

Full-frame Chassis Welding Procedures

Best-practice Guidance for the Preparation and Welding of Full-frame Chassis



Supporting New Zealand's Repair Certification Industry

About RepairCert NZ Technical Bulletins

These Technical Bulletins have been developed to support Specialist Light Vehicle Repair Certifiers (Repair Certifiers) in ensuring autobody repairs are carried out safely and correctly. Repair Certifiers should, in the first instance, be guided by (if available) relevant Vehicle Manufacturer's Information and Repair Industry Information, and in the absence of such information, refer to the guidance provided within RepairCert NZ Technical Bulletins. These Technical Bulletins can be used by the wider autobody repair industry.



Image credit ⁽¹⁾.

Purpose

This Technical Bulletin advises Repair Certifiers in the correct preparation and welding processes for full-frame chassis (chassis) of body-over-frame vehicles, during collision or corrosion welding repairs, including sectioning, and weld-on component replacement.

It also reinforces the importance of applying the relevant Vehicle Manufacturer's Information and Repair Industry Information (see Note 1) to ensure that the applicable requirements are met.

<p>Note 1</p>	<p>'Vehicle Manufacturer's Information' (also known as 'OEM Information') refers to any documentation from the vehicle manufacturer, including the Body Repair Manual (BRM), and related requirements, recommendations, and guidelines. An example of Vehicle Manufacturer's Information relevant to this Technical Bulletin is shown in <i>Image 1</i>.</p> <p>'Repair Industry Information' means information from recognised repair industry sources such as Thatcham, I-CAR, and Ezi-Methods.</p> <p>To learn more about Vehicle Manufacturer's Information and Repair Industry Information, click here to view <i>RepairCert NZ Information Sheet # 02-2024 Repair Method Options</i> on the RepairCert NZ website.</p>
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Applicable Requirements

This Technical Bulletin combines non-mandatory Best-practice Guidance, together with the relevant mandatory legislative requirements (known as ‘applicable requirements’) to support Repair Certifiers in relation to this subject.

The applicable requirements stem from *Land Transport Rule: Vehicle Standards Compliance 2002 (Compliance Rule)*, and *Land Transport Rule: Vehicle Repair 1998 (Repair Rule)*.

The *Compliance Rule* requires that an unregistered vehicle undergoes repair certification if it has ‘significant damage or deterioration to its structure, chassis, body-to-chassis attachment, suspension, or occupant protection system’.

The *Repair Rule* specifies that ‘a repair to a vehicle, its structure, systems, components or equipment, must restore the damaged or worn vehicle, structure, system, component or equipment so that they are within safe tolerance of the state of the vehicle, structure, system, component or equipment when manufactured.’

The *Light Vehicle Repair Vehicle Inspection Requirements Manual (Repair VIRM)* sets out the requirements that Repair Certifiers must meet to achieve the objectives of the *Compliance Rule* and the *Repair Rule* (see the ‘Repair VIRM Requirements’ section at the back of this Technical Bulletin).

Background

Lack of Relevant Vehicle Manufacturer Information

Most vehicle manufacturers provide comprehensive repair information for their unibody structures (including the upper body structure of body-over-frame models).

Combined with widely available repair industry welding training (*see Note 2*), a high level of autobody technician experience exists in GMA-MIG/MAG welding (*see Note 16*) of the many types of high-tensile strength steel materials used in modern vehicle unibody structures, with many technicians also holding an I-CAR or equivalent welding qualification.

Note 2	Repair industry training for autobody repair welding includes welding training programmes, hands-on skill development workshops, accreditations, and testing regimes, primarily focused on thin sheet-metals, typically up to 1 mm for outer body panels and around 1.5 mm for structural elements. The standard I-CAR MIG-steel welding qualification, for example, is limited to 1.6 mm material thickness.
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Chassis components, however, are usually constructed from much thicker steel - typically 3 mm or more. These material differences require fundamentally different preparation and welding techniques compared to unibody collision and corrosion welding repairs. Most of the available industry welding training applicable to 3 mm or more material thickness does not have any associated accreditation, except for the AS/NZS 1554 qualifications, which, while applicable to heavier steels, is not a qualification normally associated with welding repairs to light vehicles.

Vehicle Manufacturer’s Information will often specify that certain welding repairs can be made to a chassis, and will sometimes provide specific information about where sectioning can be performed on a chassis to repair collision damage. However, it is uncommon for vehicle manufacturers to provide information on the welding process itself, including preparation steps (*see Note 3*).

Note 3	A notable exception is Toyota’s frame end replacement procedures for 2005 to 2015 Hilux models (<i>see Image 2</i>).
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This lack of Vehicle Manufacturer’s Information on welding detail for thicker sheet-metals typically used in chassis construction - combined with the limited availability of repair industry technical training and certification for welding the materials found in a chassis - creates a significant risk of poor-quality welding repairs to a chassis.

For this reason, this Technical Bulletin focuses exclusively on the preparation and welding of the thicker sheet-metals incorporated within the chassis of body-over-frame vehicles.

A Brief History of Light Vehicle Structures

From the earliest days of four-wheeled motorised transport, the predominant construction design principle has consisted of an upper body attached to a steel frame structure which carries the drive-train, and steering and suspension components - commonly referred to as the ‘body-over-frame’ configuration.

The unibody structure (also referred to as unitary or monocoque) that we’re all familiar with today (integrating the body and frame into a single unit), was first introduced in the late 1930s. Over the past 60 years, it has become the preferred construction method for passenger cars, particularly among European and Asian manufacturers.

Despite this shift, most light commercial and four-wheel drive platforms continue to be based on the body-over-frame design. This is due to advantages in towing capacity, durability, and off-road performance when compared to unibody vehicles.

In the 1990s, both unibody and body-over-frame designs saw significant advancements, including the increased use of high-strength steels and other high-tech materials, alongside new attachment methods, and the introduction of advanced occupant protection technologies.

Over the last fifteen or so years, almost every major vehicle manufacturer globally has reduced, or discontinued altogether, the production of many of their traditional (primarily unibody) sedan platforms (with a common exception being some electric vehicle models), in favour of sport utility vehicles (SUVs), ‘crossovers’, and light commercial utility vehicles. While many small and mid-size SUVs and crossover models (such as Toyota RAV4, Mazda CX-series, and Mitsubishi ASX) typically use unibody construction, most full-size SUVs and light commercial vehicles (such as Toyota Land Cruiser, Prado, and Hilux; Mitsubishi Pajero Sport and Triton; Ford Everest and Ranger) retain the body-over-frame structure.

Given that body-over-frame vehicles make up a significant portion of New Zealand’s national vehicle fleet, it is considered necessary to provide this Technical Bulletin to support Repair Certifiers in making informed decisions about welding a chassis which has been affected by collision or corrosion damage.

Using This Technical Bulletin

Welding Repairs This Technical Bulletin Applies To

This Technical Bulletin is intended to assist a Repair Certifier in making informed decisions about welding repairs to a chassis affected by collision or corrosion damage where either:

- the vehicle manufacturer supplies (or supplied prior to discontinuation) replacement chassis components designed to be welded onto a chassis (*see Notes 4 to 6*); or
- a chassis is manufactured from low-strength steel (*see Note 7*); or
- a chassis is manufactured from high-strength steel (*see Notes 8 to 11*), and relevant Vehicle Manufacturer’s Information is available to support the welding repair.

Note 4	If a vehicle manufacturer provides replacement chassis components designed to be welded to a chassis, it indicates that welding is expected in these areas - regardless of the MPa rating of the chassis.
Note 5	These replacement chassis components may include mounting brackets, cab mounts, suspension mounts, flanges, and cross-members.
Note 6	Where a manufacturer-supplied replacement chassis component was available, it is also acceptable to weld on an identical second-hand component.
Note 7	‘Low-strength steel’, within the context of chassis welding, typically refers to materials with a tensile strength of up to 440 MPa.
Note 8	‘High-strength steel’, within the context of chassis welding, typically refers to materials with a tensile strength above 440 MPa.
Note 9	For clarification, welding repairs - including sectioning - may only be carried out on a chassis manufactured from: <ul style="list-style-type: none"> • low-strength steel; or • high-strength steel if supported by relevant Vehicle Manufacturer Information or Repair Industry Information.
Note 10	In the case of corrosion repairs, there may be circumstances (such as the location or extent of the corrosion) where a welding repair may be carried out on chassis components which exceed the 440 MPa threshold, providing that the situation is discussed and agreed on a case-by-case basis with RepairCert NZ.
Note 11	The scope of this Technical Bulletin is limited to <u>welding repairs</u> , so information about the repairability of chassis components which does not include welding (such as hot and cold repair allowances, straightening and re-alignment tolerances and allowances) must always be based on available and relevant Vehicle Manufacturer’s Information, Repair Industry Information, or related Best-practice Guidance.

When This Technical Bulletin Should Not Be Used

This Technical Bulletin should not be used for welding repairs to a chassis affected by collision or corrosion damage where either:

- the relevant Vehicle Manufacturer’s Information cautions against or prohibits welding in specific areas; or
- welding could compromise a crash management system, occupant protection system, or the structural integrity of a chassis.

