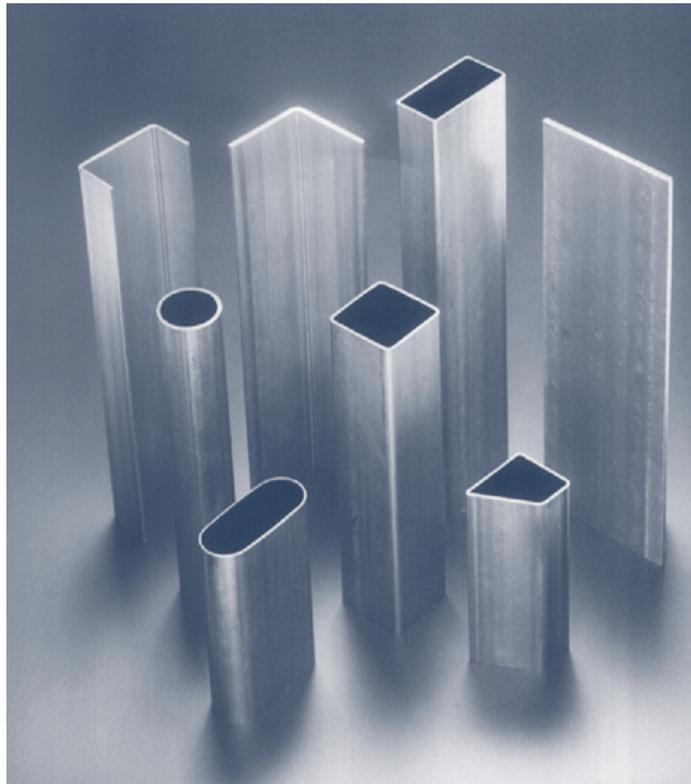


# DURAGAL<sup>®</sup>

Easy Welding Guide





The Family of DuraGal Products®

## Intent of this publication

To provide general guidance and hints on joint preparation, consumable selection and indicative machine settings for the welding and fabrication of DuraGal® Hollow Sections, DuraGal® Profiles and GaltubePlus® Hollow Sections.

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 PRODUCTS<sup>®</sup>**

This guide applies to welding techniques for low carbon steel ( $CE \leq 0.39$ ) used in **The Family of DuraGal Products<sup>®</sup>**, which includes DuraGal<sup>®</sup> Hollow Sections, DuraGal<sup>®</sup> Profiles, and Galtube Plus<sup>®</sup>.

These sections, with their lustrous, thin, evenly applied Zinc coating 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.

### **CONTENTS**

<b>THE ADVANTAGES OF DURAGAL<sup>®</sup></b> .....	3
<b>WELDING HINTS</b> .....	3
<b>GLOSSARY OF TERMS</b> .....	3
<b>PREPARING JOINTS FOR WELDING</b>	
<i>Preparing Joints in Rectangular and Square Hollow Sections</i> .....	4
<i>Preparing Joints in Circular Hollow Sections</i> .....	5
<b>FATIGUE</b>	
<i>OneSteel technical advice available</i> .....	5
<b>WELD SIZE</b>	
<i>Reduce the Size of the Weld to a Minimum</i> .....	6
<i>Don't Increase the Heat to Weld DuraGal<sup>®</sup> or Galtube Plus<sup>®</sup></i> .....	6
<b>RECOMMENDED WELDING MACHINE SETTINGS AND CONSUMABLES</b>	
<i>Introduction</i> .....	6
<i>Manual Metal Arc Welding (MMAW) "Stick"</i> .....	7
<i>Gas Metal Arc Welding (GMAW) "MIG"</i> .....	10
<i>Gas Metal Arc Welding (GMAW)with Silicon Bronze wire</i> .....	11
<i>Gas Metal Arc Welding - Pulsed "Manual"</i> .....	17
<i>Gas Metal Arc Welding - Pulsed "Robotic"</i> .....	18
<i>Gas Metal Arc Welding - Spray Transfer</i> .....	19
<i>Flux Cored Arc Welding</i> .....	21
<i>Welding Gas Comparisons</i> .....	23
<i>Nozzle Spatter Comparison</i> .....	24
<i>Recommended electrodes for DuraGal<sup>®</sup> &amp; Galtube Plus Sections</i> ..	25
<b>WELDING FUME</b>	
<i>Welding Fume</i> .....	26
<b>LEAD &amp; YOUR HEALTH</b>	
<i>Leadsafe<sup>™</sup> - the way to a Clean, Green and Safe environment</i> .....	26
<b>REFERENCES</b> .....	26

