



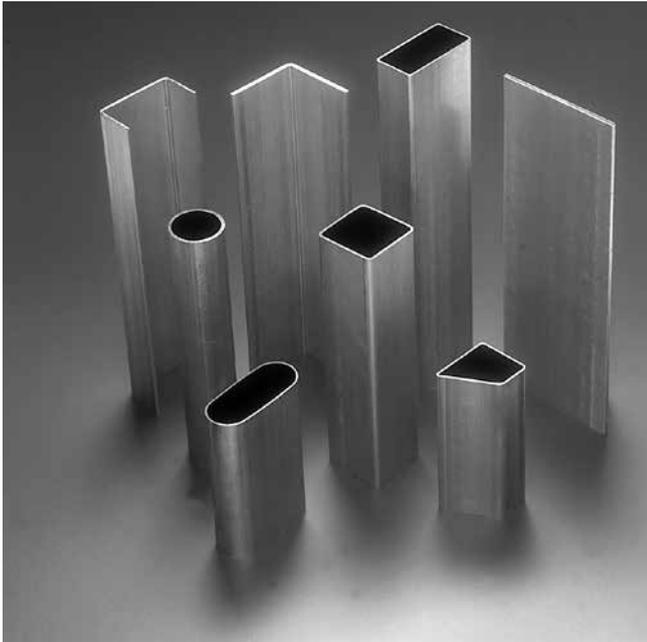
# DuraGal<sup>®</sup> Easy Welding Guide

Technical  
specifications

**DuraGal<sup>®</sup>**  
THE DIFFERENCE IS DURAGAL



**AustubeMills**  
SHAPING POSSIBILITIES



*DuraGal<sup>®</sup> and Profile products.*

## **Intent of this publication**

The intent of this publication is to provide general guidance and hints on joint preparation, consumable selection and indicative machine settings for the welding and fabrication of DuraGal<sup>®</sup> hollow sections and profiles.

For structures designed in accordance with AS 4100 and AS/NZS 4600, compliance with the requirements of the relevant parts and clauses of AS/NZS 1554 must be followed. Any advice contained in this publication must be confirmed by the establishment of welding procedures for GP or SP category welds as required by the designer.

Information on welding consumables has been provided by the consumable suppliers as listed in various sections of this publication. While current at the time of publication, they may change without notice, and users of this publication should check with the individual consumable supplier for alternatives in the event that an item is no longer available.

## The family of DuraGal<sup>®</sup> products

This guide applies to welding techniques for low carbon steel ( $CE \leq 0.39$ ) used in the DuraGal<sup>®</sup> hollow sections and profiles.

These sections, with their lustrous, thin, evenly applied zinc and zinc aluminium coatings are as readily welded as black steel. Using this guide will assist in achieving the best possible appearance and the highest quality welds with minimum spatter and fuming.

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*This welding guide was prepared with the assistance of the Welding Technology Institute of Australia.*

## The advantages of DuraGal<sup>®</sup>

Austube Mills has produced and marketed in-line galvanised (ILG) steel hollow sections (rectangular, square and circular) since the 1970's. Galtube Plus<sup>®</sup> hollow sections were first produced with the range being extended to DuraGal<sup>®</sup> hollow sections in 1990, and profiles in 1994.

These sections have been successfully fabricated and welded, and many customers have praised the ILG sections for the cost reduction provided by the surface coating.

The thin, even coating of zinc on DuraGal<sup>®</sup> and zinc aluminium on profiles means welding can be carried out safely and with minimum fuming if suitable procedures are followed.

The application of a clear passivation treatment to any of the DuraGal<sup>®</sup> products not only improves weldability and increases weld metal deposition rates, but allows most spatter that does remain on the fabrication to be easily wiped off.

DuraGal<sup>®</sup> clean smooth zinc coating allows instant work return connection (earthing) to complete the welding circuit.

Further information on DuraGal<sup>®</sup> can be found on the Austube Mills website at [www.austubemills.com](http://www.austubemills.com).

## Welding hints

The most common issues experienced in the welding of the DuraGal<sup>®</sup> hollow sections and profile products have been:

- “Burn through” or melting holes in the thinner wall sections
- Visible “worm holes” and internal porosity and/or unacceptable weld appearance
- Zinc vaporisation (explosions) and spatter.

Just a little extra care in joint preparation, slight changes in the welding technique, and the selection of correct consumables and machine settings can help avoid these common welding problems.

This publication provides general guidance and practical hints on joint preparation, consumable selection and indicative machine settings for

The welding and fabrication of DuraGal<sup>®</sup> and profile sections to assist the welder in achieving excellent results.

The advice is based on research, practical tests and field experience, and is supplementary to information given in design codes. Fabrications used in structural applications should have weld sized in accordance with the requirements of AS 4100 – Structural Steel or AS/NZS 4600 – Cold Formed Steel Structures. The joints should be prepared, and welds should be deposited in accordance with their requirements of AS/NZS 1554.1 – Welding of steel structures, and AS/NZS 1554.5 – Welding of steel structures subjected to high levels of fatigue loading.

For structural applications, the advice contained in the manual must be confirmed by the establishment of welding procedures for SP, GP or FP category welds, as required by the designer.

Information on welding consumables has been provided by consumable suppliers as listed in the various sections of this publication, they may change without notice, and users of this publication should check with the individual consumable supplier for alternatives in the event that an item is discontinued.

The machine settings provided in this manual can be used as a starting point to allow the tuning to consumables and personal preferences.

## Glossary of terms

CHS	Circular hollow sections (pipe).
Electrode stick out	The length of electrode projecting beyond the region of current pick-up during welding, also known as the contact tip to work distance (CTWD).
FCAW	Flux cored arc welding.
Flat butt	A butt weld joining two plates that are horizontal.
GMAW	Gas metal arc welding – commonly known as MIG welding.
H-fillet	Horizontal fillet – A fillet weld that has one leg on the upper side of an approximately horizontal surface and the other leg butting an approximately vertical surface.

ILG	In-line hot-dip galvanised.
LO	A charpy impact tested steel hollow section to AS/NZS 1163.
MMAW	Manual metal arc welding — commonly known as stick welding.
Profiles	Steel open sections, angle channels and flats.
RHS	Rectangular hollow section.
SHS	Square hollow section.
WTIA	Welding Technology Institute of Australia.

## Preparing joints for welding

Surfaces and edges to be welded need to be uniform, free from burrs and other contaminants such as grease or other foreign matter that would prevent proper welding taking place.

### Preparing joints in rectangular and square hollow sections

It is common practice to use smaller brace members than chord members in welded tubular construction, and in this instance joint fit-up is straight forward. The end of the smaller member is butted to the face of the larger chord and a fillet weld is made around the thinner member.

RHS or SHS branches welded to RHS or SHS chords of the same width require a combination butt/fillet weld to make the connection. A butt weld is used to attach the branch along the corner of the chord.

In cases where a 1.6 or 2.0mm branch is welded to a 4.5 or 6mm chord, and where a 3.0mm branch is welded to a 5 or 6mm thick chord, joint fit-up requires more care and attention as the corner radius of the chord member may lead to a large root gap requiring special techniques that can involve:

- Special branch end profiling
- Successive runs “buttering” on the corner radii of the chord to close the gap
- The use of backing strips

- The careful selection of welding electrode diameters to avoid the use of over-size electrodes that may result in a lack of weld penetration.

Research<sup>1</sup> has found that for MMAW a minimum root gap “G” of 4.0mm, and for GMAW a minimum root gap “G” of 3.0mm is required to allow electrode access to deposit sound quality welds. The details of gap “G” are shown in Figure 1.

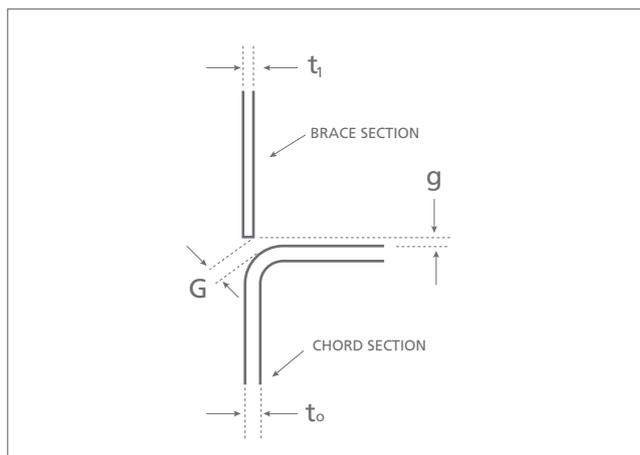


Figure 1 — Chord to branch connections.

