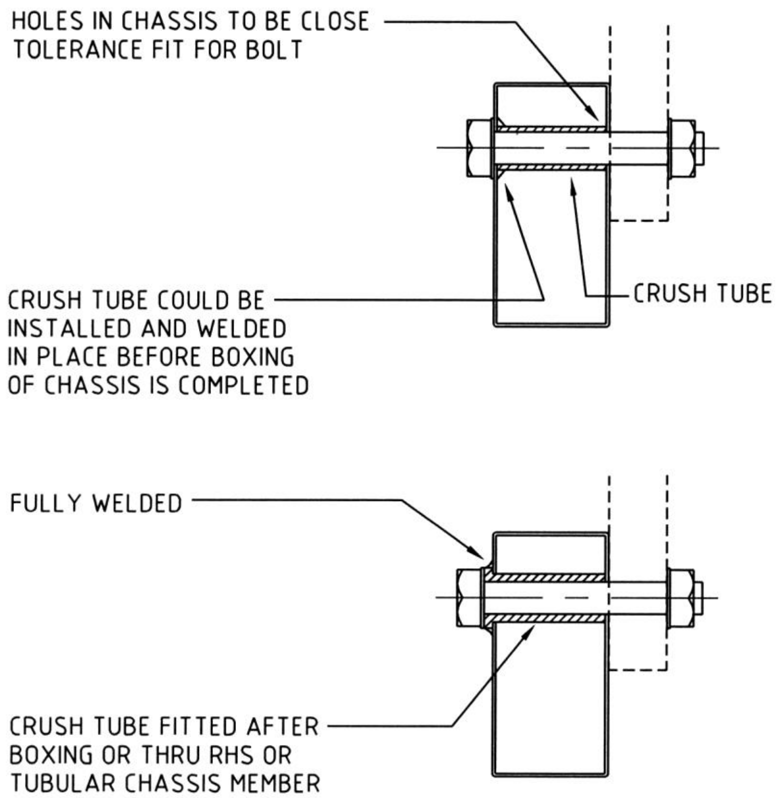
A drive-shaft safety-loop fitted to a low volume vehicle must meet all requirements, including design, construction, positioning, and attachment specified in 'Chapter 9 - Engine & Drive-train'.

5.27.1

Chapter 9 – Engine & Drive-train sets out all of the modification and construction situations where a drive-shaft safety-loop is required.

5.27.2

A lot of good information about how to correctly make and install drive-shaft safety-loops is provided in Chapter 9 – Engine & Drive-train.



Graham Walls diagram

Diagram 5.7 Crush-tube installation

Diagram 5.7

The top example shown in Diagram 5.7 illustrates where capped (or boxed) C-section material is used, and a crush-tube is positioned and tack-welded before the capping plate is welded on.

5.28 Body mounts

5.28.1

A low volume vehicle fitted with a body separate from its chassis must incorporate mounts within the chassis for the attachment of the body, of a design, size, and number:

(a) in the case of a modified production vehicle, not less than that provided by the original vehicle manufacturer; and

(b) in the case of a modified production vehicle which has the passenger compartment space extended or lengthened, the number of chassis attachment points must be increased in direct proportion to the passenger compartment extension to provide a consistent or increased ratio of mounting points to passenger compartment size; and

(c) in the case of a scratch-built replica vehicle, not less than that used by the original vehicle being replicated; and

(d) in the case of a scratch-built vehicle that is not a replica, sufficient fasteners to retain the body to the chassis in the event of a 20g deceleration.

5.28.1(a) and (c)

This would not apply in a situation where the modified or newly-constructed vehicle has seatbelts attached to the body structure, and the modified or replicated vehicle was never designed to be fitted with seatbelts. In this case, 5.25.1(d) applies.

5.28.1(d)

A 'g' figure is the mass (weight) multiplied by a pre-determined acceleration – in this case the vehicle's body weight x 20g (the maximum likely survivable crash deceleration weight). See the 'Useful Information' section of 'Chapter 18 - Attachment Systems' for a hitch-hiker's guide to this subject.