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

### THE ADVANTAGES OF DURAGAL®

OneSteel Market Mills has produced and marketed in-line galvanized (ILG) steel hollow sections (rectangular, square and circular) since 1970's. Galtube Plus® hollow sections were first produced with the range being extended to DuraGal® hollow sections in 1990, and DuraGal® 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 The Family of DuraGal Products® (100 g/m<sup>2</sup> minimum average) means welding can be carried out safely and with minimum fuming, spatter and porosity if the recommendation of this manual are followed.

The clear polymer coat applied to DuraGal® Angles greater than 50x50 mm and all the DuraGal® Channels, allows for most spatter that remains on the fabrication to be easily wiped off.

DuraGal®'s clean smooth zinc coating allows instant work return connection (earthing) to complete the welding circuit.

More information on the Galtube Plus® and The Family of DuraGal Products® can be found on the OneSteel website at [www.onesteel.com](http://www.onesteel.com).

### INTRODUCTION

The most common issue experienced in the welding of the DuraGal® and Galtube Plus® 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 even the most experienced welder 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 Galtube Plus® and DuraGal® 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 welds 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 the 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.

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

Information on welding consumables has been provided by consumable suppliers as listed in the various sections of the 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 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. May be gas shielded or self shielded
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 on an abutting approximately vertical surface.
ILG	=	In-line hot dip galvanized.
LO	=	A charpy impact tested steel hollow section to AS 1163.
MMAW	=	Manual metal arc welding - commonly known as stick welding.
Profiles	=	DuraGal® 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 straightforward. 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 2.0 mm branch is welded to a 4, 5 or 6 mm chord, and where a 3.0 mm branch is welded to a 5 or 6 mm 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 4.0 mm, and for GMAW a minimum root gap “G” of 3.0 mm is required to allow electrode access to deposit sound quality welds. The details of gap “G” are given in Fig. 1.

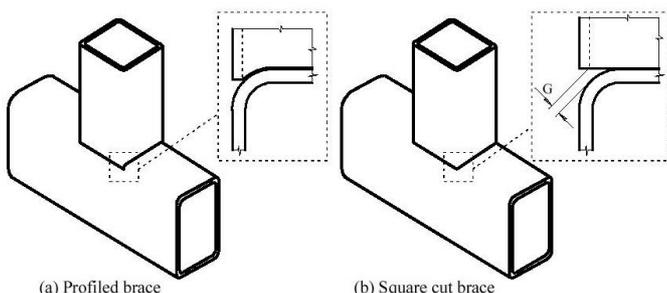


Fig 1 – Chord to Branch Connections

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

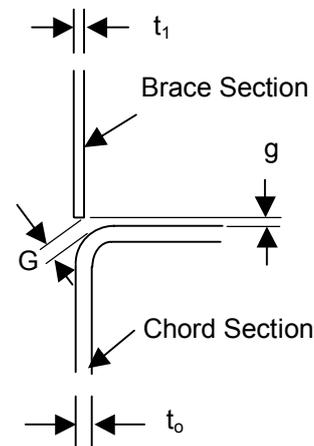


Fig 2 – Chord to Branch Gap Details

Table 1 gives values of gap “g” required to provide the dimensions “G” determined in research<sup>[1]</sup> for the DuraGal® 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 $t_o$ 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 4.0 mm for MMAW, and a minimum root gap “G” of 3.0 mm for GMAW.

Typically, when 1.6 and 2.0 mm thick branches are welded to a 4, 5 or 6 mm thick chord and where a 3.0 mm thick branch is welded to a 5 or 6 mm thick chord, 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 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 produced the best possible appearance at the corners.

Details of the welding sequence are given in Fig 3.