The research was conducted on chord sections with thicknesses of 6 and 9mm, and brace members with thicknesses of 4, 5, 6 and 9mm. MMAW was undertaken with electrodes of 3.25 and 4.00mm diameter, and for GMAW 0.9 and 1.2mm diameter filler wire was used.

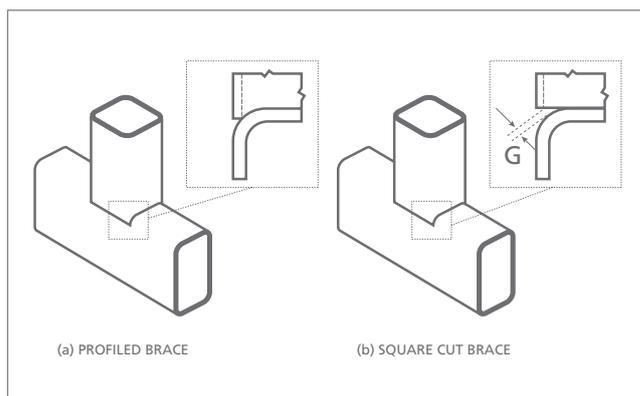


Figure 2 — Chord to branch gap details

Table 1 gives values of gap “g” required to provide the dimensions “G” determined in research<sup>1</sup> for the DuraGal<sup>®</sup> RHS and SHS sizes covered by the research<sup>1</sup>. For structural welds, AS/NZS 1554.1 and AS/NZS 1554.5 should be referred to for joint preparation requirements.

Chord Thickness $t_0$ mm	Branch Gap Dimension G (mm)					
	MMAW (stick)			GMAW (MIG)		
	$t_1$ (mm)			$t_1$ (mm)		
	4.0	5.0	6.0	4.0	5.0	6.0
6.0	1	1	2	0	0	1

Table 1 – Gap dimensions “g” for equal width RHS chord to branch connections to give a minimum root gap “G” of 4.0mm for MMAW, and a minimum root gap “G” of 3.0mm for GMAW.

Typically, when 1.6 and 2.0mm thick branches are welded to a 4, 5 or 6mm thick chord and where a 3.0mm thick branch is welded to a 5 or 6mm thick chord, this results in a larger root gap to be filled. Commonly two or more passes are deposited in the root. Firstly one or more buttering runs are deposited with the welding electrode or wire aimed at the corner of the chord to reduce the gap, then a root run is deposited to bridge the gap, again with the welding electrode or wire aimed at the corner of the chord rather than at the end of the branch.

Then the fillet welds are deposited on the other sides of the branch. Finally the finishing passes are deposited on the butt welds. This procedure minimises distortion and produces the best possible appearance at the corners. Details of the welding sequence are given in Figure 3.

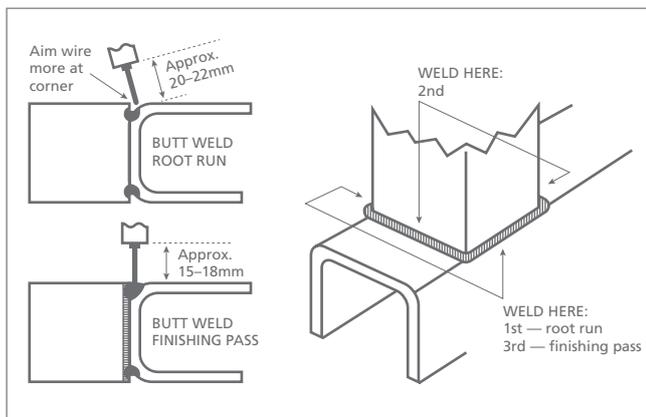


Figure 3 – Chord to branch welding sequence.

If a MIG welding machine is used, increasing the electrode stick out for the root run to 20 to 22mm (instead of the normal 12 to 18mm) reduces the chances of burn through.

Careful joint fit-up, with minimal gaps, has the following advantages:

- Reduced weld metal volumes
- Increased welding speeds
- Lower welding costs
- Elimination of burn through on thinner sections
- Reduced visible and internal porosity
- Less zinc burn back and thus less fuming.

### Preparing joints in circular hollow sections

Fully profile the branch tube to fit the mating part. This option is the most aesthetically pleasing and structurally the strongest.

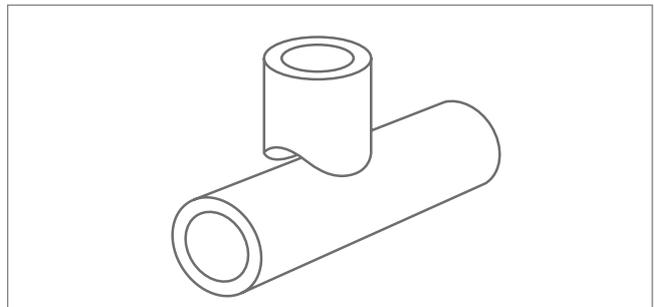


Figure 4 – CHS profile branch to chord connection.

Specialised profiling machines can automate this joint preparation. Some CAD software can prepare paper templates for CHS joining.

A similar result to the previous method, but with less perfect fit-up suitable for general non-structural applications, such as gates, can be achieved by notching. Proprietary equipment for this purpose, both manual and powered can be purchased in Australia. These simple machines can usually be used for concentric “T” joints. Specialised equipment can be purchased to process larger tube sizes and/or for “Y”s and all non-concentric joints.

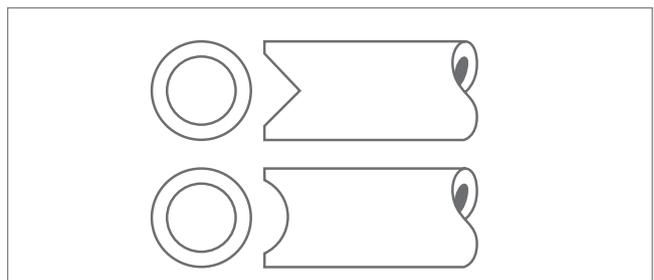


Figure 5 – CHS notched branch to chord connection.

When notching, ensure that gaps are minimised and not greater than 3mm. In the case of the V notch above, the angle of the apex will change according to the diameter of the pipe being joined.

Flattened, partially flattened, and shear flattened ends are methods of achieving good joint fit-up. All three reduce the structural capacity of the CHS to some extent.

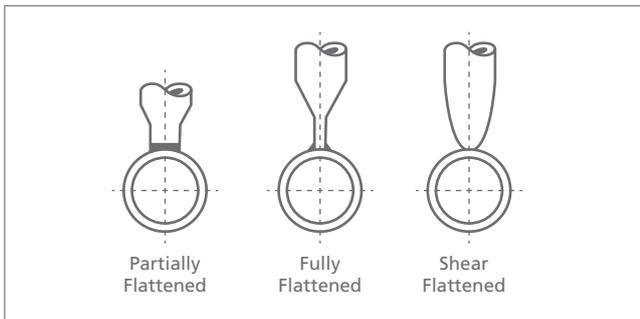


Figure 6 – CHS flattened end branch to chord connection.

## Fatigue

Austube Mills has commissioned research into the fatigue performance of welded connections in DuraGal<sup>®</sup> hollow sections and profile sections. Upon request, Austube Mills can provide advice on joint preparation and predicted fatigue life for welded connections in DuraGal<sup>®</sup> products.

## Weld size

### Reduce the size of the weld to a minimum

It can be wasteful to deposit welds with design throat thickness greater than the thickness of the thinner part being joined.

The advantages of minimising weld sizes are:

- Reduced production costs
- Reduced consumable use
- Reduced fuming and zinc burn back
- Reduced distortion.

It may be necessary to use a weld with a greater design throat thickness than the thinnest component. This is likely to occur when:

- For a fillet weld, when the tensile load in the thinnest component is above 40% of the component's capacity.

- For a butt weld, when the tensile load in the thinnest component is above 60% of the component's capacity.
- The electrode filler wire is of lower strength than the component being welded
- One or some of the components of the fabrication are of lower strength than the thinnest.

### Don't increase the heat to weld the family of DuraGal<sup>®</sup> products.

The instinctive reaction of some welders, when required to weld galvanised steel, is to substantially increase the voltage and/or amperage to burn away the zinc coating.