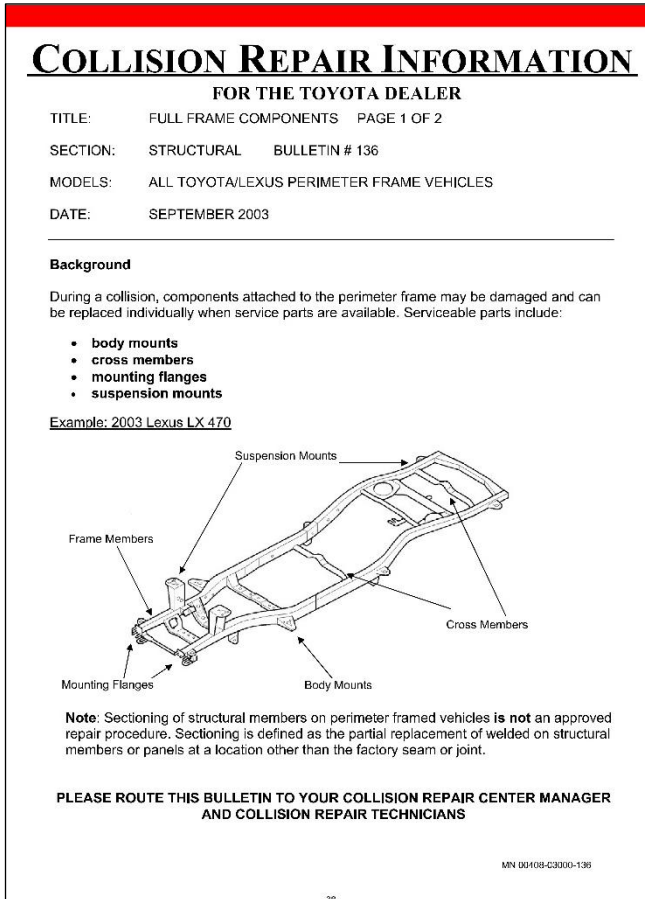


Image 1: Excerpt from Toyota Collision Repair Information Bulletin (CRIB #136 describing chassis component replacement).

Inspection Item	Standard	Check
1 Is the weld length correct? 	<ul style="list-style-type: none"> • At the length as indicated in the procedure manual and • The same as the original condition (Check the beginning and end of the weld) (The overlapping portion should be 20mm or more) 	
2 Is the bead width appropriate? 	<ul style="list-style-type: none"> • The groove portion should be filled in by the bead (bead width of 6mm more) • The bead width of the fillet welded or lap welded portions should be between 3mm and 5mm • There are no thinned out portions of the bead 	
3 Are there any blow holes? 	<ul style="list-style-type: none"> • There should be no more than 5 holes of 1mm or less on a 50mm area of the bead surface 	
4 Is there any burn-through? 	<ul style="list-style-type: none"> • There are no melted portions of the base metal edge • The bead height should be 2.0mm or more 	
5 Are there hole openings? 	<ul style="list-style-type: none"> • There should be no holes inside the bead or 2mm or more. 	
6 Is there any off-centering of the bead? 	<ul style="list-style-type: none"> • The groove portion should be filled in by the bead (bead width of 6mm more) • There are no thinned out portions of the bead • The welded portion between the pane edges should not be visible 	
7 Is there any undercut? 	<ul style="list-style-type: none"> • The reduction of the panel thickness on the bead corner should be no more than 0.5mm 	
8 Is there any overlap? 	<ul style="list-style-type: none"> • The height of the bead edge is taller than normal (no more than 0.5mm) 	
Repair Procedure		
	<ul style="list-style-type: none"> • Overlap the repaired bead portion 5mm or more over the correct bead portion on both sides 	

Image 2: Excerpt from the (18 page) Toyota procedure for replacing the crush horns on 2005 to 2015 Hilux models.

Preparation and Welding Information in This Technical Bulletin

Welding Information Sections

Other than the ‘Repair VIRM Requirements’ section, the remainder of this Technical Bulletin provides Best-practice Guidance on performing collision or corrosion damage welding repairs on a chassis, including sectioning and weld-on component replacement. The content is divided into the following sections:

- Cutting and Removal Methods
- Preparation Procedures for Weld Joints
- Terms Used to Describe Weld Structures
- Descriptions and Specifications of the Three Common Weld Joint Configurations
- Setting up the Welding Machine
- Wire Selection and Shielding Gas
- Practice Welds to Confirm Correct Welder Settings

- Destructive Testing of Practice Welds
- Common Weld Faults
- Welding Techniques
- Non-destructive Testing
- Sectioning Joint Variations
- Repair VIRM Requirements
- In Summary.

Cutting and Removal Methods

Importance of Correct Cutting Process

The thicker sheet metal and continuous welds typically used to connect chassis sections together make removing damaged weld-on components more challenging. This work often requires different cutting equipment than that used on unibody structures.

Cutting and separating continuous weld joints primarily requires carefully cutting through weld beads without generating too much heat and avoiding cutting into, and damaging, the existing areas on the chassis where the replacement components will be joined.

Recommended Cutting Tools

To follow are the tools that can be used for this work, with their advantages, and in some cases disadvantages.

- Reciprocating saws operate at slower speeds, generating less heat, and offer greater cutting efficiency compared to the air-operated body saws typically used to cut unibody panels.
- Cut-off wheels are effective for cutting thicker metals - especially thinner-edged wheels. However, the circular cutting action can limit access to certain weld locations and configurations (such as right angle and T-fillet joints).
- Plasma-arc cutters offer fast and precise cutting through thicker sheet-metals and weld beads. Despite being a thermal cutting process, the heat-affected zone (HAZ) is minimal with virtually no heat damage to the area outside of the cut zone. Performed correctly, cuts are well-defined, and require minimal slag removal.

Note however that plasma-arc cutters should not be used if there are inner elements (such as inner reinforcements and gussets) directly behind the component being cut, as molten slag expelled by the (superheated) plasma stream will be blown directly onto the inner components, causing heat damage and surface contamination (*see Image 3*).

- Oxy-acetylene cutting equipment should not be used to remove chassis components due to the excessive heat and potential for damaging surrounding areas.

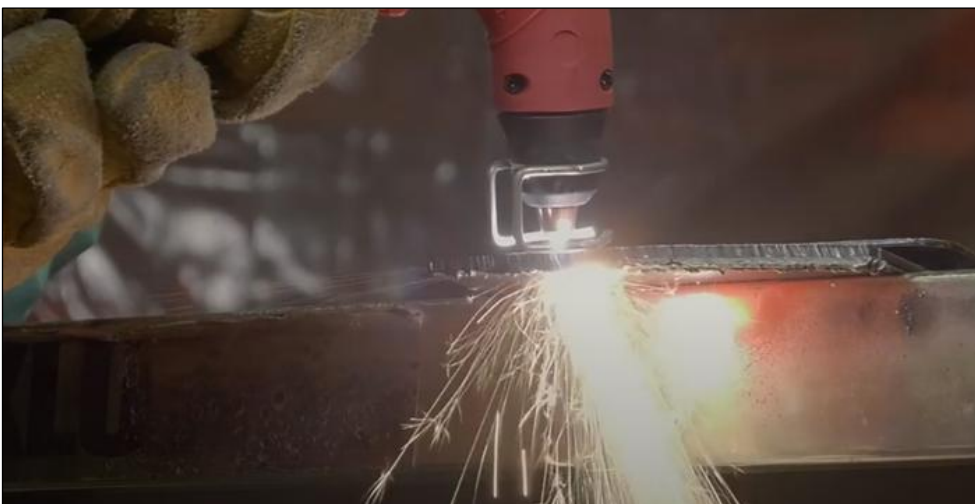


Image 3: Molten metal slag blown through the back side of plasma cuts can easily damage inner components in close proximity.

Preparation Procedures for Weld Joints

Surface Coatings

Before welding, all surface coatings should be removed from both the vehicle (such as paint and sealers), and the replacement component (including factory E-coat if the component is new) in the immediate vicinity where welding will be performed. A bare metal area of 20 to 25 mm either side of the weld site is recommended, using abrasives and techniques that do not reduce material thickness.

Weld-through Primers

There is ongoing debate amongst industry experts regarding the use of weld-through primers (WTP) on sheet-metal components being welded using GMA-MIG/MAG (see Note 16) processes (both for continuous welding and plug welding), especially when welding the thicker sheet-metals used in a chassis. This is because the increase in the amount of sustained high heat generated at the weld site will most likely completely burn off or 'boil away' any WTP coatings that have been applied, eliminating any corrosion protection benefits.

Additionally, the presence of WTP coatings is associated with weld faults affecting weld strength and integrity such as porosity, a reduction in weld penetration, and an increase in weld spatter (see Note 12).

Note 12	To learn more about weld-through primers, click here to view <i>RepairCert NZ Technical Bulletin # 01-2024 - The Correct Use of Weld-through Primers</i> on the RepairCert NZ website .
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At least one vehicle manufacturer explicitly advises against using WTP coatings when performing GMA-MIG/MAG welding (see Note 16) on chassis components (see Image 4). Generally speaking, for chassis welding repairs, WTP coatings should only be applied if specified by the vehicle manufacturer.

Existing Weld Joints

When installing replacement chassis components at factory joint locations after the removal of damaged components, any remaining weld beads must be carefully removed. This is typically done using disc grinders, die grinders, disc sanders, or belt sanders.

Extreme care must be taken when 'dressing down' weld remnants and removing coatings to avoid:

- overheating the base metal; or
- reducing the base metal thickness.

Sectioning Joints (Cut and Join Locations)

Chassis components that are replaced away from factory joints are referred to as 'sectioning procedures' or 'cut and join locations'. In these cases, 'open-butt welds' are used almost exclusively to weld the replacement components.