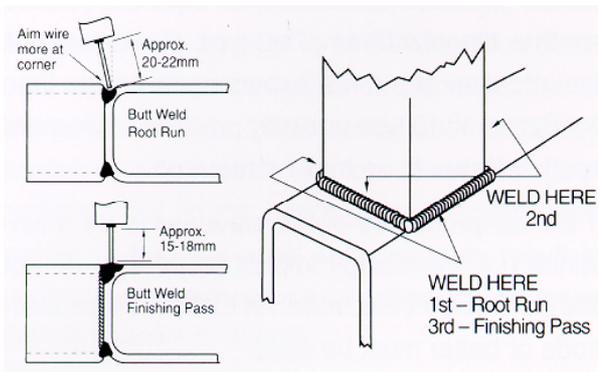


Fig 3 – Chord to Branch Welding Sequence

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

Careful joint fit-up, with minimum 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 the structurally the strongest .

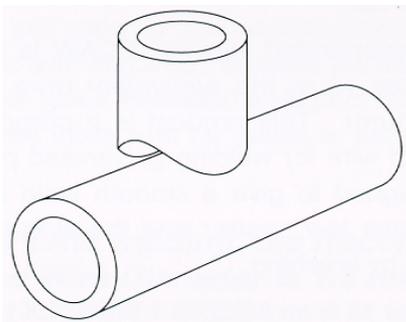


Fig 4 – CHS Profile Branch to Chord Connection

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 purchases to process larger tube sizes and/or for “Y”s and all non-concentric joints.

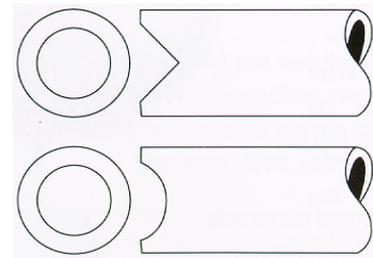


Fig 5 CHS Notched Branch to Chord Connections

When notching ensure that gaps are minimised and not greater than 3 mm. 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.

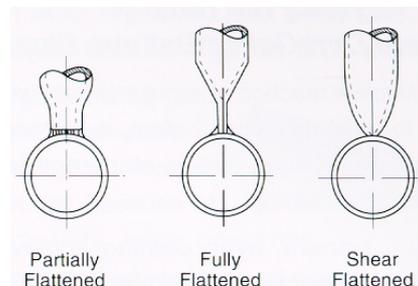


Fig 6 – CHS Flattened End Branch to Chord Connection

### FATIGUE

OneSteel has commissioned research into the fatigue performance of welded connections in DuraGal® sections. Upon request, OneSteel can provide advice on joint preparation and predicted fatigue life for welded connections in The Family of DuraGal 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 components capacity.
- For a butt weld, when the tensile load in the thinnest component is above 60% of the components capacity.
- The electrode filler wire is of lower strength than the component being welded.
- One or some of the components of the fabrication is of lower strength than the thinnest.

#### Don't increase the heat to weld The Family of DuraGal Products<sup>®</sup>.

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

OneSteel Market Mills world leading ILG process ensures that welding the Galtube Plus<sup>®</sup> and DuraGal<sup>®</sup> is as easy as welding uncoated steel. Only a small increase in weld heat is required to weld Galtube Plus<sup>®</sup> and DuraGal<sup>®</sup> products.

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

- Reduced zinc vaporisation (explosions)
- Reduced spatter
- Elimination or reduction of visible and internal porosity
- Minimal fuming
- Minimum 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 unnecessary

All of OneSteel Market Mills steel sections, including the ILG types, are made from steels with carbon equivalents (CE) less than or equal to 0.39. Economical joints made from these steels do not require preheat. Of course welding should generally not be carried out when the metal temperature is below 0°C or the surface is damp.

### 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) at 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) electrodes suit The Family of DuraGal Products®, refer to the chart on the next page.

### For superior appearance

Use AS/NZS1553.1 E4112-0 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 if 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 “For Strength” section.

### For Charpy impact properties

For designs using L0 grades of DuraGal® where matching Charpy impact performance is required in the weld zone, select electrodes with an impact grade of 2 or higher e.g. E4113-2 rather than E4113-0.