Austube Mills world leading ILG process ensures that welding DuraGal<sup>®</sup> hollow sections and profiles is as easy as welding uncoated steel. Only a small increase in weld heat is required to weld DuraGal<sup>®</sup> hollow sections and profiles.

Not "turning up the heat" on DuraGal<sup>®</sup> and profiles will result in the following advantages:

- Reduced zinc vaporisation (explosions)
- Reduced spatter
- Elimination or reduction of visible and internal porosity
- Minimal fuming
- Minimal burn back of the zinc coating.

A testing program carried out in conjunction with WTIA, BOC GASES and the Co-Operative Research Centre for Welded Structures using the GMAW welding process has shown that, compared to black steel, a 0.5 to 2 volt increase is enough to maintain a given arc length if welding speed is kept constant.

### Preheating is GENERALLY unnecessary

All of Austube Mills steel sections, including the ILG types, are made from steels with carbon equivalents (CE) less than or equal to 0.43. Economical joints made from these steels do not generally require preheat. Of course welding should generally not be carried out when the metal temperature is below 0°C or if the surface is damp. Refer AS/NZS 1554.1 for further information.

## **Recommended welding machine settings and consumables**

The following tables and data sheets in each section set out the initial welding parameters that should be an adequate starting point for most operators.

### **Explanation of gas metal arc and flux cored welding terms.**

#### **Voltage**

The voltages are working voltages, measured between the current pick-up for torch at the wire feed block and the welding workpiece.

#### **Current**

The current given in the data sheets is dependent on wire feed rates, voltage and electrode stick out.

#### **Electrode stick out**

The electrode stick out is taken to be equal to the distance between the contact tip to workpiece distance (CTWD) for currents at or below 200 Amps except in pulsed transfer welding. In the data sheets values between 12 to 18mm are used.

With conventional GMAW power sources an increase in electrode stick out at a given voltage setting will cause a reduction in the current.

#### **Inductance**

Where adjustable, higher inductance gives slightly lower spatter and increased heat input, if set too high a wire “Stubbing” effect may occur.

#### **New generation power sources**

Power sources offering “improved dip transfer” may be beneficial in providing low spatter stable transfer under CO<sub>2</sub> shielding gas.

Some units are optimised for GMAW with coated steels, whilst others use special control waveforms to enhance performance.

Most leading manufacturers can provide assistance on whether they have machines in this category.

## Manual metal arc welding (MMAW) — “stick”



### Use the right type of electrode

Most general purpose (GP) rods suit DuraGal<sup>®</sup> products including profile sections. Refer to the chart on the next page.

### For superior appearance

Use AS/NZS 4855 E4312 electrodes. This type of electrode is ‘all positional’ and will give a smooth weld with no visible porosity. The fluid slag and softer arc action of these electrodes allow the gases formed during welding to escape into the slag before the weld solidifies.

These electrodes give welds with a minimum yield strength of 350 MPa. These electrodes will only be suitable for welding joints in 450 MPa DuraGal fabrications when the loads to be carried are lower than the allowable capacity of the weld group.

When GP electrodes cannot give a suitable joint capacity, use the electrodes suggested in the next section.

### For strength

For increased strength use E49XX rather than E43XX electrodes.

### For strength, Charpy impact performance and crack resistance

For strength and/or Charpy impact performance use low hydrogen electrodes conforming to AS/NZS 4855 E4918-2 or AS/NZS 1553.1 - E4916-2. See the comparison table on the following page.

This type of electrode requires the attention of a more experienced welder than the AS/NZS 4855 E4312-0 type, mentioned in the previous section, and may produce a little more spatter. Better fit-up may be required.

### The recommended electrode diameter depends on the thickness of the DuraGal<sup>®</sup> product

The preferred electrode diameters are set out in ‘recommended welding machine settings and consumables’.

During the testing carried out in conjunction with manufacturers of electrodes to develop the recommended welder settings, 1.6mm to 5.0mm thick DuraGal<sup>®</sup> products were welded using 2.5mm and 3.2mm diameter electrodes at low power settings. This combination of readily available consumables and low power settings is preferred, but in the hands of an inexperienced welder welding thin wall steel sections, may result in undercut which will reduce joint strength and make the slag harder to detach.

Less experienced welders may find it easier to use a smaller diameter electrode, (when available in the required AS/NZS 4855 or AS/NZS 1553.1 classification), such as 2.0mm, to weld the thinner ILG sections until they have refined their technique.

## MMAW welding consumable comparisons

Classification		BOC	CIGWELD	Lincoln Electric	LiquidArc	WIA	Comments
AS/NZS 4855	AS/NZS 1553.1						
B E4311 A	E4112-0	Smootharc 12	GP 6012, Murex Speedex 12		EasyArc Supa 12		Medium strength, good appearance
B E4312A				Supa Easyarc 6012			Medium strength, good appearance
B E4313 A			Ferrocrafft 12XP Satincraft 13	Pantafix Easyarc 6013		Austarc 12P Austarc 13S	Medium strength, good appearance
B E4313 F	E4113-0	Smootharc 13			EasyArc Supa 13		Medium strength
B E4303 A U	E4113-2		Weldcraft				Medium strength, good impact
B E4914 A U	E4814-2		Ferrocrafft 21				High strength, high deposition and good impact suitable for LO material
B E4916 A U H5R				ConArc 51			Higher strength, very low hydrogen, coating resistant to moisture pick up
B E4916 A U H10	E4816-2 H10		Ferrocrafft 16 Twincoat Ferrocrafft 55U		EasyArc Supa 16		Higher strength, good impact, low hydrogen
B E4916 A U H10	E4816-3 H10		Ferrocrafft 7016				Higher strength, good impact, low hydrogen
	E4816-4 H10					Austarc 16TC	Higher strength, better impact, low hydrogen
	E4816-4 H5	Smootharc 16					Higher strength, better impact, very low hydrogen
B E4916 A U H5R	E4816-4 H5			Conarc 51			Higher strength, better impact, very low hydrogen, coating resistant to moisture pick up
B E4918 A U H10	E4818-2 H5				EasyArc Supa 18		High strength, good impact, low hydrogen, higher deposition & easier to use than E4816 types
B E4918 A U H10	E4818-3 H10		Ferrocrafft 61				High strength, good impact, low hydrogen, higher deposition & easier to use than E4816 types
B E4918-1 A U H5	E4818-4 H5	Smootharc 18		Jetweld LH-70 Conarc 49C			High strength, better impact, very low hydrogen, higher deposition & easier to use than E4816 types
B E4918-2 A U H5	E4818-5 H5R		Ferrocrafft 61 H4			Austarc 77	High strength, best impact, low hydrogen, higher deposition & easier to use than E4816 types
B E4918 A U H5R	E4818-5 H5					Austarc 18TC	High strength, good impact, very low hydrogen, coating resistant to moisture pick up, higher deposition & easier to use than E4816 types
B E4924 A	E4824-0	Smootharc 24	Ferrocrafft 22	Ferrod 185T	EasyArc Supa 24	Austarc 24	High strength, fast down hand welding
B E4924 A	E4824-2			Ferrod 135T Ferrod 165A			High strength, good impact, fast down hand welding

## Hints for selection of appropriate electrodes

**Hint 1** — E4312, E4313 and E4918 electrodes operate with a quiet, medium penetrating arc with low spatter.

**Hint 2** — E4916 electrodes operate with a quiet, medium penetrating arc with globular transfer of metal from the electrode to the weld pool and medium spatter.

**Hint 3** — E4312 electrodes are noted for general ease of handling in all weld positions and an ability to bridge gaps in work having poor fit-up. Some may be suitable for vertical down welding.

**Hint 4** — E4313 electrodes have similar characteristics to E4312 electrodes but more suitable for welding in the vertical up and overhead positions.

**Hint 5** — E4914 electrodes offer higher strength, higher deposition rates, can be used in all positions and are more tolerant to poor fit-up. They have a less penetrating arc than E4312, E4313 or E4918 types.

**Hint 6** — For Charpy impact performance choose an electrode with a E4 XXX XXX X 0, E4 XXX XXX X 2, E4 XXX XXX X 3, E4 XXX XXX X 4, E4 XXX XXX X 5 or E4 XXX XXX X 6 classification.