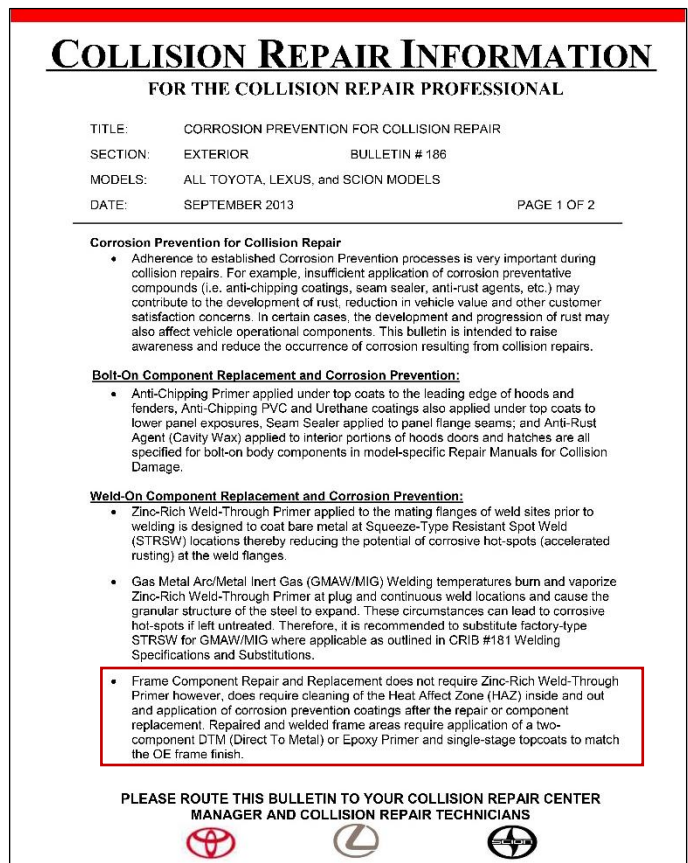


Image 4: Page 1 of Toyota's Collision Repair Information Bulletin (CRIB) #186, includes information on the use of WTP coatings.

Corrosion Repairs

Corrosion damage that requires cutting out affected areas and welding in new sections typically uses the same open-butt weld method. These joints are also known as sectioning procedures (see Notes 13 and 14, and Image 5).

<p>Note 13</p>	<p>Welding repairs for corrosion damage on a chassis must:</p> <ul style="list-style-type: none"> • be limited to components with a tensile strength of 440 MPa or less (unless the conditions in Notes 9 and 10 are met); and • use steel of the same grade and thickness as the section being repaired; and • not be performed in areas which include or affect crash management systems.
<p>Note 14</p>	<p>Corrosion damage welding repairs on a chassis are also subject to Notes 9 and 10.</p>



Image 5: Typical example of a conventional corrosion damage welding repair being performed on a chassis rail which has a tensile strength of 440 MPa or less.

Description of an Open-butt Joint

To ensure full penetration and proper weld strength, open-butt welding on chassis components over 3 mm in thickness typically requires preparation of a ‘single-V joint’ layout (see Image 6).

A single-V joint layout consists of a:

- **Bevel angle** on each of the outside cut edges of the two pieces to be welded together - the recommended (individual) bevel angle ranges from 15 - 30 degrees (15° - 30°) or an included angle range between 30 and 60 degrees (30° - 60°); and
- **Root gap** between the cut edges of the two pieces to be welded together - the recommended root gap measurement range is 1 - 3 mm; and
- **Root face** which is the cut edge of the two pieces to be welded together that is not beveled or grooved - the recommended root face measurement range is 1 - 2 mm.

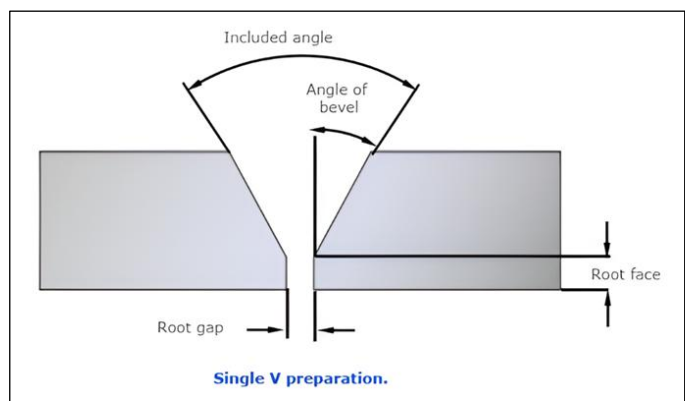


Image 6: Geometry of a single-V open-butt joint, showing bevel angles, root gap and root face aspects. Image credit (iii).

Dependent on the vehicle manufacturer, open-butt weld sectioning joint configurations for a chassis that is of closed C-channel construction can be specified as either ‘single cut’ sectioning joints or ‘staggered cut’ sectioning joints (see Images 7 and 8).



Image 7: Single cut sectioning joint.



Image 8: Staggered cut sectioning joint

Terms Used to Describe Weld Structures

Visual inspection of completed welds involves evaluating key characteristics to help determine weld integrity and structure.

This section outlines the common types of weld joints used for chassis component welding, and defines key terms used to describe weld features. These terms are illustrated in the following diagrams (see Images 9 and 10):

- Legs (the two sides of the weld where it meets each piece of base metal); and
- Toes (the outer edges where the weld bead joins the base metal); and
- Face (the visible surface of the weld); and
- Throat (the shortest distance from the weld root to the weld face; this is the strongest part of the weld); and
- Root (the point where the weld begins deep within the joint); and
- Fusion line (the boundary between the weld metal and the base metal); and
- Heat-affected zone (HAZ) (the area of base metal that was not melted but was altered by heat).

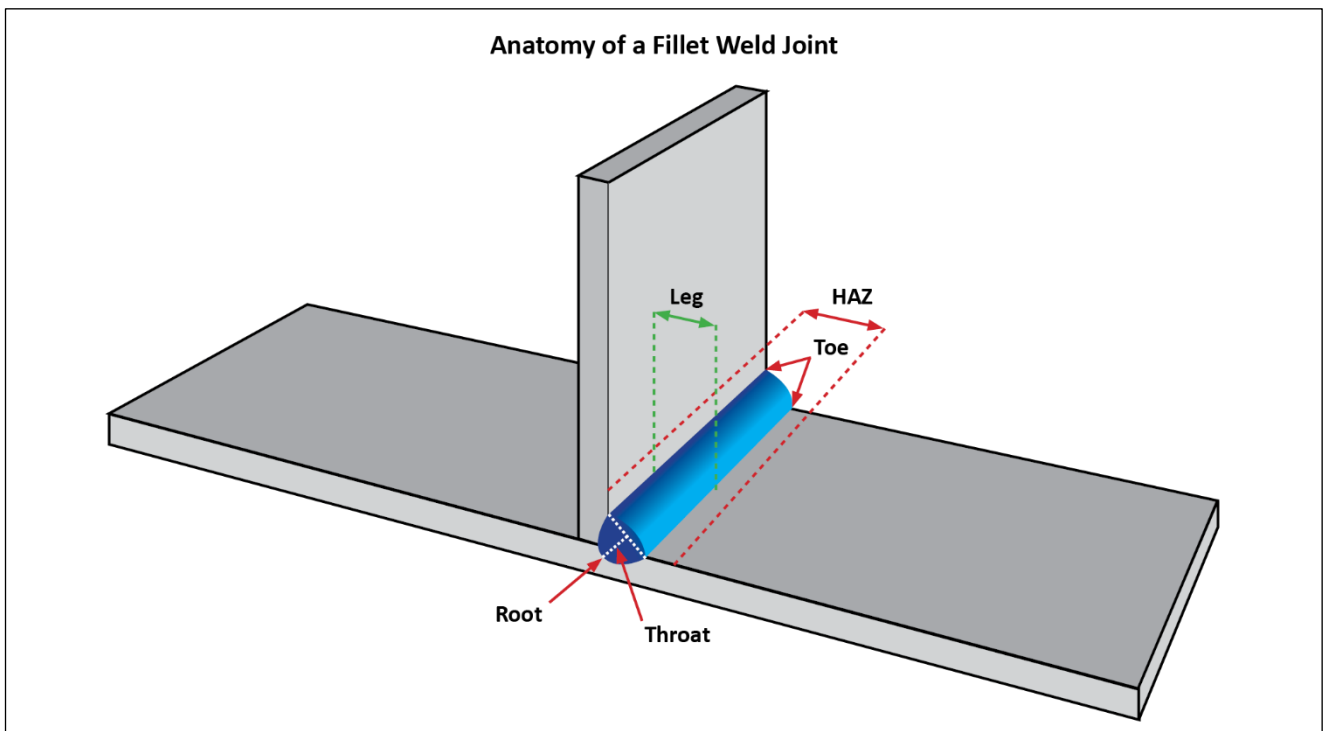


Image 9: Terms used to describe the characteristics of a fillet weld joint.