### For strength

For increased strength use E48XX rather than E41XX electrodes.

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

For strength and/or Charpy impact performance use “low hydrogen” electrodes conforming to AS/NZS 1553.1 E4818-2 or AS/NZS 1553.1 - E4816-2. See the comparison table on the following page

This type of electrode requires the attention of a more experienced welder than the AS/NZS 1553.1 E4112-0 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® 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 welding machine settings, 1.6 mm to 5.0 mm thick DuraGal® products were welded using 2.5 mm and 3.2 mm 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 of 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 1553.1 classification), such as 2.0 mm, to weld the thinner ILG sections until they have refined their technique.

## MMAW WELDING CONSUMABLE COMPARISONS

AS/NZS 1553.1 Classification	BOC	CIGWELD	LINCOLN	LiquidArc	WIA	Comments
E4112-0	Smootharc 12	GP 6012 Ferrocraft 12XP Murex Speedex 12		EasyArc Supa 12	Austarc 12P	Medium strength, good appearance
E4113-0	Smootharc 13	Satincraft 13 Murex Speedex 13		EasyArc Supa 13	Austarc 13S	Medium strength
E4113-2		Weldcraft				Medium strength, good impact
E4814-2		Ferrocraft 21				High strength, high deposition and good impact suitable for LO material
E4816-2 H10		Ferrocraft 16TXP Ferrocraft 55U	ConArc 51	EasyArc Supa 16		Higher strength, good impact
E4816-3 H10		Ferrocraft 7016				Higher strength, good impact
E4816-4 H5	Smootharc 16					Higher strength, better impact, low hydrogen
E4816-4 H10					Austarc 16TC	Higher strength, better impact
E4816-5 H10						Higher strength, best impact
E4818-2 H5				EasyArc Supa 18		High strength & impact, low hydrogen, higher deposition & easier to use than E4816 types
E4818-3 H10		Ferrocraft 61				High strength & impact, low hydrogen, higher deposition & easier to use than E4816 types
E4818-4 H5	Smootharc 18		Jetweld LH-70		Austarc 18XL	High strength, better impact, low hydrogen, higher deposition & easier to use than E4816 types
E4818-5 H5		Ferrocraft 61 H4	Jetweld LH-75MR		Austarc 18TT	High strength, best impact, low hydrogen, higher deposition & easier to use than E4816 types
E4824-0	Smootharc 24			EasyArc Supa 24	Austarc 24	High strength, fast down hand welding
E4824-2		Ferrocraft 22				High strength, good impact, fast down hand welding

### Hints for selection of appropriate electrodes

Hint 1	E4112, E4113 and E4818 electrodes operate with a quiet, medium penetrating arc with low spatter.
Hint 2	E4816 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	E4112 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	E4113 electrodes have similar characteristics to E4112 electrodes but more suitable for welding in the vertical up and overhead positions.
Hint 5	E4814 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 E4112, E4113 or E4818 types.
Hint 6	For Charpy impact performance choose an electrode with a E4XXX-2, E4XXX-3, E4XXX-4 or E4XXX-5 classification.
Hint 7	E4816 and E4818 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.

## MANUAL METAL ARC WELDING (MMAW) – “STICK” SETTINGS – Typical for AS/NZS 1553.1 E4112 & E4113 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 E4814 & E4818 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

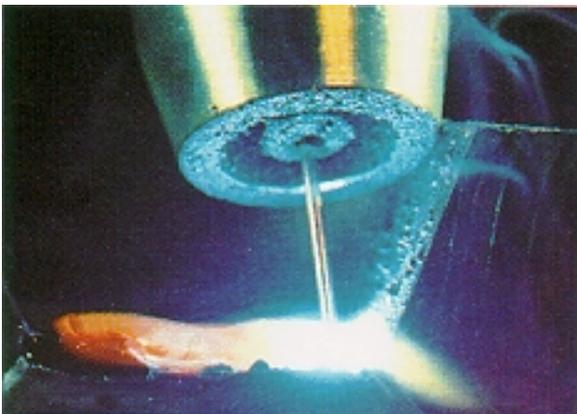
The recommended wires for GMAW Welding are AS/NZS 2717.1 ES4 or ES6 types. These are AS/NZS 2717.1 ES4-GX-W502XH<sub>x</sub> or ES6-GX-W502XH<sub>x</sub> specification wires and their performance will exceed that required to make use of the strength and L0 properties of all The Family of DuraGal Products<sup>®</sup>, including Galtube Plus<sup>®</sup>.