**Hint 7** — E4916 and E4918 electrodes are known as low hydrogen and are recommended on heavier sections where cracking of the weld metal or heat affected zone may occur. These electrodes require careful conditioning and a higher skill level to get best results.

**Hint 8** — If using EXX16 or EXX18 electrodes (Low Hydrogen types) a d.c. output machine is recommended.

## Settings — typical for AS/NZS 1553.1 E4312 and E4313 electrodes

Wall Thickness mm	Weld type	Electrode size mm	Weld size mm	Arc Volts V	Current Amps A	Travel Speed mm/min	Heat Input KJ/mm
1.6	Fillet	2.0	3.0	24	50	190	0.38
1.6	Butt	2.0	1.6	24	50	135	0.53
1.6	Fillet	2.5	3.2	24	70	265	0.38
1.6	Butt	2.5	1.6	24	75	205	0.53
3.2	Fillet	3.2	4.8	24	105	155	0.98
3.2	Butt	3.2	3.2	24	115	110	1.5
5.0	Fillet	3.2	7	24	130	90	2.08
5.0	Butt*	3.2	5.0	24	130	140	1.37
5.0	Fillet	4.0	7	24	150	105	2.08
5.0	Butt*	4.0	5.0	24	170	160	1.37

\* Two runs required

## Settings — typical for AS/NZS 1553.1 E4914 and E4918 electrodes

Wall Thickness mm	Weld type	Electrode size mm	Weld size mm	Arc Volts V	Current Amps A	Travel Speed mm/min	Heat Input KJ/mm
1.6	Fillet	2.5	3.2	24	75	310	0.35
1.6	Butt	2.5	1.6	24	75	272	0.42
3.2	Fillet	3.2	4.8	24	105	195	0.78
3.2	Butt	3.2	3.2	24	115	140	1.20
5.0	Fillet	3.2	7	24	120	105	1.66
5.0	Butt*	3.2	5.0	24	125	150	1.22
5.0	Fillet	4.0	7	24	150	130	1.66
5.0	Butt*	4.0	5.0	24	170	200	1.22

\* Two runs required

## Gas metal arc welding (GMAW) – “MIG”

### Use the right type of wire

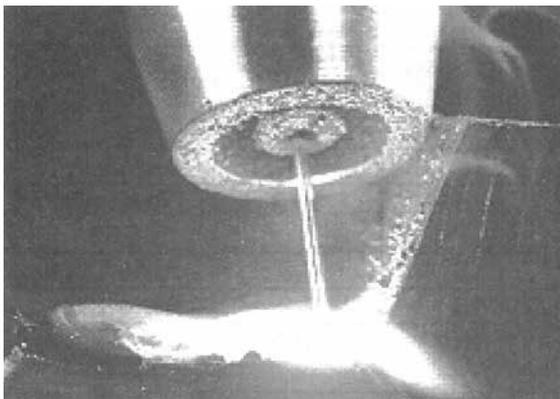
The recommended wires for GMAW Welding are AS/NZS 2717.1 ES4 or ES6 types. These are AS/NZS 2717.1 ES4-GX-W502XHx or ES6-GX-W502XHx specification wires and their performance will exceed that required to make use of the strength and LO properties of DuraGal<sup>®</sup> Hollow Sections and Profiles.

Note: Generally, W503XHx wires are more readily available and can be used in place of the W4502XHx wire.

### The recommended wire diameter is 0.9mm

Testing at manufacturers facilities has shown that 0.9mm wire reduces spatter and the risk of porosity while still allowing economical welding rates. Using this diameter wire decreases the amp to volt ratio which gives increased weld pool fluidity, reduced weld pool depth to width ratio and thus allows more time for gases to escape from the pool.

Note: For larger weld beads 1.2mm wire can be used but spatter and porosity levels may increase.



### For DuraGal<sup>®</sup> the preferred gas is an Argon + CO<sub>2</sub> mix (up to 25% CO<sub>2</sub>)

Austube Mills, through practical experience in the use of ILG hollow sections in its own manufacturing operations, has found that welding grade CO<sub>2</sub> reduces the likelihood of visible and internal porosity when welding DuraGal<sup>®</sup> products. This has been confirmed by independent testing by gas and consumable manufacturers.

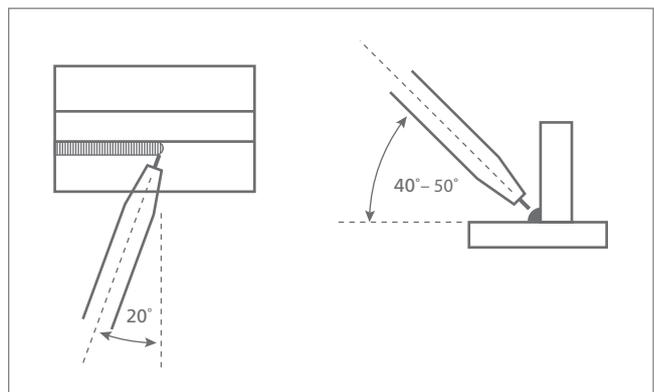
Welding Grade CO<sub>2</sub> may lead to high spatter levels and may be impracticable for thinner sections.

Argon based mixed shielding gases with high CO<sub>2</sub>, typically 15 to 25% CO<sub>2</sub>, whilst still suitable for welding black and painted material, are recommended for most applications because of their versatility, wide operating envelope, reduced spatter and high weld speed capacity. Spatter levels with these mixed gases are very low due to increased arc stability. Weld appearance is excellent, and weld internal porosity is generally low.

Argon based mixed shielding gases with less than 15% CO<sub>2</sub> are very widely used, primarily for welding black steel. Experienced welders can achieve welds of excellent appearance with a weld quality suitable for many applications when fabricating DuraGal<sup>®</sup> products.

### When MIG welding, a handpiece lead angle of 20°, is recommended

Testing has shown that inclining the MIG handpiece 20°, with the wire pointing in the direction of travel, known as forehand welding, substantially reduces porosity and nozzle cleaning frequency. For fillet welds the lateral angle should be between 40° and 50°.



**(Dip or short arc transfer)**

**GMAW welding consumable comparisons**

AS/NZS 14341 Classification	AS/NZS 2717.1 Classification	Shielding Gas	BOC	CIGWELD	Lincoln	LiquidArc	WIA	Comments
B-G49A 3 C1 S4	ES4-GC-W503AH	Welding Grade CO <sub>2</sub>		Autocraft LW1	UltraMag S4	Steelultramig S4	Austmig ES4	Suitable for all DuraGal <sup>®</sup> products – welding using CO <sub>2</sub> shielding for lowest porosity levels
B-G49A 3 M20 S4	ES4-GM-W503AH	Argon +15% - 25% CO <sub>2</sub>		Autocraft LW1	UltraMag S4	Steelultramig S4	Austmig ES4	Suitable for all DuraGal <sup>®</sup> products – welding using shielding for lowest spatter levels
B-G49A 3 C1 S4	ES6-GC-W503AH	Welding Grade CO <sub>2</sub>	BOC Mild Steel MIG Wire	Autocraft LW1-6	UltraMag S6	Steelultramig S6	Austmig ES6	Suitable for all DuraGal <sup>®</sup> products – welding using shielding for lowest porosity levels
B-G49A 3 M20 S6	ES6-GM-W503AH	Argon +15% - 25% CO <sub>2</sub>	BOC Mild Steel MIG Wire	Autocraft LW1-6	UltraMag S6	Steelultramig S6	Austmig ES6	Suitable for all DuraGal <sup>®</sup> products – welding using shielding for lowest spatter levels

**Hints for selection of appropriate electrodes and shielding gas**

**Hint 1** – ES4 – provides adequate strength and deoxidation in most applications and can be used with either welding grade CO<sub>2</sub> or Argon + CO<sub>2</sub> shielding.

**Hint 2** – ES6 – for highest quality welding using welding grade CO<sub>2</sub> shielding – has the highest combination of manganese and silicon, permitting high penetration sound welds even on relatively poor (rusty) surfaces.

**Hint 3** – For optimal results, use the wire manufacturers recommended shielding gas mixtures.

**Hint 4** – Welding grade CO<sub>2</sub> has a C Group classification and provides the deepest and broadest penetration pattern, used only for thicker sections, it reduces the likelihood of visible and internal porosity. Low cost, but narrowest operating range. Spatter levels are high compared to Argon based mixed gases.