5.29 Chassis welding

5.29.1

All welding incorporated within a chassis on a low volume vehicle must meet all welding requirements specified in 18.7 and 18.8 of 'Chapter 18 - Attachment Systems'.

5.30 Chassis fasteners

5.30.1

All fasteners incorporated within a chassis on a low volume vehicle must meet all fastening requirements specified from 18.2 to 18.6 inclusive in 'Chapter 18 - Attachment Systems'.

5.30.2

In addition to 5.30.1, fasteners that attach cross-members, brackets, or spring hangers, that are under, or transmit, high loadings within any chassis modification or construction in a low volume vehicle, must pass through holes that are drilled for a close-tolerance fit.

5.31 Condition

5.31.1

All areas within a production chassis of a low volume vehicle that have been modified, and all areas of a custom chassis in a low volume vehicle, must:

(a) be protected against corrosion; and

(b) not have any rust, corrosion, cracking, or any other kind of damage, to the extent that the chassis may be weakened as a result; and

(c) where the chassis is not readily visible when fitted with its body panels, be inspected by a Low Volume Vehicle Certifier prior to being fitted with the outer body panels.

Exclusions:

5.32 Design criteria exclusions

5.32.1

A low volume vehicle that was originally manufactured before 1 March 1999 is not required to comply with 5.6, 5.12, or 5.17.

5.31.1(c)

This is particularly relevant in the case of a space-frame chassis, which is often fully enclosed by riveted body panels.

5.32.1

This means that a vehicle built or modified before March 1999 is not required to meet frontal impact requirements.

5.33.1 (next page)

This enables the fitment of typical items that are required for motor-sport purposes, but have the effect of stiffening a forward structure, such as sump-guards, forward roll-bar sections, and suspension strut braces.

Note that motor-sporting regulations require the use of additional occupant protection measures to compensate for these structural modifications.

5.33 Motor-sport use exclusions

5.33.1

A low volume vehicle, for which a valid MotorSport New Zealand Authority Card that specifies Frontal Impact is issued, is not required to comply with 5.6, 5.12, or 5.17.

5.34 All-terrain vehicle exclusions

5.34.1

Scratch-built four-wheel drive all-terrain vehicles designed and constructed to be operated in conditions, and for uses, which would make the incorporation of an energy-absorbing frontal section impractical, are not required to meet 5.6, 5.12, or 5.17.

5.34.1

This provides the ability for military-type assault vehicles, or serious-duty off-road vehicles to be constructed without frontal impact protection where the vehicle's design and intended use makes such protection impractical.

Useful information:

Adding cross-members to production chassis (refer to section 5.2)

There is a general view that when converting a vehicle which was originally equipped with a beam-type front axle to an independent front suspension (IFS), that – because of the greater loads that an IFS applies to a chassis over a beam-type axle – additional cross-members should be fitted to the chassis to support these additional loadings. This view is reflected in 5.2.2.

There are however certain chassis types where this requirement is not always appropriate, such as a 1950's American pickup or other vehicle type designed for commercial activities such as those in 5.4.3. Where an IFS conversion occurs in these commercial vehicles, particularly where a relatively low-powered small-block V8 engine is used, additional crossmembers may not be necessary.

Constructors should keep in mind however that without the torsional improvements that additional or better cross-members will bring, the vehicle will not achieve anywhere near the expected benefits from the IFS upgrade due to that chassis flex that will still exist, as a result of the inherent chassis design. Fully boxing the chassis and adding suitable cross-members and diagonal members is preferred when higher-powered engines are being used, or when improved cornering, road-holding, or general chassis performance is desired.

Cross-member attachment to production chassis (refer to section 5.4)

The requirements specified in 5.4.1 are primarily aimed at those cross-members and mounting brackets attaching an engine, or locating the vehicle's suspension system. In some situations, a cross-member or mounting bracket is neither designed nor required to transmit torsional loadings between chassis rails, but is simply supporting the weight of the gearbox or other component like a fuel tank. There are many OEM examples of this; for example, gearbox cross-members attached to the underside of the chassis rail, or to brackets attached to the side of the chassis rails.