**Note:** Generally, W503XH<sub>x</sub> wires are more readily available and can be used in place of the W4502XH<sub>x</sub> wire.

#### The recommended wire diameter is 0.9 mm

Testing at manufacturers facilities has shown that 0.9 mm 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 **1.2 mm 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 (upto 25% CO<sub>2</sub>)

OneSteel Market 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 The Family of DuraGal Products<sup>®</sup>. This has been confirmed by independent testing by gas and consumable manufacturers.

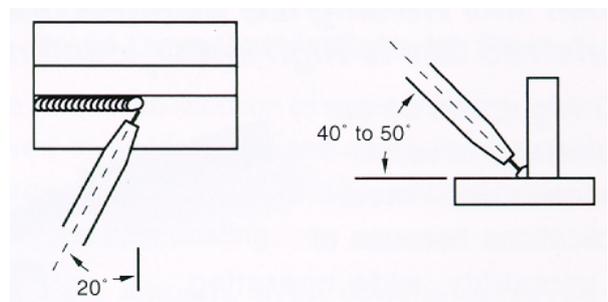
Welding Grade CO<sub>2</sub> may lead to high spatter levels and may be impracticable for thinner sections.

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 the DuraGal<sup>®</sup> Family of 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°.



# GAS METAL ARC WELDING (GMAW) – “MIG”

## (DIP OR SHORT ARC TRANSFER)

## GMAW WELDING CONSUMABLE COMPARISONS

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

0.9 mm 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).

**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, 385 mm/min Travel Speed, Electrode stick out 12mm, Shielding gas (Argon +5% CO<sub>2</sub>+ 2 to 3% O<sub>2</sub>).

### MIG (GMAW) with shielding gases

<b>Material</b>	:	<b>DuraGal® RHS</b>	
<b>Joint Type</b>	:	<b>Butt</b>	<b>Fillet</b>
<b>Position</b>	:	<b>Flat Butt</b>	<b>Horizontal</b>
<b>Polarity</b>	:	<b>Electrode +ve</b>	
<b>Wire Type</b>	:	<b>AS/NZS 2717.1 ES4/6-GC/M-503AH</b>	
<b>Wire Diameter</b>	:	<b>0.9 mm</b>	
<b>Gas Flow Rate</b>	:	<b>15 l/min</b>	
<b>Electrode stick out</b>	:	<b>12 to 18 mm (CTWD)</b>	
<b>Welding Method</b>	:	<b>Dip Transfer</b>	

#### **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

### **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 12 of 12**

Power Source : Conventional Mig - Transistorised  
Shielding Gas : Argon + 5 to 7% Oxygen

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

## 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 2717.1 Classification	Shielding Gas	BOC	CIGWELD	LINCOLN	LiquidArc	WIA	Comments
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			Suitable for all DuraGal® products - Use Argon + CO <sub>2</sub> + He, for lowest spatter levels
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	Steelmig S6	Austmig ES6	Suitable for all DuraGal® products - Use Argon + CO <sub>2</sub> + He, 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***

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

### ***Data Sheet 1 of 1***

Power Source : Conventional MIG  
 Shielding Gas : Argon + CO<sub>2</sub> or Argon + Helium + CO<sub>2</sub>

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

## **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.

## SPRAY TRANSFER GMAW WELDING

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 2717.1 Classification	Shielding Gas	BOC	CIGWELD	LINCOLN	LIQUIDARC	WIA	Comments
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			Suitable for all DuraGal <sup>®</sup> products – Use Argon + CO <sub>2</sub> +He or lowest spatter levels
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	SteelMig S6	Austmig ES6	Suitable for all DuraGal <sup>®</sup> 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> .