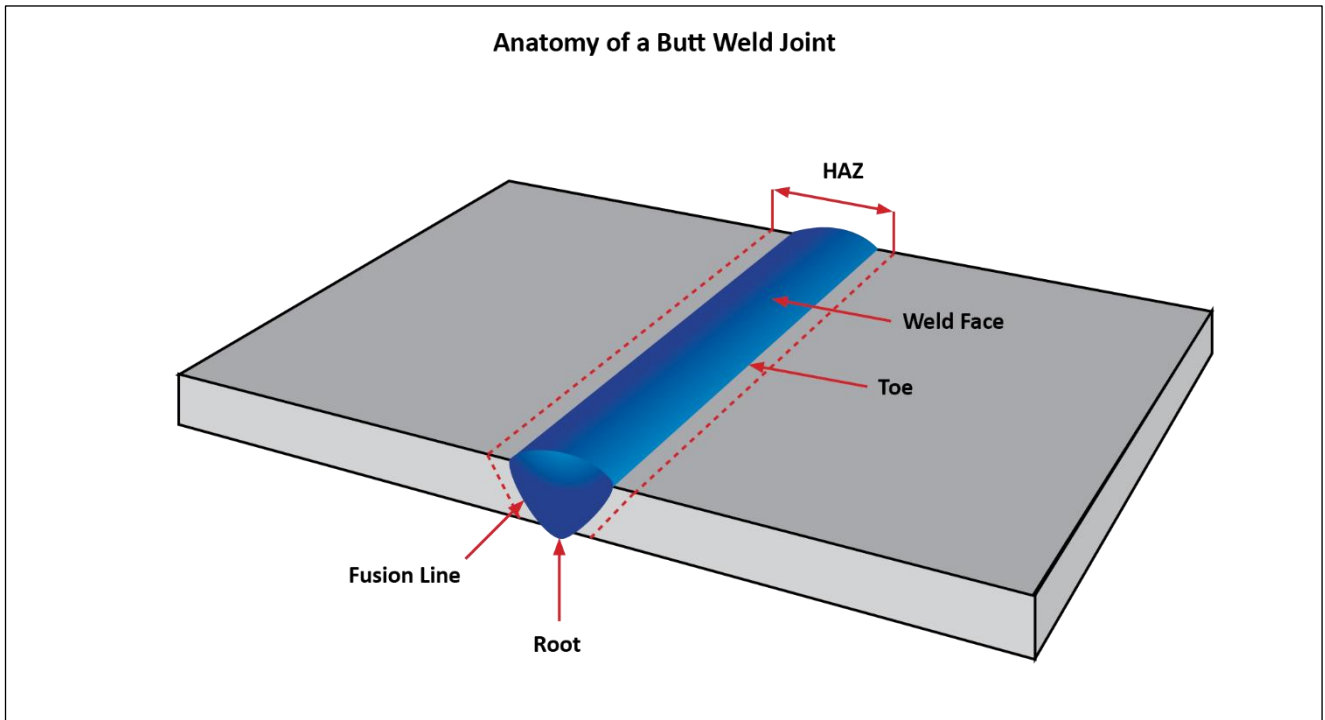


Image 10: Terms used to describe the characteristics of a butt weld joint.

Descriptions and Specifications of the Three Common Weld Joint Configurations

While there are some exceptions, most vehicle manufacturers who provide chassis component replacement or sectioning procedures in their Vehicle Manufacturer’s Information for body-over-frame platforms do not include specific information on how the various types of welds should be performed.

The examples below (see Images 11 and 12) illustrate this gap: They clearly indicate the location for sectioning or component replacement, but provide no details on the welding process required.

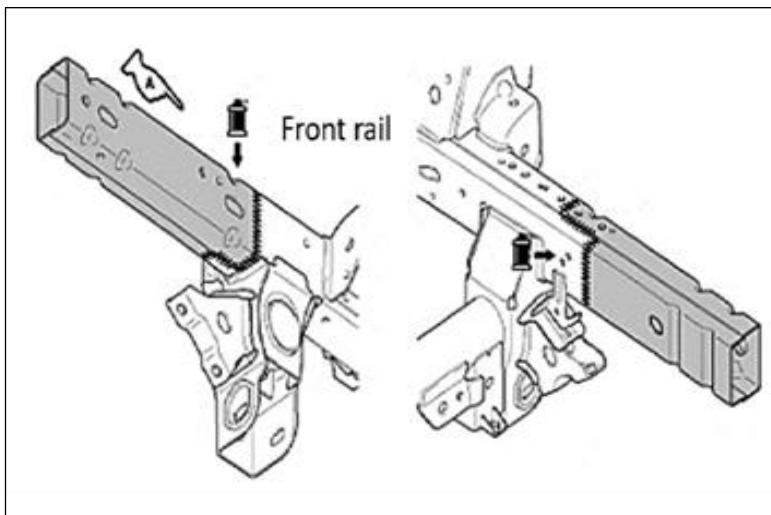


Image 11: Mitsubishi Triton BRM excerpt only shows the location on the chassis rail where sectioning can be performed.

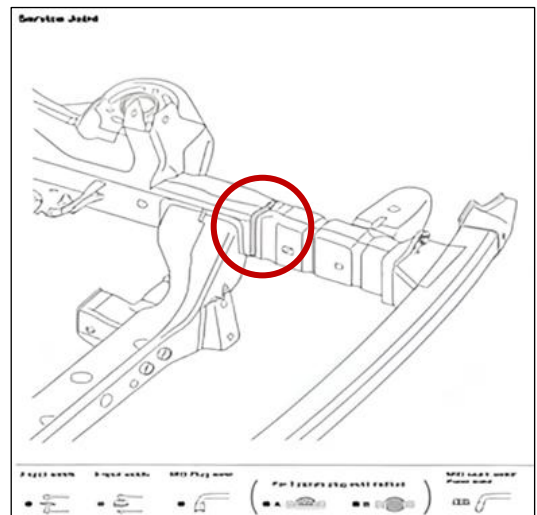


Image 12: Nissan Navara BRM excerpt only shows where the replacement chassis component is to be joined.

Common Weld Joints Used on a Chassis

The three most common types of weld joints that are used on a chassis (including the general recommended weld bead dimensions for each) are shown in the following diagrams (see Images 13 to 15):

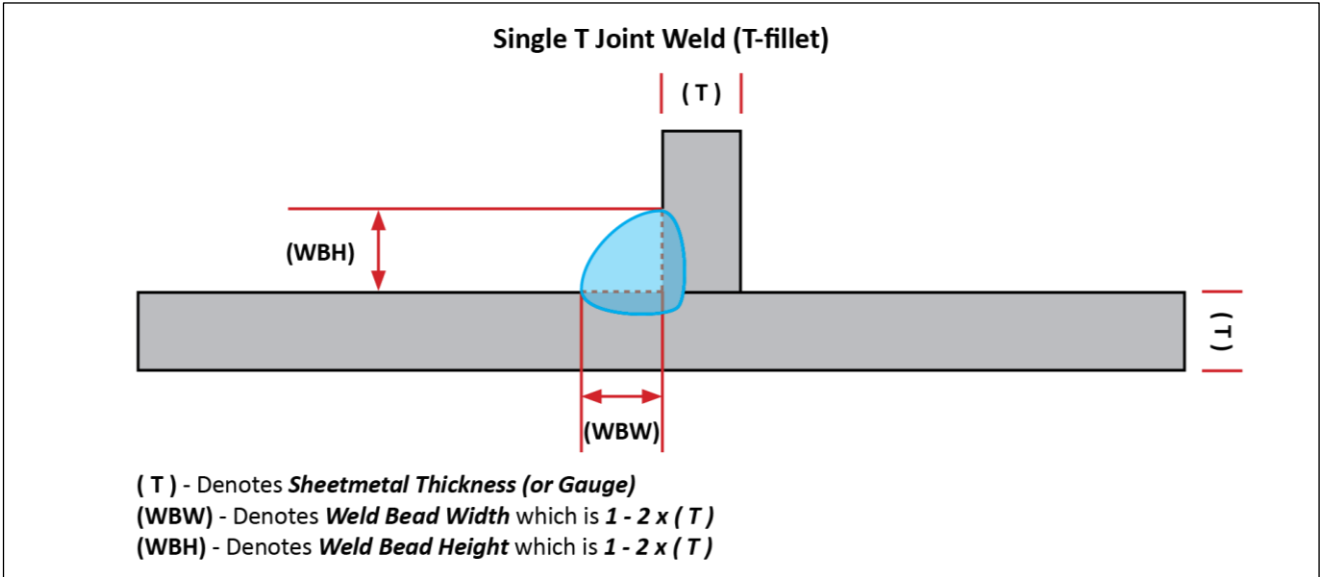


Image 13: Single-T joint weld (T-fillet).

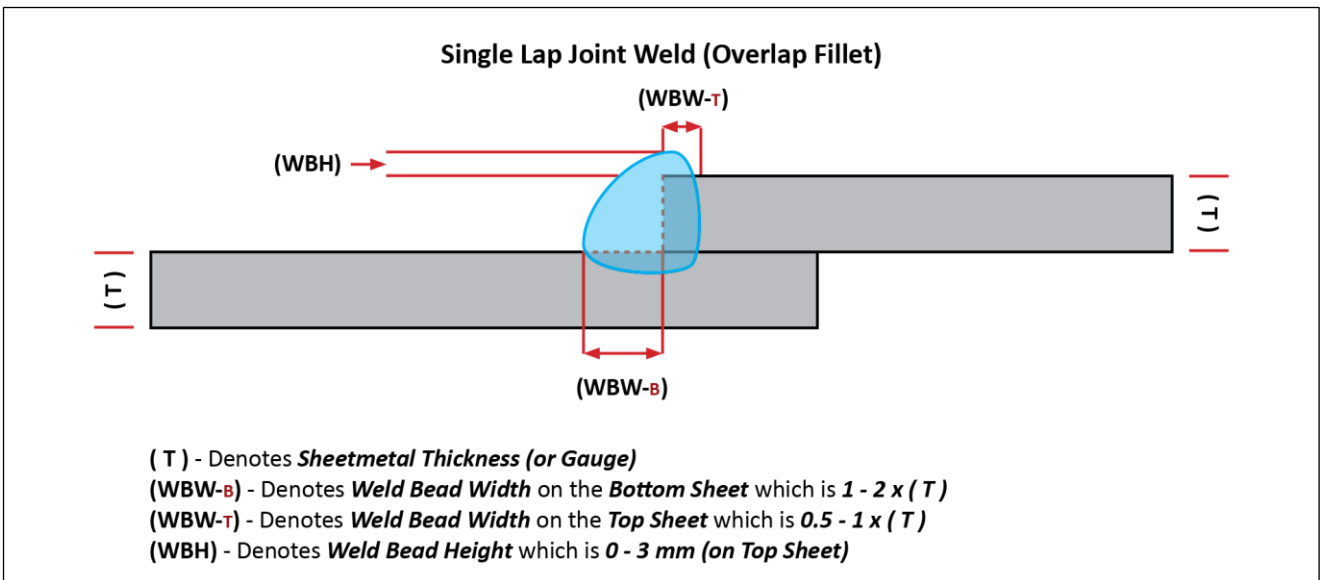


Image 14: Single-lap joint weld (overlap-fillet).