Where a cross-member or mounting bracket is only supporting the weight of the component, and no engine torque, or chassis torsional loads will be transmitted, there is no risk of oil-canning, and therefore the requirements specified in 5.4.1 may be relaxed, provided fit-for-purpose mounting and attachment practices are incorporated.

Another situation where the attachment system specified in 5.4.1 is not necessary is the situation where two tubes are positioned one above the other against the chassis rail to create a 'dual-plane' cross-member system - provided of course that the tubes are positioned as far apart (vertically) as practicable. Sometimes, some 'staggering' of the top-to-bottom tube attachments points on the chassis rail is necessary, but this should be kept to a minimum.

Torsional strength (refer to section 5.5)

'Torsional' strength refers to the ability of an item – in this case a chassis – to resist 'twisting' down its length. Torsional strength is very different to bending strength.

It cannot be assumed that any combination of bodies and chassis will provide adequate torsional strength, and each component has to be considered in conjunction with the other. For example, the combination of an unmodified Holden utility chassis fitted with an early American pick-up cab will have significant torsional twist. This is because the Holden cabs were designed to provide part of the vehicle's overall structure, whereas the American manufacturers tended to build a stronger chassis and the body was expected to provide a comparatively minor role in achieving overall torsional strength.

This situation quickly becomes evident with a simple jacking test where the door gaps on the cab will open up significantly. In these cases, additional chassis cross-members will be required.

Torsional testing

There are some situations where it is necessary to assess the torsional strength of a vehicle or a chassis, such as in the case of a stretched limousine, a custom space-frame chassis, or a particularly unusual or innovative design or method of construction.

There are a number of methods available to assess the torsional stiffness of a vehicle or a chassis. These methods include a simple diagonal jacking test (using door openings and gaps to visually determine the level of twist), the more repeatable LVVTA-developed laser-pointer test commonly used for stretched limousines, and the Australian Government's torsional test requirements which are more commonly used for complex or unusual chassis designs or vehicle modifications.

To determine which type of test is the most suitable, constructors are encouraged to discuss this with an LVV Certifier, or to contact a technical staff member at the LVVTA Office.

Ladder chassis material specifications (refer to section 5.8)

Conventional hot rod style hobby cars have typically used 75 mm x 40 mm x 3.0 (3" x 1 ¾" x 1/8") as a minimum frame spec for lighter vehicles such as T-buckets and light roadsters. This spec is marginal, and time has proven that these frames will bow outward at the point where the engine is positioned in the chassis if there isn't an under-slung cross-member at that point linking the two rails.

The following size materials should be followed as a minimum guide for RHS and c-section:

- for light vehicles under 1200 kg (2642 lb), the main rails should be manufactured from no less than 75 mm x 50 mm x 3.0 mm (3" x 2" x 1/8"), with cross-members (irrespective of width and height specs) maintaining 3.0 mm wall thickness; and

- for heavier vehicles over 1200 kg (2642 lb), the main rails should be manufactured from no less than 100 mm x 50 mm x 3.0 mm (4" x 2" x 1/8"), with cross-members (irrespective of width and height specs) maintaining 3.0 mm (1/8") wall thickness.

Space-frame chassis design principles (refer to section 5.13)

Space-frame chassis are built to give the advantage of lightness and rigidity. They comprise predominantly straight small-diameter tube sections, arranged in a fully triangulated truss-like design, some tube sections acting in compression, with others acting in tension. The rigidity of the space-frame chassis relies on the configuration and the spacing of the tube sections acting in unison to contribute to the overall strength.

The strength and rigidity of the overall space-frame chassis structure is dependent on the accuracy of the tube joints and the welding that has been carried out. The failure of one welded or brazed joint can seriously affect the strength of a space-frame chassis.

Because the material typically used in the construction of a space-frame is so small and light, special attention has to be paid to the attachment of components that can transmit high loads back to the chassis, such as suspension, steering, and braking components. Gussets are usually required to assist in spreading the loads being transmitted throughout the greatest possible area of chassis, rather than having the load concentrated on one small area.