**Hint 5** – Select Argon + CO<sub>2</sub> (15-25%) where reduced spatter is important but good penetration is needed. Internal porosity is generally low. Usually the best choice for thicker material. The useful operating range is increased within this range of CO<sub>2</sub> levels. For best results a Argon + CO<sub>2</sub> content of 25% should not be exceeded.

**Hint 6** – Argon based gases with less than 15% CO<sub>2</sub> are widely used in the welding of black steel. Experienced welders can achieve welds of excellent appearance with these gases when fabricating the thinner profile sections.

**Hint 7** – Oxygen when added to Argon + CO<sub>2</sub> mixtures in amounts up to 7% stabilises the arc and reduces the surface tension, helping to prevent undercut on the edge of fillet welds and improves appearance. However oxygen reduces the ease of use for positional work because of the reduced surface tension. A straight Ar + CO<sub>2</sub> would be better for positional work.

**Hint 8** – AS/NZS 2717.1 group M1 & M2 gases (see page 23) are generally more suited to thinner sections or positional welding, where minimal spatter is important and deep penetration is not necessary. Porosity levels may be higher.

The gases in these groups can operate in spray transfer, dip transfer or globular transfer modes.

Argon mixtures with M1 classification provide the least penetration, increasing the amount of carbon dioxide or oxygen or both, increases the depth and width of penetration.

**Hint 9** – AS/NZS 2717.1 group M3 & C gases (see page 23) are generally employed for highest penetration applications and for positional welding with heavier sections using the dip transfer technique. GMAW Spray transfer applications are unachievable with M3 or C group gases.

**Hint 10** – Argon + Carbon Dioxide + Helium mixtures while more expensive, provide for very favourable heat input, wide weld bead profile and penetration. Welding speeds can be very high, and this can have economical advantages over lower cost gases.

## GMAW with silicon bronze filler wire — also known as MIG brazing

GMAW with Silicon Bronze filler wire (AWS A5.7 ERCuSi-A) gives very good results on zinc coated steel especially for joining thin walled ( $\leq 1.6\text{mm}$ ) sections. This type of wire is used extensively in the automotive and fencing industries and is used where 100% joint efficiency IS NOT required.

The benefits are lower heat input, less coating damage and excellent corrosion performance. 0.9mm diameter wire is normally recommended and this may be operated with conventional GMAW power sources in the range 100 to 200 Amps at 18 to 25 volts under Argon or (Argon + 1 to 2% O<sub>2</sub>) or (Argon + 5% CO<sub>2</sub> + 2 to 3% O<sub>2</sub> shielding).

### Data Sheet 1 of 12

Power Source: Conventional MIG  
Shielding Gas: Welding Quality Carbon Dioxide

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	3.5	2.7	66	18.00	255	0.28
2.5	3.4	78	19.75	212	0.44	
3.5	4.3	99	20.25	237	0.51	
5.7	5.6	120	23.25	212	0.79	

### Data Sheet 2 of 12

Power Source: Conventional MIG  
Shielding Gas: Argon + 23 to 25% Carbon Dioxide

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	3.9	84	18.25	365	0.25
2	4	3.2	72	17.75	237	0.32
3	5	5.8	129	18.75	250	0.58
5	6	10.1	186	24.25	273	0.99

### Data Sheet 3 of 12

Power Source: Conventional MIG  
Shielding Gas: Argon + 16 to 18% Carbon Dioxide + 2 to 2.5% Oxygen

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	3.8	81	18.75	332	0.27
2	4	3.2	72	17.50	194	0.39
3	5	5.6	129	20.50	290	0.55
5	6	8.7	174	24.00	309	0.81

Note: AWS/ASME-SFA A5.7 ERCuSi-A Silicon Bronze filler wire typically has material yield strength of 170 MPa and tensile strength of 380 MPa, compared with AS/NZS 2717:1 W502XH electrode wire with yield strength of 390 MPa and tensile strength of 500 MPa. Typical settings: 0.9mm wire, 18 V, 100 Amps, 6.75mm/min Wire Feed Speed, 385mm/min Travel Speed, Electrode stick out 12mm, Shielding gas (Argon +5% CO<sub>2</sub> + 2 to 3% O<sub>2</sub>)

## MIG (GMAW) – steel filler wire with shielding gases

Material	DuraGal <sup>®</sup> RHS
Joint Type	Butt Fillet
Position	Flat Butt Horizontal
Polarity	Electrode +ve
Wire Type	AS/NZS 2717:1 ES4/6-GC/M-503AH
Wire Diameter	0.9mm
Gas Flow Rate	15 l/min
Electrode stick out	12 to 18mm (CTWD)
Welding Method	Dip Transfer

### Data Sheet 4 of 12

Power Source: Conventional MIG

Shielding Gas: Argon + 5% Carbon Dioxide + 2 to 3% Oxygen

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	3.6	81	17.75	267	0.32
2	4	3.3	78	18.00	207	0.41
3	5	5.6	129	20.75	295	0.54
5	6	9.8	186	24.25	289	0.94

### Data Sheet 5 of 12

Power Source: Inverter MIG

Shielding Gas: Welding Quality Carbon Dioxide

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	2.8	63	22.00	227	0.37
2	4	3.9	90	21.50	243	0.48
3	5	5.3	105	24.75	250	0.62
4	4.5	5	118	20.6	299	0.46
4	5	7.5	149	21.6	386	0.49
4	5.5	10	191	22.2	426	0.57
5	6	6.6	135	24.50	220	0.90

### Data Sheet 6 of 12

Power Source : Inverter MIG

Shielding Gas : Argon + 23 to 25% Carbon Dioxide

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	2.7	60	18.25	306	0.21
2	4	4.2	99	18.25	246	0.44
3	5	5.0	117	20.75	285	0.51
4	4.5	5	110	20.75	299	0.44
4	5	7.5	155	21.25	386	0.51
4	5.5	10	205	21.0	426	0.56
5	6	6.2	138	22.25	228	0.81

### Data Sheet 7 of 12

Power Source: Inverter MIG

Shielding Gas: Argon + 16 to 18% Carbon Dioxide + 2 to 2.5% Oxygen

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	2.6	75	19.00	330	0.26
2	4	3.3	93	20.00	300	0.37
3	5	4.6	115	21.00	295	0.49
5	6	6.9	150	22.25	320	0.63

**Data Sheet 8 of 12**

Power Source: Inverter MIG

Shielding Gas: Argon + 5% Carbon Dioxide + 2 to 3.1% Oxygen

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
4	4.5	5	104	18.5	299	0.36
4	5	7.5	156	19.3	386	0.43
4	5.5	10	195	20.6	426	0.51

**Data Sheet 9 of 12**

Power Source: Conventional MIG – Transistorised

Shielding Gas: Welding Quality Carbon Dioxide

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	3.0	63	16.50	250	0.25
2	5	3.6	78	18.25	227	0.38
3	5	6.0	129	19.50	230	0.66
5	6	7.9	158	23.50	206	1.08

**Data Sheet 10 of 12**

Power Source: Conventional MIG – Transistorised

Shielding Gas: Argon + 23 to 25% Carbon Dioxide

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	5.1	111	15.75	299	0.35
2	5	5.2	108	18.00	262	0.45
3	5	5.7	123	17.50	235	0.55
5	6.5	6.3	144	21.00	242	0.75

**Data Sheet 11 of 12**

Power Source: Conventional MIG – Transistorised

Shielding Gas: Argon + 16 to 18% Carbon Dioxide + 2 to 2.5% Oxygen

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
1.6	4	2.6	78	19.50	333	0.27
2	5	3.4	93	20.25	300	0.38
3	5	4.4	114	21.25	295	0.49
5	6.5	7.1	153	22.25	327	0.62

**Data Sheet 11 of 12**

Power Source: Conventional MIG – Transistorised

Shielding Gas: Argon + 5 to 7% Oxygen

Wall thickness mm	Fillet leg length mm	Wire Feed Speed m/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
2	3	9.8	180	25.50	500	0.55
3	3	9.6	171	23.25	500	0.48
4	4	11.9	192	26.25	429	0.70
5	4	10.1	180	23.00	346	0.72
6	5	11.9	189	25.00	400	0.71

## Pulsed GMAW welding – manual

This type of GMAW has some of the advantages of both dip transfer and spray arc, and can be used with Argon based mixtures of both CO<sub>2</sub> and Helium.