### ***SPRAY MIG (GMAW) with shielding gases***

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

### ***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 2203.1 ETP-(GNn or GNp)-W500A.CM2H** 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 L0 properties of The Family of DuraGal Products® are required.

For L0 Grades where improved impact performance is required use an **AS 2203 ETP-GNn-W502A.CM2H** type wire.

### Gas shielded FCAW

The recommended wire is an **AS 2203.1 ETD-(GCp or GCn or GMp) -W502A.CM1H** type wire. For optimal results, use the wire manufacturers recommended shielding gas mixtures.

### *Flux Cored Arc Welding (FCAW)*

<b>Material</b>	:	<b>DuraGal® RHS</b>	
<b>Joint Type</b>	:	<b>Butt</b>	<b>Fillet</b>
<b>Position</b>	:	<b>Flat</b>	<b>Horizontal</b>
<b>Polarity</b>	:	<b>Electrode -ve</b>	
<b>Wire Type</b>	:	<b>AS 2203.1 ETP-GNn-500A.CM2</b>	
<b>Wire Diameter</b>	:	<b>1.2 mm</b>	
<b>Gas Flow Rate</b>	:	<b>N/A</b>	
<b>Welding Method</b>	:	<b>Spray Arc</b>	

### *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

AS 2203.1 Classification	BOC	CIGWELD	LINCOLN	WIA	Comments
ETPS-GNn-W500A.CM2 ETP-GNn-W500A.CM2 ETD-GNp-W500A.CM2 ETP-GNn-W500A.G ETD-GNn-W503A.CM1		Shield-Cor 15	NR-152 NR-211 MP  NR-212 NR-203 MP	Fabshield 23 Fabshield 21B Fabshield 4	Gasless Gasless Gasless Gasless
ETD-GCp-W502A.CM1 ETP-GMp -W502A.CM1 ETP-GMp -W503A.CM1 ETP-GCp -W502A.CM1 ETP-GCp -W502A.CM1	Smooth-Cor 711  Smooth-Cor 711	Verti-Cor XP  Verti-Cor XP	  Outershield Elite  Outershield E712C	Fluxofil 11Ni Ausfil 71T-1M  Hobart 71T	Gas shielded Gas shielded Gas shielded Gas shielded Gas shielded

### Hints for selection of appropriate FCAW consumables

Hint 1	ETD - denotes an electrode of tubular construction suitable for use in the horizontal-fillet or downhand position.
Hint 2	ETP - denotes an electrode of tubular construction suitable for use in any position.
Hint 3	GNn - denotes a gasless wire used with electrode negative polarity.
Hint 4	GNp - denotes a gasless wire used with electrode positive polarity.
Hint 5	GCp - denotes a CO <sub>2</sub> gas shielded wire used with electrode positive polarity.
Hint 6	GMp - denotes a mixed gas (Argon + CO <sub>2</sub> ) shielded wire used with electrode positive polarity.
Hint 7	For optimal results, use the wire manufacturers recommended shielding gas mixtures.
Hint 8	W500 - denotes a weld metal tensile strength of 500 MPa and NO Charpy impact requirements.
Hint 9	W502 - denotes a weld metal tensile strength of 500 MPa and Charpy impact requirements of 47 Joules at 0 Degrees C.
Hint 10	Follow manufacturers recommendations on gas shielding to get optimum results from gas shielded wires
Hint 11	For Charpy impact performance choose an electrode with a W502X, W503X, W504X or W505X for welding L0 grades of DuraGal®.
Hint 12	Gasless wires are popular for welding outdoors or where maintenance of gas shielding is difficult.
Hint 13	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 a 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)