Whilst the technical requirements don't specify a limit for the amount of torsional rigidity for a space-frame chassis, it is essential that any flexing that may occur will not lead to cracking of the frame, brackets, or welds, and will not adversely affect front and rear steering geometry.

Space-frame chassis material specifications (refer to section 5.14)

For chassis design similar in size and weight to a Lotus 7, where most tubular boxes can be triangulated, the following size materials should be followed as a minimum guide:

- for vehicles with under 200 horsepower, the main tubes should be manufactured from no less than 25 mm x 1.6 mm (1" x 1/16"), with diagonal bracing manufactured from no less than 19 mm x 1.6 mm (3/4" x 1/16"); and

- for vehicles with over 200 horsepower, the main tubes should be manufactured from no less than 32 mm x 1.6 mm (1 17/64" x 1/16"), with diagonal bracing manufactured from no less than 25 mm x 1.6 mm (1" x 1/16").

Electric Resistance Welded (ERW) tube is considered to be an acceptable material for space-frame chassis construction.

A space-frame type chassis being submitted to the Technical Advisory Committee of the LVVTA for the Build Approval process will require more detailed drawings than a ladder chassis. In the case of a recognised design following closely that of previously manufactured and approved cars such as Lotus 7, Locost, PBR's, space-framed replica Ford GT40's and such, reference to the previous designs should be accompanied by any alterations that are proposed from the original.

Detailed drawings of the original are not usually required, but the TAC may request these.

Space-frame chassis corrosion protection

Space-frame chassis are treated with particular care in the area of corrosion protection, because:

- the pre-body inspection is necessary because parts of a space-frame chassis are often not visible when the outer body panels are fitted, and this is the only time that the corrosion protection issue can be properly assessed; and

- the frame material is usually so thin that corrosion can have a greater effect and in a shorter time than other vehicle types, and unlike purpose-built race-cars which use space-frame chassis, a road-going space-frame chassis is not usually subjected to the same routine strip down and check that a race-car typically receives.

Composite chassis (refer to section 5.18)

The construction of a chassis from composite materials such as fibreglass, Kevlar, carbon-fibre, or aluminium sandwich panel, is a very specialised area, which should not be undertaken by anyone unless the builder has a professional background in working with these materials in structural and load-bearing applications.

Welding high-strength steel (refer to paragraph 5.1.3)

Welding high-tensile or high-strength steels having a strength of less than 440 MpA is generally safe, provided that either MIG or TIG welding is carried out.

Any steels having a strength of more than 440 MpA may not be readily weldable, and should not be welded unless an appropriate welding process is readily available or has been developed and agreed by LVVTA.

Bodies

It is recommended that vehicles fitted with a separate body should have packers or packer strips made from rubber or another type of flexible material to isolate the passenger compartment from chassis vibration and mechanical harmonics.

Frontal Impact performance of production vehicles (refer to section 5.6)

As a result of increased power and torque, a vehicle may need its chassis stiffened in order to improve its torsional performance to maintain or improve handling and body durability. The challenge is to do this without increasing the impact loadings applied to occupants during a collision.

Chassis modifications should ideally achieve the improved torsional stiffness of the vehicle without decreasing the original 'crushability' of the forward part of the vehicle structure.

Any frontal structure modifications made to vehicles manufactured to meet a frontal impact standard may affect the vehicle's ability to progressively deform and thereby absorb frontal crash energy. Also, air-bag deployment could be affected by any stiffening or softening of the vehicle's frontal structure.

It is important, therefore, to obtain expert advice before proceeding with structural modifications to1990-on vehicles.

Generally speaking, the only way such modifications can be legally made (for road-going competition vehicles) is through the use of a valid LVV Authority Card which specifies Frontal Impact Protection. This process may require a complete alternative occupant protection system, which may include removal of airbags and substitution of occupant restraint systems.

However, this Authority Card only applies to legitimate competition vehicles used by an owner who holds a competition license and is a regular motor-sport competitor.