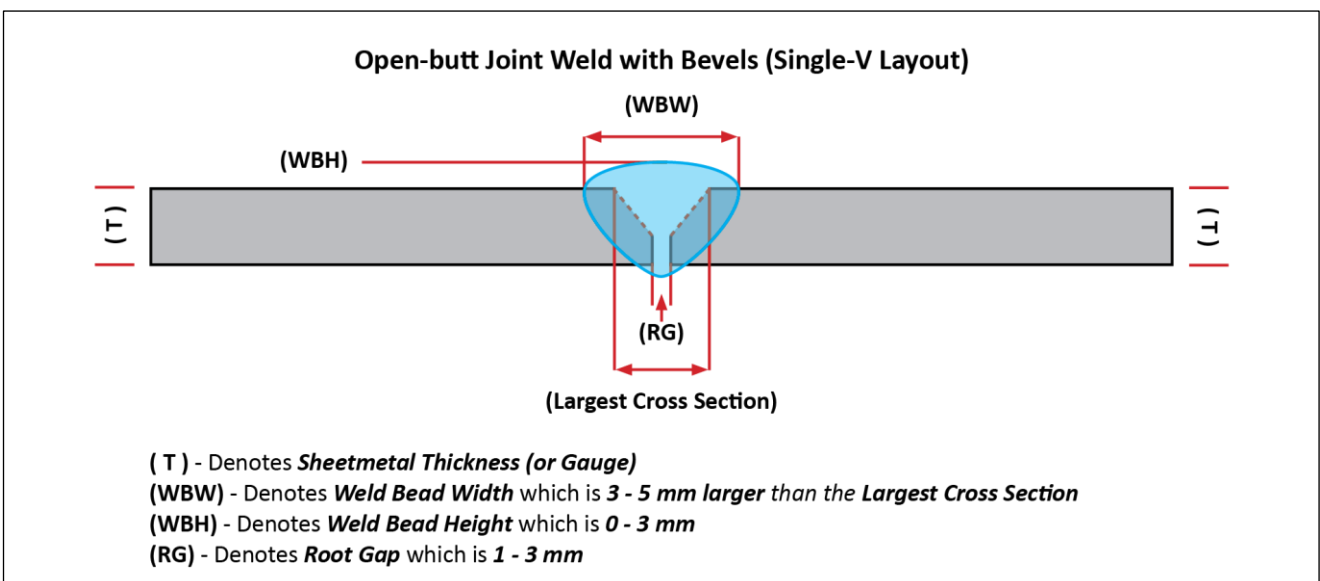


Image 15: Open-butt joint weld (single-V layout).

Setting up the Welding Machine

Welding Equipment Guidelines

Welding thicker sheet-metals requires higher current output GMA-MIG/MAG welding equipment (see Note 16) that is capable of welding consistently at higher amperages.

Newer-generation inverter-based welders typically handle higher output without issue, even at smaller current outputs. In contrast, older transformer-based welders - often used in body shops for everyday unibody repairs - may lack the current capacity and weld cycle time to effectively weld thicker sheet-metals and achieve the required weld strength.

Other important factors, such as wire selection and shielding gas type, must also be considered (see Image 16). These are covered in detail in the 'Wire Selection and Shielding Gas' section of this Technical Bulletin.

LINCOLN ELECTRIC		SUGGESTED SETTINGS FOR WELDING										LINCOLN ELECTRIC			
		FOR STAINLESS STEEL AND ALUMINUM SETTINGS - SEE MANUAL													
PROCESS	WELDING WIRE	SHIELDING GAS	STEEL THICKNESS												
			24 gal/.024 in./0.60 mm	22 gal/.030 in./0.80 mm	20 gal/.036 in./1.0 mm	18 gal/.048 in./1.2 mm	16 gal/.060 in./1.6 mm	14 gal/.075 in./2.0 mm	12 gal/.105 in./2.5 mm	10 gal/.135 in./3.5 mm	3/16 in./5.0 mm	1/4 in./6.0 mm	5/16 in./8.0 mm		
MIG DC(+)	.025 in. (0.6 mm) DIA. SOLID STEEL WIRE LINCOLN WELD® L-56	CO ₂	A-2	B-3	B-3	C-4	C-4	D-6	E-8						
		C20 or C25 (75-80% Argon, 25-20% CO ₂)	A-2	A-2	B-3	C-4.5	C-4.5	D-7	E-10						
	.030 in. (0.8mm) DIA. SOLID STEEL WIRE LINCOLN WELD® L-56	CO ₂		B-2	B-2	C-2.5	C-2.5	D-4	E-6						
		C20 or C25 (75-80% Argon, 25-20% CO ₂)		A-2	B-2.5	B-2.5	C-3.5	D-5.5	E-7.5	E-7.5					
GASLESS FLUX-CORED DC(-)	.039 in. (0.9mm) DIA. INNERSHIELD® NR®-211-MP	NONE				A-1.5	A-1.5	B-2	C-2.5	C-2.5					
	.045 in. (1.2mm) DIA. INNERSHIELD® NR®-211-MP	NONE				A-1.5	B-1.5	B-1.5	C-1.5	C-1.5	D-2	D-2*	E-2.5*		

Image 16: Weld settings chart example - for this particular (transformer-based) single-phase welder, the recommended sheet-metal thickness that can be welded is up to 3.5 mm, depending on wire size and the shielding gas used.

Welder Settings

When welding thicker sheet-metal, the two primary adjustment parameters - voltage (heat control), and amperage (wire speed/weld penetration control) - must be set significantly higher than those used for thinner materials.

Welders equipped with synergic functionality simplify this adjustment process and improve accuracy. In a synergic system, voltage and wire speed are automatically synchronised through a single control, with most machines also allowing for fine-tuning within the selected setting (see Image 17).



Image 17: Single control system provided by Synergic technology. Image credit (iii).

Wire Selection and Shielding Gas

Selecting the Correct Welding Wire Size

In addition to using larger GMA-MIG/MAG welding equipment (see Note 16) with higher weld settings, the diameter (or size) of the welding wire that is used (sometimes referred to as ‘electrode wire’) should also increase as the sheet-metal thickness increases (see Note 15).

Note 15	All welding wire diameter recommendations for both chassis and unibody GMA-MIG/MAG welding specify ‘Solid-core’ wires. ‘Flux-core’ and ‘Gasless’ wires should not be used, unless specifically recommended by the vehicle manufacturer.
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Although there are inconsistencies in some specifications (dependent to some degree on the welding equipment that is being used), many subject matter experts, including welding equipment manufacturers and training institutions, provide general wire size recommendations for a range of sheet-metal thicknesses. These are typically presented in the form of charts or tables (see Image 18).

GMA-MIG/MAG (Steel) Solid Welding Wire Diameter Chart for Sheet-metals (Thickness Range of 0.6 mm to 6.0 mm)					
Sheetmetal Thickness		Recommended Wire Diameters			
Millimetres (mm)	Guage Equivalent (Approximate) (GA)	0.6 mm	0.8 mm	1.0 mm	1.2 mm
0.6	24	✓	✗	✗	✗
0.8	22	✓	✓	✗	✗
1.0	20	✓	✓	✗	✗
1.2	18	✓	✓	✓	✗
1.6	16	✗	✓	✓	✗
2.0	14	✗	✓	✓	✓
3.0	11	✗	✓	✓	✓
4.0	8	✗	✗	✓	✓
5.0	6	✗	✗	✓	✓
6.0	4	✗	✗	✓	✓

NOTE: Multiple passes may be required on 5 mm thickness or greater.

Image 18: Example of a Welding Wire Size Selection chart.

Shielding Gas Information

The shielding gases most commonly used for GMA-MIG/MAG welding repairs on both chassis and unibody structures (and often specified within Vehicle Manufacturer’s Information, for unibody welding in particular) are known as ‘mixture-gases’. These typically consist of argon (75% to 80%) which acts as the ‘inert gas’, and carbon dioxide (CO2 20% to 25%) as the ‘active’ gas (see Note 16). In most overseas markets, these mixtures are designated ‘C20’ or ‘C25’.

In New Zealand however, industrial welding gas suppliers often use their own trade names for these mixture-gases, such as ‘Argoshield Light’, ‘Shieldmix’, and ‘Coregas 07’.

Note 16	The term ‘GMA-MIG/MAG welding’ refers to the two Gas Metal Arc (GMA) welding processes used in the autobody industry, which are: <ul style="list-style-type: none"> • MIG (Metal Inert Gas) welding; and • MAG (Metal Active Gas) welding.
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Most body shop welders are set up to use a mixture-gas. However, many industry experts - and some vehicle manufacturers - now suggest that 100% CO₂ shielding gas (C100) can be used successfully when welding the thicker sheet-metals found in chassis components.

While there are some disadvantages, such as increased weld spatter and poor aesthetic appearance, 100% CO₂ shielding gas offers several advantages, including:

- deeper root penetration of the weld bead profile (see Image 19); and
- a higher rate of heat transfer, increasing weld pool fluidity; and
- cost-effectiveness (CO₂ is the least expensive of the common shielding gases); and
- improved burn-off of surface contaminants, such as grease and oil, that may remain at the weld site.