The advantages of both the Argon + CO<sub>2</sub> and Argon + Helium + CO<sub>2</sub> mixtures is a more stable arc, less prone to short circuits caused by vaporised zinc in the arc, and thus less spatter.

A small percentage of O<sub>2</sub> added to an Argon + CO<sub>2</sub> mix improves edge wetting and appearance.

The Argon+Helium+CO<sub>2</sub> mix appears to perform slightly better than the Argon+CO<sub>2</sub>+O<sub>2</sub>.

Note: Welding Grade CO<sub>2</sub> cannot be used when GMAW Pulse welding. This gas does not allow the pulsed arc to be maintained.

### Pulsed GMAW – consumable comparisons

AS/NZS 14341 Classification	AS/NZS 27171 Classification	Shielding Gas	BOC	CIGWELD	Lincoln	LiquidArc	WIA	Comments
B-G49A 3 M20 S4	ES4-GM-W503AH	Argon + CO <sub>2</sub> , or Argon + CO <sub>2</sub> + O <sub>2</sub> , or Argon + CO <sub>2</sub> + He		Autocraft LW1	UltraMag S4	Steelultramig S4	Austmig ES4	Suitable for all DuraGal products – Use for lowest spatter levels
B-G49A 3 M20 S6	ES6-GM-W503AH	Argon + CO <sub>2</sub> , or Argon + CO <sub>2</sub> + O <sub>2</sub> , or Argon + CO <sub>2</sub> + He	BOC Mild Steel MIG Wire	Autocraft LW1-6	UltraMag S6	Steelultramig S6	Austmig ES6	Suitable for all DuraGal products – Use for lowest spatter levels

### Hints for selection of appropriate electrodes and shielding gas

**Hint 1** – ES4 – provides adequate strength and deoxidation in most applications and can be used with either Argon + CO<sub>2</sub> or Argon + Helium + CO<sub>2</sub> shielding.

**Hint 2** – ES6 – for higher deoxidation with the highest combination of manganese and silicon, permitting sound welds even on relatively poor (rusty) surfaces.

**Hint 3** – For optimal results, use the wire manufacturers recommended shielding gas mixtures.

**Hint 4** – Select Argon + CO<sub>2</sub> shielding for economy. Spatter levels will be slightly higher than for Argon + Helium + CO<sub>2</sub> types.

**Hint 5** – Select Argon + Helium + CO<sub>2</sub> where

minimal spatter is important. This gas gives best performance but at extra cost.

**Hint 6** – Select Argon + CO<sub>2</sub> + O<sub>2</sub> shielding for improved edge wetting and appearance particularly on thinner materials.

**Hint 7** – For pulse welding, arc stability is also a function of available machine settings as much as the shielding gas.

### Pulsed GMAW (MIG) with shielding gases

Material	DuraGal <sup>®</sup> RHS
Joint Type	Butt Fillet
Position	Flat Horizontal
Polarity	Electrode +ve
Wire Type	AS/NZS 27171 ES4/6-GC/M-503AH
Wire Diameter	0.9 mm
Gas Flow Rate	20 l/min
Welding Method	Pulsed Spray Transfer

### Data Sheet 1 of 1

Power Source: Conventional MIG

Shielding Gas: Argon + CO<sub>2</sub> or Argon + Helium + CO<sub>2</sub>

Wall thickness mm	Fillet leg length mm	Wire Feed Speed mm/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
2	3	8.4	138	25.50	600	0.35
3	3	8.4	141	24.25	500	0.41
4	4	12.1	168	27.75	500	0.56
5	4	15.9	195	31.00	500	0.73
6	5	15.9	195	31.00	350	1.04

## Pulsed GMAW welding – robotic

Robotic welding using pulsed GMAW has all the advantages of the manual version of this process, with the ability to substantially increase arc travel speeds.

## Gas metal arc welding (GMAW) – spray transfer

Experienced welders can achieve sound attractive welds at very high welding rates using this technique. Welds of excellent appearance can be produced with low spatter.

These welds generally show no visible porosity and low levels of internal porosity. The successful use of spray transfer welding requires the components

to have good joint fit-up and the material to be thick enough to support the heat input. The thinner the steel being welded the better the joint fit up required.

Spray arc is mostly used for butt welds in the flat or downhand position and fillet welds in the flat or horizontal/vertical position.

### SPRAY GMAW – consumable comparisons

AS/NZS 14341 Classification	AS/NZS 2717.1 Classification	Shielding Gas	BOC	CIGWELD	LINCOLN	LiquidArc	WIA	Comments
B-G49A 3 M20 S4	ES4-GM-W503AH	Argon + CO <sub>2</sub> , or Argon + CO <sub>2</sub> + O <sub>2</sub> , or Argon + CO <sub>2</sub> + He		Autocraft LW1	UltraMag S4	Steelultramig S4	Austmig ES4	Suitable for all DuraGal' products – Use Argon + CO <sub>2</sub> + He or lowest spatter levels
B-G49A 3 M20 S6	ES6-GM-W503AH	Argon + CO <sub>2</sub> , or Argon + CO <sub>2</sub> + O <sub>2</sub> , or Argon + CO <sub>2</sub> + He	BOC Mild Steel MIG Wire	Autocraft LW1-6	UltraMag S6	Steelultramig S6	Austmig ES6	Suitable for all DuraGal' products – Use Argon + CO <sub>2</sub> + He or lowest spatter levels

## Hints for selection of appropriate electrodes and shielding gas

**Hint 1** — ES4 provides adequate strength and deoxidation in most applications and can be used with either Argon + CO<sub>2</sub> or Argon + Helium + CO<sub>2</sub> shielding.

**Hint 2** — ES6 for higher deoxidation with the highest combination of manganese and silicon, permitting sound welds even on relatively poor (rusty) surfaces.

**Hint 3** — For optimal results, use the wire manufacturers recommended shielding gas mixtures.

**Hint 4** — Select Argon + CO<sub>2</sub> shielding for economy. Spatter levels will be higher than for Argon + Helium + CO<sub>2</sub> types.

**Hint 5** — Select Argon + Helium + CO<sub>2</sub> where reduced spatter is important. This gas gives best performance but at extra cost.

**Hint 6** — Shielding gases with Argon + CO<sub>2</sub> + O<sub>2</sub> may give better appearance than Argon + CO<sub>2</sub>.

## Pulsed GMAW (MIG) with shielding gases

Material	DuraGal <sup>®</sup> RHS
Joint Type	Butt Fillet
Position	Flat Horizontal
Polarity	Electrode +ve
Wire Type	AS/NZS 2717.1 ES4/6-GC/M-503AH
Wire Diameter	0.9 mm
Gas Flow Rate	20 l/min
Welding Method	Spray Transfer

## Data Sheet 1 of 1

Power Source: Conventional MIG

Shielding Gas: Argon + CO<sub>2</sub> + (O<sub>2</sub>) or Argon + Helium + CO<sub>2</sub>

Wall thickness mm	Fillet leg length mm	Wire Feed Speed mm/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
2	3	10.5	155	26.00	600	0.40
3	3	10.5	155	26.00	600	0.40
4	4	11.7	237	28.75	500	0.82
5	4	11.8	240	29.00	450	0.93
6	5	11.8	240	29.00	400	1.04

## Flux Cored Arc Welding (FCAW)

### Gasless FCAW

The recommended wire is an AS/NZS 17632 T49-3 TX-XN type wire. This is a purpose built flux cored wire for welding galvanized products.

Note: This wire type is not suitable for applications where the LO properties of the family of DuraGal<sup>®</sup> products are required.

For LO Grades where improved impact performance is required use an AS/NZS 17632 T49-0 TX-XN type wire.

### Gas shielded FCAW

The recommended wire is an AS/NZS 17632 T49-0 TX-XX type wire. For optimal results, use the wire manufacturers recommended shielding gas mixtures.

### Spray MIG (GMAW) with shielding gases

Material	DuraGal <sup>®</sup> RHS
Joint Type	Butt Fillet
Position	Flat Horizontal
Polarity	Electrode -ve
Wire Type	AS/NZS 17632 ETP-GNn-500A.CM2
Wire Diameter	1.2 mm
Gas Flow Rate	N/A
Welding Method	Spray Arc

### Data Sheet 1 of 1

Power Source: Conventional MIG

Shielding Gas: N/A

Wall thickness mm	Fillet leg length mm	Wire Feed Speed mm/min	Amps	Working Volts	Travel Speed mm/min	Heat input kJ/mm
2	2.5/3.5	4.0	90	17.00	400	0.23
3	3.0/3.5	4.0	90	17.00	350	0.26
4	5	4.5	130	19.00	325	0.46
6	6.0/7.0	5.2	180	20.00	275	0.79

Notes:

- a) All settings above use Negative Polarity
- b) Best results achieved with DRAG method.