Frontal Impact-compliant chassis used in scratch-built LVVs

The frontal impact issue also has to be considered when using a production vehicle chassis on a scratch-built vehicle. In theory, if you were to use a chassis from a frontal impact-compliant vehicle in your scratch-built hot rod/sports car, you would have to build the car in such a way as to not mess up the frontal impact characteristics of the chassis.

The reality is however, that it is very unlikely that you'll need to worry about this. Almost all frontal impact-compliant vehicles are of unitary-construction design, so they'll be of no help to your project. About the only frontal impact-compliant vehicles out there that are of separate body/chassis design are ones that are unlikely to find their way under your project because they're either high-end sports cars like Corvettes, or from large 4WD vehicles. Even the 4WD vehicles are mostly going towards unitary construction.

Frontal Impact performance of old-style chassis (refer to section 5.12)

Both original and reproduction chassis on early style cars, will, by their inherent design, naturally provide a considerable degree of frontal impact protection. Energy absorbing deformation will occur to some extent during a frontal impact, because of the taper in the front rails forward of the front cross-member, and also from the way in which the front section of the chassis rails 'droop' downwards. Both of these features will cause some deformation and subsequential energy-absorption within the front of the chassis.

A front-tie-bar between the rails at the forward-most point of the chassis will also assist to absorb crash energy if impacted, by pulling the front of the two front rail sections together and inward.

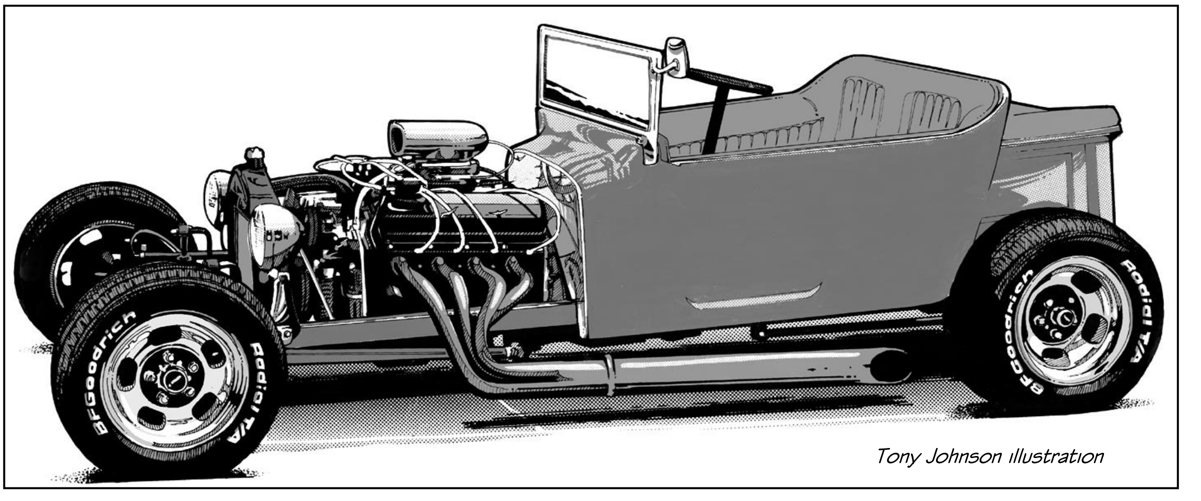
Terms & definitions for Chapter 5 Chassis Modification & Construction

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.
Aramid ply	is the generic name for what we know as 'Kevlar'.
Beam-type axle	means a type of axle where wheels are connected laterally by a solid beam or shaft, usually incorporating a kingpin-type swivel at either end on a steering axle.
Capping plate	means a plate fitted to enclose an opening or void in a chassis section.
Carbon	means a non-metallic chemical element, and used in the manufacturing process of steel, gives the steel high strength characteristics.
Chamfered	means the application of a radius, to give a smooth rounded shape to an edge or a corner.
C-notch	means a chassis modification where a 'C' is notched out of the rear chassis rails to increase axle housing clearance during suspension compression, usually carried out in conjunction with significant suspension lowering.
Composite	means a combination of multiple elements used to create a material with different properties.