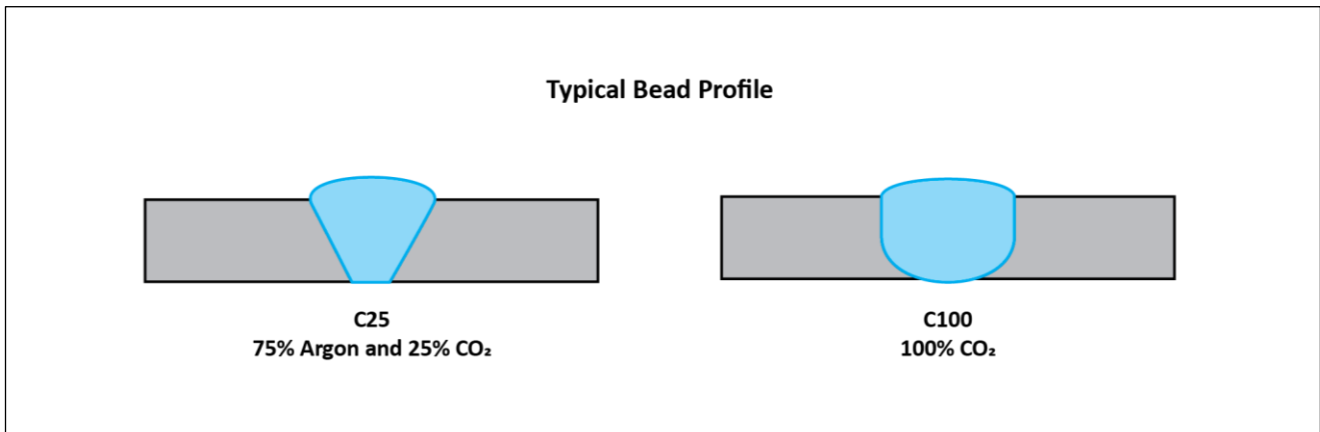


Image 19: This diagram shows the differences in weld bead profiles created by use of the two different shielding gases - Mixture Gas vs 100% CO₂.

Practice Welds to Confirm Correct Welder Settings

Before any welding is performed on a chassis, practice welds should be completed on ‘test coupons’ (see Note 17) made from the same steel type and thickness as the damaged components being replaced.

Note 17	‘Test coupon’ is an autobody repair industry term for a sample of sheet-metal material used for practicing or testing welds. Additional information about ‘practice welding’ is available in the ‘Welding Techniques’ section.
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Whenever possible, test coupons should be made from the damaged components previously removed from the chassis. This ensures the test material closely replicates the grade and thickness of the replacement components that are to be welded onto the chassis. Practice welding on test coupons enables:

- visual inspection of the weld bead quality; and
- destructive testing to confirm correct welding machine settings, and weld strength and integrity.

It is recommended that test coupon weld beads (for all three common weld joint configurations) be no longer than 50 mm (see Image 20). This mirrors the shorter weld lengths typically used on the chassis itself (as explained in the ‘Welding Techniques’ section) and makes destructive testing more manageable - because longer weld beads are harder to ‘break’ and evaluate effectively (as described in the ‘Destructive Testing of Practice Welds’ section).



Image 20: The recommended length of practice weld beads is 50 mm.

After performing practice welds on the test coupons:

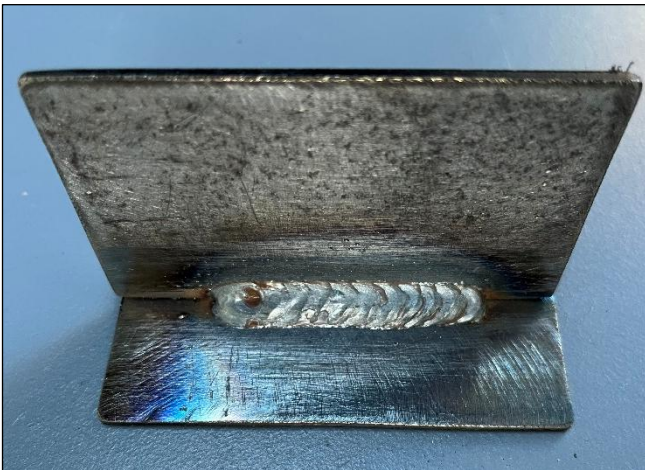
- the appearance of the weld bead should be closely inspected to ensure that it meets the criteria described in the 'Common Weld Joints Used on Chassis' sub-section (under the 'Descriptions and Specifications of the Three Common Weld Joint Configurations' section); and
- a thorough visual inspection should confirm that there is little or no porosity evident on the weld bead itself.

Destructive Testing of Practice Welds

After the weld beads on the practice coupons have been visually confirmed as satisfactory, a simple destructive test should be performed to verify weld integrity, penetration, and strength.

This test is conducted by securing the test coupons in a vice and using locking pliers to lever one of the coupons back and forth until it breaks off. Successful welds will exhibit the following results:

- Single-T joint weld (T-fillet): the weld bead should remain intact (with no cracking or splitting along the weld bead) on the base coupon. The (top) vertical coupon should exhibit full-length tear out (see Images 21 and 22).
- Single-lap joint weld (overlap-fillet): the weld bead should remain intact (with no cracking or splitting along the weld bead) on the base coupon. The top (overlapping) coupon should exhibit full-length tear out (see Images 23 and 24).
- Open-butt joint weld: the weld bead should remain intact on one of the two coupons (with no cracking or splitting along the weld bead). The other coupon (without the weld bead) should exhibit full-length tear out (see Images 25 and 26).



Images 21 and 22: Single-T joint weld (T-fillet). The weld bead remains entirely on the base coupon with full length tear out in the top (vertical) coupon.



Images 23 and 24: Single-lap joint weld (overlap-fillet). The weld bead remains entirely on the base coupon with full length tear out in the top (overlapping) coupon.



Images 25 and 26: Open-butt joint weld with bevels (single-V layout). The weld bead remains entirely on one coupon, with full length tear out in the other coupon.

Common Weld Faults

The following weld faults are commonly encountered during practice welds. Performing a thorough visual inspection and destructive test of each pair of test coupons after every weld will help identify:

- insufficient (or no) penetration into the base metal; and
- cracking or splitting (of the weld bead); and
- excessive porosity; and
- excessive weld spatter; and
- an excessive heat-affected zone (HAZ); and
- excessive or insufficient weld bead width; and
- excessive or insufficient weld bead height; and
- undercutting.

Welding Techniques

Once all preparation steps are complete and welder settings confirmed, replacement components can be aligned, clamped, and tack welded into place.

Welding procedures should take into account the following best practices:

- for open-butt welds on box-section and C-channel components (such as chassis rails or cross-members), tack welds should be positioned away from corners and tight bends (*see Image 27*); and
- a continuous weld bead should be formed using a series of short overlapping 'stitches' - achieved by momentarily releasing the trigger at regular intervals to improve control over the molten weld pool, maintain weld bead profile consistency, and minimise the HAZ (*see Image 28*); and
- each weld bead should be kept short, and completed in 'staggered' quadrants along the joint (commonly known as the 'skip technique'), to minimise distortion and heat build-up (*see Image 29*); and
- each weld quadrant should start away from tight bends or corners (such as those found on stamped box-sections and C-channel components) and proceed to weld 'through' the bend or corner. This reduces stress concentration in the weld and ensures proper penetration (which is often more difficult to achieve at corners and bends on thicker sheet-metals) (*see Image 30*).



Image 27: Position tack welds away from tight bends and corners (staggered cut joint shown).



Image 28: Create a continuous weld bead by laying down a series of overlapping 'stitches'.



Image 29: Weld in quadrants, staggering the location of each weld run to control distortion and the HAZ.

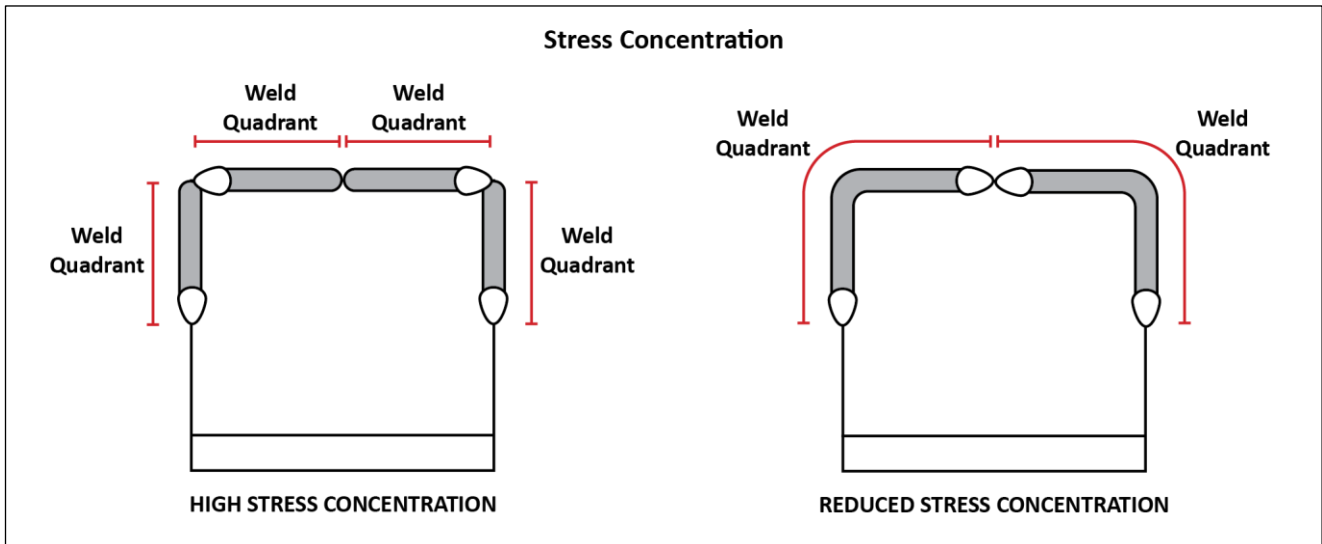


Image 30: Each weld quadrant is completed by welding through each bend or corner.