## FCAW — consumable comparisons — gasless or gas shielded

Classification		BOC	CIGWELD	Lincoln	WIA	Comments
AS/NZS ISO 17632	AS 2203.1					
B T 49 Z T11-1 N A	ETP-GNn-W500A.CM2		Shield-Cor 11			Gasless
B T 49 Z T 14-1N-S-H15	ETP-GNn-W500A.CM2		Shield-Cor 15	Innershield NR-152		Gasless
B T 49 Z TG 1 S N A	ETP-GNn-W500A.CM2				Fabshield 23	Gasless
B T 49 Z T11-1 N A H15	ETP-GNn-W500A.CM2			Innershield NR-211 MP		Gasless
B T 49 Z TG-1 N A H15				Steelcore 71T-GS		Gasless
B T 49 Z T11-1 N A	ETD-GNn-W500A.CM2				Fabshield 21B	Gasless
B T 49 Z T4-O N A	ETD-GNp-W500A.CM2				Fabshield 4	Gasless
B T 49 Z TG-1N A G H15	ETP-GNn-W500A.G			NR-212		Gasless
B T 49 2 T11 C A H10	ETP-GCp-W502A.CM1H10		Verti-Cor Ultra			Gas shielded (CO <sub>2</sub> )
B T 49 2 T1-1 C A O H10	ETP-GCp-W503A.CM1H10				Ausfil 71T	Gas shielded (CO <sub>2</sub> )
B T 49 2 T11 C A U H10	ETP-GCp -W502A.CM1H10		Verti-Cor 71T			Gas shielded (CO <sub>2</sub> )
B T 49 4 T11 CA-U H5	ETP-GCp -W502A.CM1	Smooth-Cor 711			TM-71 HYD	Gas shielded (CO <sub>2</sub> )
B T 49 3 T1-1 M A-K-U H10	ETP-GMp-W502A.CM1			Outershield 71-MX		Gas shielded (mixed)
B T 49 2T1-1 M A-U H10	ETP-GMp-W503A.CM1H10		Verti-Cor XP		Ausfil 71T-1M	Gas shielded (mixed)
B T 49 3 T1-1 C A-K-U H10	ETP-GMp -W502A.CM1	Smooth-Cor 711	Verti-Cor XP	Outershield 71-CX Primacore LW-71		Gas shielded (mixed)
B 49 3 T12-1 C A U H10	ETP-GCp-W503A.CM1		Verti-Cor 3XP			Gas shielded (CO <sub>2</sub> )
B49 3 T12-1 M A U H10	ETP-GMp -W503A.CM1		Verti-Cor 3XP			Gas shielded (mixed)
B49 3 T12-1 M A U H5	ETP-GMp -W503A.CM1 H5		Verti-Cor 3XP H4 - Seamless			Gas shielded (mixed)

### Hints for selection of appropriate FACW consumables

**Hint 1** — Gasless wires are popular for welding outdoors or where maintenance of gas shielding is difficult.

**Hint 2** — Gas shielded wires produce less fumes, minimal spatter and generally less post weld cleaning.

### Additional Information

OneSteel commissioned the Co-Operative Research Centre for Welded Structures to undertake research on the welding of DuraGal® to determine:

- the fume generated during flux cored arc welding with and without a shielding gas, and
- The operating parameters for flux cored arc welding using an austenitic stainless steel and a ferrite stainless steel filler wire and the corrosion resistance of the welds.

The reports detailing this work can be found on the OneSteel website at [www.onesteel.com](http://www.onesteel.com).

## As NZS ISO 17632 Designation

<p>B - T XX X TX-X X X-XXX-U HX</p>	<p>The “B” indicates classification by tensile strength and 27 J impact requirements.</p>
	<p>Designates a tubular cored electrode.</p>
	<p>Tensile Strength designator. Two digits are used to indicate the minimum tensile strength (when multiplied by 10 MPa)</p>
	<p>Charpy V-Notch impact strength designator. Indicates a temperature in °C at or above which the impact of the weld metal referred to above meets or exceeds 27 J. The letter “Y” is used to indicate a test temperature of + 20°C. This designator is omitted in the classification for single-pass welding electrodes as these have no Charpy V-Notch impact requirements under AS/NZS ISO 17632.</p>
	<p>Usability designator. This designator is “T1” through “T15” or “TG”. The designator refers to the usability of the electrode with requirements for polarity and general operating characteristics. The designator “TG” indicates that the polarity and general operating characteristics are not specified.</p>
	<p>Position designator. This designator is either “0” or “1”. It indicates the position of welding for which the electrode is intended. “0” is for flat and horizontal positions only. “1” is for all positions.</p>
	<p>Shielding gas designator. Indicates the type of shielding gas used for classification.</p>
	<p>Designates the condition of heat treatment in which the tests were conducted. “A” for as-welded condition, “P” for post-welded heat-treated condition and “AP” for as-welded and post-weld heat-treated condition. This designator is omitted in the classification for single-pass welding as these are tested only in the as-welded condition.</p>
	<p>Chemical composition designator. Indicates chemical composition of all-weld metal. The designation is omitted for electrodes meeting a general carbon steel weld metal composition requirement and for electrodes classified for single run techniques.</p>
	<p>Diffusible hydrogen designator. “H5”, H10, or H15 is used to indicate a maximum diffusible hydrogen content of 5 ml/100 g, 10 ml/100 g or 15 ml/100 g of deposited metal, respectively.</p>
<p>Charpy V-Notch designator. The “U” indicates that the weld deposit will also meet an average of 47 J at the classification temperature.</p>	

Flux core electrode classification system in accordance with AS/NZS ISO 17632 for tubular electrodes based upon tensile strength and 27 J minimum impact energy

## Welding gas comparisons

Process		AS/ NZS 2717:1 Group Index <sup>1</sup>	Air Liquide		BOC Gases		Linde Gas	Nominal Gas Composition In Argon (Ar) (Vol %)			
GMAW	FCAW		Australia	New Zealand	Australia	New Zealand	Australia	CO <sub>2</sub>	O <sub>2</sub>	He	
✓	✓	C	WELDING QUALITY CARBON DIOXIDE (CO <sub>2</sub> )					>99.5			
✓	✓	M3	BLUESHIELD 8				CORGON 25	25			
✓	✓	M3			ARGOSHIELD HEAVY	ARGOSHIELD HEAVY		18	3		
✓	✓	M3			ARGOSHIELD 52			23			
✓	✓	M3			ARGOSHIELD UNIVERSAL	ARGOSHIELD UNIVERSAL		16	2.75		
✓	✓	M3	BLUESHIELD 10					16	2.5		
✓	✓	M3					CORGON 16/2	16	2		
✓	✓	M3		BLUESHIELD MS4 <sup>2</sup>				-			
✓	✓	M2	BLUESHIELD 7				CORGON 18	18			
✓		M2	BLUESHIELD 5				CORGON 7		7		
✓		M2	BLUESHIELD 24					8	2		
✓		M2			ARGOSHIELD LIGHT (50)	ARGOSHIELD LIGHT (50)		5	3.1		
✓		M2					CORGON He30	10		30	
✓		M2			ARGOSHIELD 100			10		25	
✓		M2			ARGOSHIELD 40				5		
✓		M2	Arcal MS-3 <sup>2</sup>					-		-	
✓		M2		BLUESHIELD MS3 <sup>2</sup>				-			
✓		M1			ARGOSHIELD 54	ARGOSHIELD 54		7	1.5		
✓		M1	BLUESHIELD 23					4.5	2.5		
✓		M1					CORGON 5/2	5	2		
✓		M1		BLUESHIELD MS2 <sup>2</sup>				-			
✓		M1		BLUESHIELD MS1 <sup>2</sup>				-	-		

<sup>1</sup> Refer Appendix A of AS/NZS 2717:1:1996

<sup>2</sup> Gas composition withheld at the request of the manufacturer

## Nozzle spatter comparisons

(For high productivity welding applications)

5 x 91mm fillet welds were completed with each gas		
Shielding Gas	Ar + 16% CO <sub>2</sub> + 2.75% O <sub>2</sub>	Ar + 10% CO <sub>2</sub> + 25% He
Nozzle Weight Before (g)	130.2	130.3
Nozzle Weight After (g)	132.4	131.3
Spatter Weight On and In Nozzle (g)	2.2	1.0

Power Source	Cigweld 350 ZR-R Pulse
Robot	5 Axis CIGWELD Transrobo WS-0550
Wire	CIGWELD 0.9mm LW1
Amps	210
Volts	28.5
Wire Feed Rate	12.2 m/min
Travel Speed	550 mm/min

**Hint 1** — Using Ar + CO<sub>2</sub> + Helium gas mixtures can result in substantially less nozzle spatter than Ar + CO<sub>2</sub> + O<sub>2</sub> mixtures when used in automated high productivity welding applications and this may have economical advantages over lower cost gases.