### 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 %)			
			Australia	New Zealand	Australia & New Zealand	Australia	CO <sub>2</sub>	O <sub>2</sub>	He	
GMAW	FCAW									
✓		M1	Arcal MS-2 <sup>2</sup>	BLUESHIELD MS2 <sup>2</sup>			-			
✓	✓	M2	BLUESHIELD 7			CORGON 18	18			
✓	✓	M2		BLUESHIELD MS3 <sup>2</sup>			-			
✓	✓	M3			ARGOSHIELD 52		23			
✓	✓	M3		BLUESHIELD MS4 <sup>2</sup>			-			
✓	✓	M3	BLUESHIELD 8			CORGON 25	25			
✓		M1								
✓		M1		BLUESHIELD MS1 <sup>2</sup>		CORGON 5/2	5	2		
✓		M1	BLUESHIELD 23				-	-		
✓		M1			ARGOSHIELD 54		4.5	2.5		
✓		M2			ARGOSHIELD LIGHT (50)		7	1.5		
✓		M2	BLUESHIELD 24				5	3.1		
✓	✓	M3				CORGON 16/2	8	2		
✓	✓	M3	BLUESHIELD 10				16	2		
✓	✓	M3			ARGOSHIELD UNIVERSAL		16	2.5		
✓	✓	M3			ARGOSHIELD HEAVY		18	3		
✓	✓	M1			ARGOSHIELD 100		10		25	
✓	✓	M1				CORGON He30	10		30	
✓	✓	M2	Arcal MS-3 <sup>2</sup>				-		-	
✓		M2			ARGOSHIELD 40			5		
✓		M2	BLUESHIELD 5			CORGON 07		7		
✓	✓	C	WELDING QUALITY CARBON DIOXIDE (CO <sub>2</sub> )					>99.5		

<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 COMPARISON

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(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)	<b>2.2</b>	<b>1.0</b>

<p><b>Power Source</b> - Cigweld 350 ZR-R Pulse <b>Robot</b> - 5 Axis Cigweld Transrobo WS-0550 <b>Wire</b>- Cigweld 0.9mm LW1 <b>Amps</b> - 210 <b>Volts</b> - 28.5 <b>Wire Feed Rate</b> - 12.2 m/min <b>Travel Speed</b> - 550 mm/min</p>
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**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, DuraGal® Profiles and Galtube Plus® Hollow Sections are shown in the table below:

Process	Product			
	Grades C400L0 & C450L0		Grades C350L0	
	DuraGal® RHS DuraGal® Profiles		DuraGal® CHS Galtube Plus® CHS & RHS DuraGal® Angles ( ≤50 x 50 mm)	
	If L0 Needed	If L0 Not Needed	If L0 Needed	If L0 Not Needed
<b>Manual Metal Arc (Stick) AS/NZS 1553.1</b>	E48XX.2 or better	E48XX.0	E41XX.2 or E48XX.2 or better	E41XX.0 or E48XX.0
<b>Gas Metal Arc (MIG) AS/NZS 2717.1</b>	W502XH <sub>x</sub>	W500XH <sub>x</sub>	W502XH <sub>x</sub>	W500XH <sub>x</sub>
<b>Flux Cored Arc AS 2203.1</b>	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>
<b>Submerged Arc (Sub Arc) AS 1858.1</b>	W502Y	W500Y	W402Y or W502Y	W400Y or W500Y

A lower strength electrode (E41XX) may be used with

- DuraGal® CHS.
- Galtube Plus® Hollow sections.
- DuraGal® 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 DuraGal® Profiles.

L0 indicates that the ILG products have Charpy impact properties as specified in AS 1163 Structural Steel Hollow Sections.

AS 4100 Steel Structures permits impacted tested L0 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® 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 DuraGal® open 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 Products® produces far less zinc fume than welding batch galvanized steel products which can have zinc coatings between 390g/m<sup>2</sup> to 600 g/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 OneSteel's LeadSafe™ Galvanized Products

OneSteel is leading the way with its Leadsafe™ In-line, Hot-dipped galvanized Family of DuraGal Products® that covers DuraGal® Hollow Sections, DuraGal® Profiles and Galtube Plus®, by using High Grade zinc which is better than **99.97% Lead Free**.

Good news for anyone working with galvanized steel, good news for the environment and good news for your health

It's another part of OneSteel'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® RHS"
- [4] - Worksafe Australia "Exposure Standards for Atmospheric Contaminates in the Occupational Environment - Guidance Note and National Exposure Standards"
  - AS 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

### ADDITIONAL INFORMATION

OneSteel Market Mills has sponsored ongoing research into the welding of DuraGal®. Technical papers are available for viewing or to download from our web site at [www.onesteel.com](http://www.onesteel.com)

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