Non-destructive Testing

Visual Examination of Welds Using Liquid Penetrant Testing

For final confirmation that completed welds are free from major surface-breaking defects (such as cracks, large voids, or excessive porosity that may not be visible during a visual inspection), a non-destructive test (NDT) should be carried out using liquid penetrant testing. This process is commonly referred to as Dye Penetrant Testing (DPT) or Dye Penetrant Inspection (DPI).

A typical DPT kit includes the following components (see Image 31):

- surface cleaner; and
- dye penetrant; and
- developer.



Image 31: Example of a Dye Penetrant Inspection kit.

The Dye Penetrant Testing Procedure

Dye Penetrant Testing (DPT) should only be performed after the final surface condition of the weld has been achieved. If the weld is to be dressed or ground for cosmetic appearance, this should be completed prior to testing (see Note 18 and Images 32 and 33).

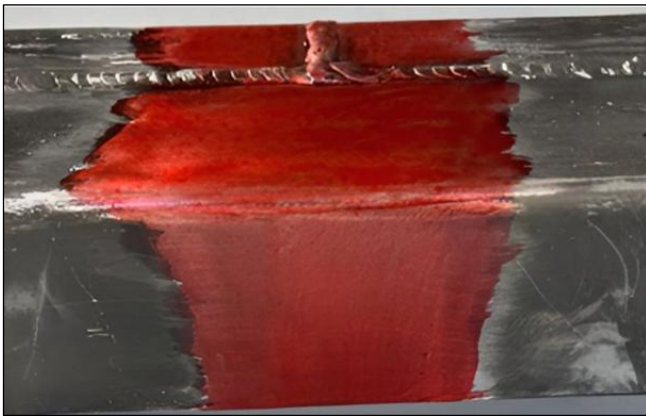
Note 18	Wherever possible, completed weld beads should be left in their as-welded condition. Grinding or dressing weld beads may reduce the overall strength of the welded joint.
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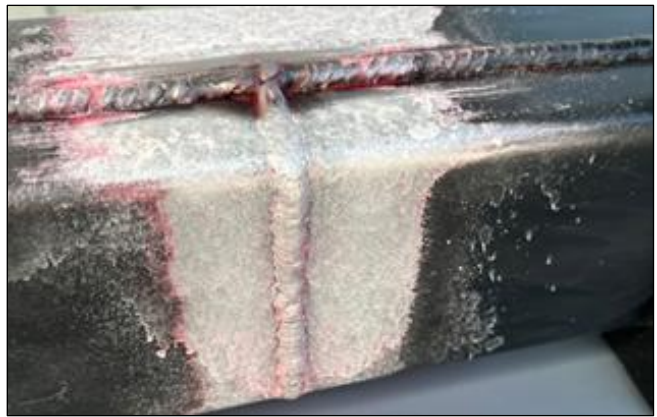
Images 32 and 33: The DPT procedure is completed only after the final surface condition of the weld has been achieved.

To perform the DPT procedure:

- remove any weld spatter and weld scale, and use the surface cleaner to thoroughly clean the weld site of any other contaminants; and
- liberally apply the dye penetrant (typically red) to the weld area and allow it to 'stand' for 10 - 15 minutes or longer (depending on product instruction), enabling capillary action to draw the dye into any surface-breaking flaws (see *Images 34 and 35*); and
- thoroughly clean the area with a clean dry cloth (to avoid false readings, take extra care to ensure that all the dye is removed on undressed weld beads); and
- spray or brush on the developer (see *Images 36 and 37*) which will draw any dye that has entered any flaws to the surface, clearly highlighting defect locations (see *Image 38*).



Images 34 and 35: Apply dye penetrant liberally and allow to 'stand' for 10 - 15 minutes (or longer).



Images 36 and 37: After cleaning off the dye penetrant, the developer draws out the locations of any surface-breaking cracks or flaws.

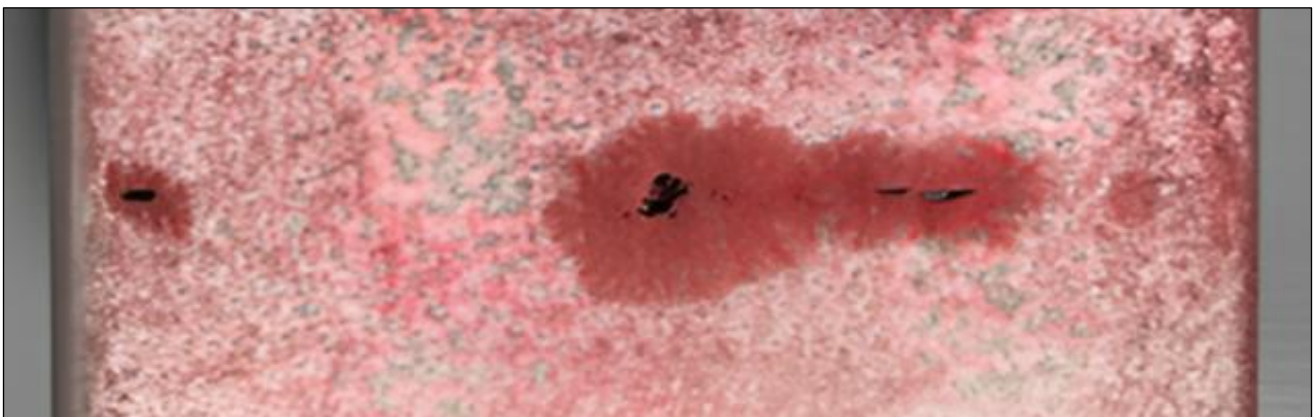


Image 38: Example of surface-breaking flaws identified by the DPT process.

Sectioning Joint Variations

Butt Joint With Backing

Some full-frame chassis vehicle manufacturers specify what is known as a ‘butt joint weld with backing’ method when sectioning certain chassis components on specific models. As the name implies, this technique incorporates welding reinforcement or backing plates behind the butt weld joint.

Currently, two vehicle manufacturers known to RepairCert NZ (and there may be others) specify this butt-welding joint method for sectioning specific chassis components (*see Note 19*), which are detailed below.

Note 19	The relevant model-specific Vehicle Manufacturer’s Information (including methods, requirements and recommendations) should be obtained, read, and understood before carrying out any sectioning procedure.
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Nissan

Vehicle Manufacturer’s Information provided by Nissan lists, for at least one of their body-over-frame models, a sectioning procedure for the front frame tip (crush horn) which uses the ‘staggered cut’ joint, in conjunction with welded backing plates (*see Image 39*). This requires that:

- backing plates are fabricated from the removed (damaged) section, and plug-welded into place using GMA-MIG/MAG plug welding (*see Note 16*); and
- a continuous GMA-MIG/MAG butt weld (*see Note 16*) is then applied over the joint.

Because Nissan does not provide any detailed welding specifications, RepairCert NZ recommends following the Best-practice Guidance outlined in this Technical Bulletin for welding procedures.

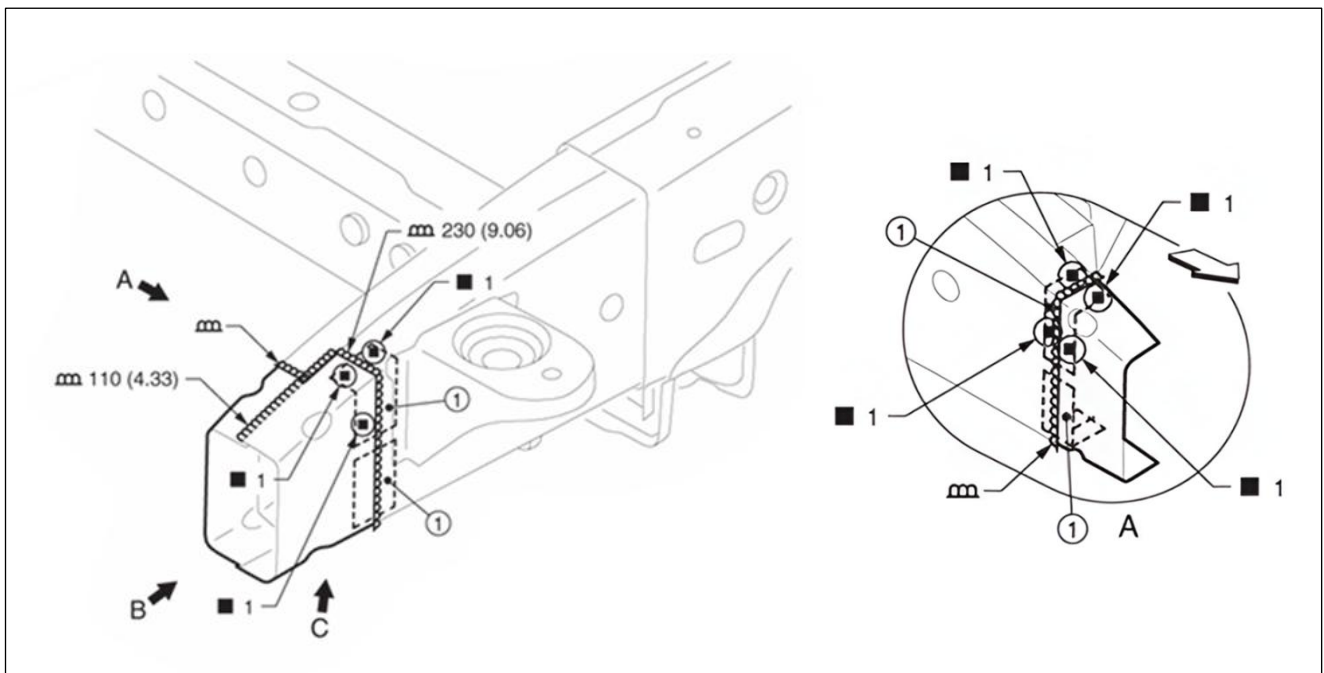


Image 39: Excerpt from a Nissan full-frame chassis sectioning procedure, showing backing plates.