Cross-member	means a section or beam used to join two parallel sections of chassis, sometimes incorporating a load-bearing mount for engine, drive-line, and suspension components.
Cruciform chassis	means a variation on the ladder frame chassis design, where the central section is reinforced by crossed beams placed perpendicular to each other. This overcomes the inherent lack in torsional stiffness of the basic ladder frame design.
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.
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.
Delamination	means the separation of two or more bonded materials, usually through weathering or damage.
Dual-plane	means a type of tubular cross-member design used in chassis construction, where two tubular members sit on top of each other (on two planes).
Drive-shaft safety-loop	means a safety device intended to contain the potentially high rotational forces of a disengaged drive-shaft.
ERW	is an abbreviation for electric resistance welded, which is a common type of steel tubing material.
Fish-plate	means a plate that is positioned on one side of the chassis rail to reinforce the point at which two or more chassis sections join. A fish-plate can be positioned on either the outside or the inside of the chassis rail.
Flange	means a flat surface where two components can be joined, or in the case of a C-section chassis, the top and bottom horizontal surfaces of the chassis rail.
‘g’	is an abbreviation for g-force, which is a unit of force equal to the force exerted by gravity, used to indicate the force to which a body is subjected, when accelerated or decelerated.
Gusset	means a rib or triangulation attached or incorporated into a component to increase its strength or torsional rigidity.
Gross Vehicle Mass	means the maximum legal weight at which a vehicle can be operated, including the vehicle’s tare, and its payload.
GVM	is an abbreviation for gross vehicle mass.
Kevlar	is a brand name for a particularly light but very strong aramid-fibre, manufactured by the DuPont Company.
Ladder chassis	means a chassis in which parallel side members are joined at intervals by transverse beams, giving the appearance of a ladder.
Longitudinal	means lengthwise (front to back) rather than from left-side to right-side.

Low volume vehicle	means, in simplest terms, a vehicle that is built or modified in small numbers, and includes individual home-built or modified vehicles. See the full low volume vehicle definition contained in the Low Volume Vehicle Code.
MegaPascal	is a unit of pressure.
MpA	is an abbreviation for MegaPascal.
Modified production (low volume vehicle)	means, in simplest terms, a vehicle which, while modified, maintains a sufficient percentage of body or chassis from one primary mass-produced vehicle, that it can still be considered to be that vehicle. See the full modified production (low volume vehicle) definition contained in the Low Volume Vehicle Code.
Modulus	is a physics term for a constant factor or ratio.
Monocoque	means the same as unitary construction.
Osmosis	means the diffusion of fluids through a semi-permeable membrane or porous partition, often found in the automotive world as moisture absorbed and trapped in fibre-glass, resulting in blistering or bubbling of the outer surface.
Perimeter chassis	means a type of chassis frame, commonly used in the construction of 1950s American cars, where the middle sections are outboard of the front and rear chassis rails, to allow for a lower floor-pan in the passenger compartment.
Pull-test	means a test where a pulling force is applied to a component to assess its strength.
RHS	is an abbreviation of rectangular hollow section.
Rectangular hollow section	means a configuration of steel section commonly used in the manufacture of chassis, and other motor vehicle component fabrication.
Scratch-built	is as defined in the Low Volume Vehicle Code.
Space-frame chassis	means a chassis that is built to give the advantage of lightness and rigidity, by using predominantly straight small-diameter tube sections, arranged in a fully triangulated truss-like design, with some tube sections acting in compression and others acting in tension.
Transversely-mounted	means mounted across the vehicle (in an east-west configuration), rather than along its length (in a north-south configuration).
Torsional	means, in the context of this manual, the rotational twisting loads applied throughout the length of a chassis during vehicle operation.
Ultra-high modulus carbon	means, in relation to carbon-fibre, carbon fibres which are extremely stiff, however with less tensile strength than normal carbon.
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.

Web	means the middle or vertical surface of a C-section chassis rail.



Tony Johnson illustration