## Recommended consumables

The recommended electrodes for welding DuraGal® hollow sections and profiles are shown in the table below:

Process	Product			
	Grades C400LO & C450LO		Grade C350LO	
	DuraGal RHS Profiles		DuraGal CHS Profile Angles ( ≤50 x 50mm)	
	If LO needed	If LO not needed	If LO needed	If LO not needed
Manual Metal Arc (Stick) AS/NZS 1553.1 or AS/NZS 4855	E49XX.2 or better	E49XX.0	E43XX.2 or E49XX.2 or better	E43XX.0 or E49XX.0
AS/NZS 4855	B E49 XX XXX X O HX	B E49 XX XXX X Z HX	B T43 XX XXX X O HX	B T43 XX XXX X Z HX
Gas Metal Arc (MIG) AS/NZS 2717.1 or AS/NZS 14341	W502XH <sub>x</sub>	W500XH <sub>x</sub>	W502XH <sub>x</sub>	W500XH <sub>x</sub>
Flux Cored Arc AS 2203.1 or AS/NZS 17632	W502X.CMXH <sub>x</sub>	W500X.CMXH <sub>x</sub>	W402X.CMXH <sub>x</sub> or W502X.CMXH <sub>x</sub>	W400X.CMXH <sub>x</sub> or W500X.CMXH <sub>x</sub>
AS/NZS 17632	B T49 O TX - XXX - U HX	B T49 Z TX - XXX - U HX	B T43 O TX - XXX - U HX or B T49 O TX - XXX - U HX	B T43 Z TX - XXX - U HX or B T49 Z TX - XXX - U HX
Submerged Arc (Sub Arc) AS 1858.1 or AS/NZS 14171	W502Y	W500Y	W402Y or W502Y	W400Y or W500Y

A lower strength electrode (E43XX) may be used with:

- DuraGal® CHS.
- DuraGal® RHS in Grade C350LO (typically for sizes up to 75 x 25 and 50 x 50).
- Profile Equal Angles (With leg lengths less than or equal to 50 x 50 mm).

These sections or sizes have a yield strength of 350 MPa compared to the 450 MPa yield strength of DuraGal® RHS and most of the profiles.

LO indicates that the ILG products have Charpy impact properties as specified in AS/NZS 1163 Structural Steel Hollow Sections. AS 4100 Steel Structures permits impacted tested LO grades to have the following minimum service temperatures.

Thickness mm	Lowest One Day Mean Ambient Temperature °C
t ≤ 6	- 30
6 < t ≤ 12	- 20

## Welding fumes

All welding produces fumes. Normal welding processes generally keep these fumes to acceptable levels. The Welding Technology Institute of Australia (WTIA) publishes a manual, “Technical Note 7, Health & Safety in Welding<sup>[2]</sup>”, which gives comprehensive advice on the level of ventilation required for a range of welding and cutting processes.

All welding can be injurious to the health unless sensible welding practices are used. Worksafe Australia have published exposure standards for weld fume, which in their words “represent air borne concentrations of individual chemical substances which, according to current knowledge, should neither impair the health of nor cause undue discomfort to nearly all workers”.

Further information on fume management is available in the “Fume Management Guidelines” which is downloadable from [www.wtia.com.au](http://www.wtia.com.au). Exposure to zinc fumes should be less than the allowable limit in a normal fabrication shop environment where actual arc time is often less than a quarter of the total working time.

Testing<sup>[3]</sup> has shown that the zinc fume given off when welding DuraGal<sup>®</sup> hollow section products, provided the arc power is kept in the lower amp to volt working range, does not exceed the zinc oxide exposure standard of an 8 hour time weighted average (TWA) of 5mg/m<sup>3</sup> and a short term exposure limit (STEL) of 10mg/m<sup>3</sup> <sup>[4]</sup>. However, operating in higher current short arc or spray arc conditions when welding profiles, or welding in confined spaces will require natural or forced ventilation and/ or some form of air circulation or extraction.

See the recommendations contained in:

- WTIA Technote 7 “Health & Safety in Welding” and WTIA “Fume Management Guidelines”
- Worksafe Australia Standard, “Exposure Standards for Atmospheric Contaminants in the Occupational Environment”.

Welding the family of DuraGal<sup>®</sup> products produces far less zinc fume than welding batch galvanized steel products which can have zinc coatings between 390g/m<sup>2</sup> to 600g/m<sup>2</sup>.

## Lead and Your Health

Lead has played a major role in the industrial revolution — its corrosion resistance and low melting point making it a popular and widely used metal. However, lead's toxicity has prompted governments and health authorities to encourage lead safe practices. Lead can cause long-term health problems. So it is important for you to know about lead poisoning and how it can happen. Lead gets into our bodies when we breathe in air, eat food or drink water that contains lead fumes or dust.

How to reduce the risk

- Check out the home and work place for lead hazards.
- Have adequate ventilation and always use your safety equipment (ie. safety masks and overalls).
- Use products that have reduced lead levels in them.

### The good news about Austube Mills Leadsafe™ galvanised products

Austube Mills is leading the way with its Leadsafe™ In-line, hot-dipped galvanised DuraGal<sup>®</sup> hollow sections and profiles, by using high grade zinc which is better than 99.97% lead free. This is good news for anyone working with galvanised steel, good news for the environment and good news for your health. It's another part of Austube Mill's ongoing commitment to a clean, green and safe environment.

## References

- [1] Rasmussen K.J., Teh L.H, "Strength of Butt Welded Connections between Equal-width Rectangular Hollow Sections, Research Report No R817, The Department of Civil Engineering, The University of Sydney, April 2002.
- [2] WTIA Tech Note 7 "Health and Safety in Welding"
- [3] Deakin University Centre for Biological and Chemical Research Report TMCG5 "Emissions from Welding DuraGal<sup>®</sup> RHS"
- [4] Worksafe Australia "Exposure Standards for Atmospheric Contaminates in the Occupational Environment – Guidance Note and National Exposure Standards"
  - AS/NZS 1163 Structural steel hollow sections
  - AS/NZS 1553.1 Covered electrodes for welding – Low carbon steel electrodes for manual metal-arc welding of carbon steels and carbon-manganese steels
  - AS/NZS 1554:1 Welding of steel structures.
  - AS/NZS 1554:5 Structural steel welding – Welding of steel structures subject to high levels of fatigue loading
  - AS 1858.1 Electrodes and fluxes for submerged-arc welding – Carbon steels and carbon-manganese steels
  - AS 2203.1 Cored electrodes for arc-welding – Ferritic steel electrodes
  - AS/NZS 2717.1 Welding – Electrodes – Gas metal arc – Ferritic steel electrodes
  - AS 4100 Steel Structures
  - ASNZS 4600 Cold-formed steel structures
  - AS/NZS 4855 Welding consumables – Covered electrodes for manual metal arc welding of non-alloy and fine grain steels – Classification
  - AS/NZS 14171 Welding consumables – Solid wire electrodes, tubular cored electrodes and electrode/flux combinations for submerged arc welding of non alloy and fine grain steels – Classification
  - AS/NZS 43141 Welding consumables – Wire electrodes and weld deposits for gas shielded metal arc welding of non alloy and fine grain steels – Classification (ISO 14341:2010, MOD)
  - AS/NZS ISO 17632 Welding consumables – Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels – Classification (ISO 17632:2004, MOD)

## Additional information

Austube Mills has sponsored ongoing research into the welding of DuraGal<sup>®</sup>.

Additional information is available to download from [www.austubemills.com](http://www.austubemills.com)





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