Volkswagen

Vehicle Manufacturer’s Information provided by Volkswagen has a procedure for sectioning the front frame portion of the chassis on certain body-over-frame models. This procedure includes weld joint preparation instructions and requires the fabrication and installation of ‘reinforcements’.

Unlike Nissan’s approach - or the common industry practice of placing backing or reinforcement plates behind the butt joint - Volkswagen specifies that the reinforcement plates are installed on the outside of the weld joint, after the butt weld has been completed (*see Image 40*).

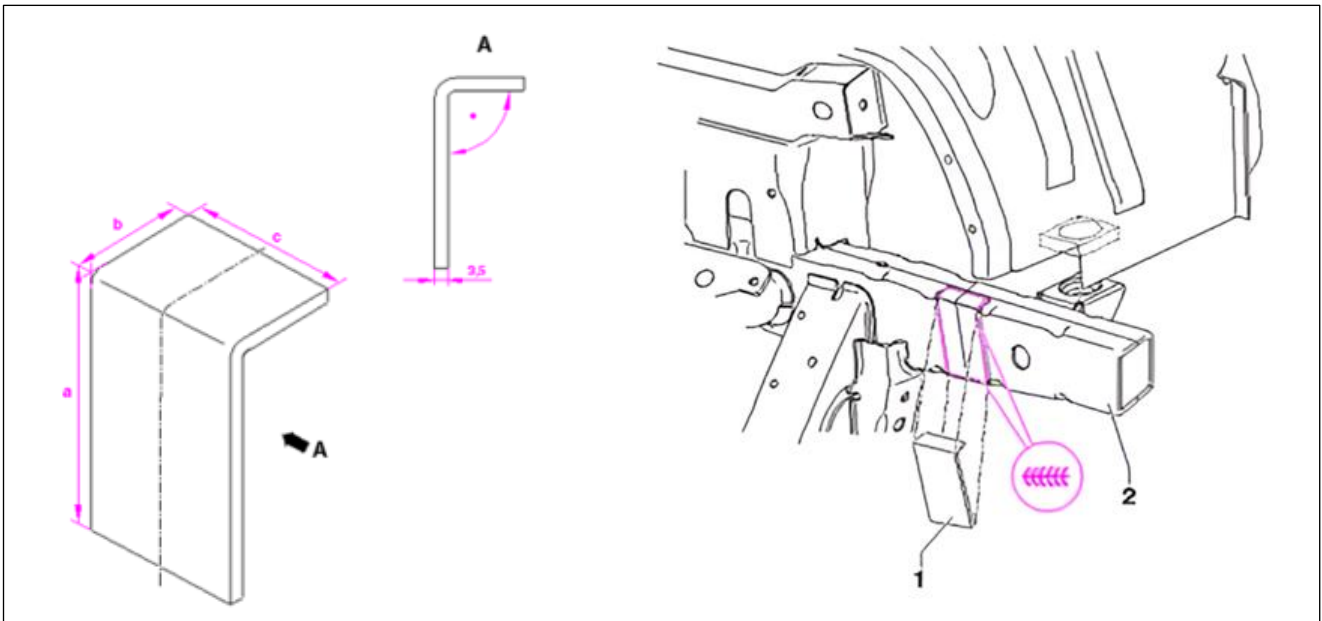


Image 40: Excerpts from the Volkswagen front chassis sectioning procedure.

Repair VIRM Requirements

Mandatory Content

While the Best-practice Guidance contained in this Technical Bulletin (up to the Repair VIRM Requirements heading above) is provided as (non-mandatory) supporting information to help a Repair Certifier achieve the best possible outcomes, the following requirements are copied from the NZTA *Repair VIRM* (consolidated for clarification) and must in all cases be applied.

Appropriate Repair Methods

Vehicle Manufacturer’s Information must be applied in the first instance, and where this is not available and relevant, then available and relevant Repair Industry Information must be applied (*see Note 1*).

The chosen repair method must be appropriate for the vehicle age and type, and the material specifications of the chassis.

Welding Technician Attributes

A person performing welding repairs to a chassis affected by collision or corrosion damage must:

- in all cases, be a suitably experienced technician, in whom the Repair Certifier has confidence; and
- in the case of a post-1990 vehicle, hold some form of welding qualification, even if not necessarily appropriate for welding the thicker materials used on a chassis (see Note 20).

Note 20	<p>The requirements for technicians carrying out ‘major body structural repairs’ are contained in the <i>Repair VIRM, Technical Bulletin 8 (Repairer categories, capabilities and requirements)</i>, which requires technicians to hold ‘current manufacturer’s, I-CAR, or equivalent welding certificates for the material being welded’. AS/NZS 1554 is referred to within the <i>Repair VIRM</i> as the required specific qualification, however, in practice, AS/NZS 1554 is not a qualification normally associated with welding repairs to light vehicles.</p> <p>For this reason, as detailed in the ‘Welding Technician Attributes’ sub-section above, a repairer must hold some form of welding qualification, must be suitably experienced, and must have the confidence of the Repair Certifier to do the work. Carefully following this RepairCert NZ Technical Bulletin will ensure that any welding performed on a chassis is fit for purpose.</p> <p>A recommended course to help a repairer develop the necessary skills for welding repairs to a chassis affected by collision or corrosion damage is I-CAR’s ‘Full-frame Steel Welding Hands-on Skills Development Course FFWO1’.</p>
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Chassis Sectioning Requirements

A chassis rail must not be sectioned during the repair of a chassis affected by collision or corrosion damage (see Notes 21 and 22):

- if the vehicle manufacturer’s instructions prohibit it; or
- if the vehicle manufacturer’s instructions relating to sectioning have not been followed; or
- where no vehicle manufacturer’s instructions relating to sectioning are available, if relevant recognised repair research organisation information has not been followed; or
- unless permitted by the vehicle manufacturer, if the sectioning is at or near:
 - engine, suspension, steering, or drive-train mounting points; or
 - crush-zones.

Note 21	Applying the Best-practice Guidance about chassis sectioning in sub-sections ‘Welding Repairs This Technical Bulletin Applies To’ and ‘When this Technical Bulletin Should Not be Used’ on pages 3 and 4 will help ensure that the sectioning requirements above have been met.
Note 22	Because the <i>Repair VIRM</i> states, as a general requirement that ‘the chosen repair method must be appropriate for the vehicle age and type, and the material specifications of the chassis’, it is a reasonable expectation that the requirements specified above for sectioning a chassis would be relaxed when sectioning an older chassis manufactured from low-strength steel (meaning typically up to 440 MPa).

General Welding Requirements

Weld defects which must not be accepted during the repair certification of welding repairs to a chassis affected by collision or corrosion damage include:

- porosity, cracks, undercut, cold lap, or poor penetration; and
- use of incorrect shielding gas or electrode wire; and
- weakened base metal (due to the application of excessive heat); and
- the use of brazing, unless explicitly authorised by the vehicle manufacturer.

Coating Requirements

Appropriate corrosion protection must be applied to any welding repairs to a chassis affected by collision or corrosion damage if the (see Note 23):

- vehicle manufacturer applied corrosion protection to the area; or
- application of post-repair corrosion protection is specified by the vehicle manufacturer; or
- application of weld-through primer is specified by the vehicle manufacturer (see Note 12).

Note 23	Click here to view <i>RepairCert NZ Technical Bulletin # 04-2025 - Corrosion: Surface Coating</i> to learn more about corrosion protection, on the RepairCert NZ website .
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In Summary

When addressing collision or corrosion damage on a vehicle with a full-frame chassis that requires welding, Repair Certifiers and autobody repairers should always first refer to any relevant and available Vehicle Manufacturer’s Information, including any variations to the sectioning joint configurations such as those described in this Technical Bulletin.

Where relevant Vehicle Manufacturer’s Information is unavailable or incomplete, then Repair Industry Information, or the Best-practice Guidance provided in this Technical Bulletin, should be followed.

Additional factors to consider include the:

- availability of replacement components; and
- location and accessibility of the affected areas; and
- tensile strengths of all related components.

Key best practices to ensure consistent, high-quality welds include:

- thorough preparation of the weld site; and
- a clear understanding of the requirements for each weld joint type; and
- use of appropriate welding equipment capable of handling thicker sheet-metals; and
- technician familiarity with setting and adjusting welding parameters.

To validate weld quality and integrity:

- perform practice welds on matching test coupons; and
- carry out destructive and non-destructive testing.

Welding techniques should be employed that minimise heat distortion, reduce stress concentration, and provide effective control of the HAZ.

By following the Best-practice Guidance in this Technical Bulletin, a Repair Certifier's decisions will be correct, and compliant with the *Compliance Rule*, *Repair Rule*, and the *Repair VIRM*.



FOR FURTHER INFORMATION PLEASE CONTACT REPAIRCERT NZ.

Image Credits

- (i) <https://www.zintilon.com/blog/mig-welding/>
- (ii) <https://amarineblog.com/2019/09/05/groove-design-bevel-preparation/>
- (iii) <https://ncsequipment.com.au/product/telwin-210-synergic-mig-welder/>

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