LINCOLN® ELECTRIC

TECHNICAL INFORMATION BULLETIN

TIB 125
03/11

TECHNICAL BULLETIN 5

Welding of
JFE EHSP
Super Abrasion Resistant Steel Wear Plate

total quality total service **Total Steel**

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

TECHNICAL INFORMATION BULLETIN

TIB 125 03/11

WELDING OF EHSP

Super Abrasion Resistant Steel Wear Plate

General rules for good welding practice with EHSP steel

1.0 INTRODUCTION

JFE steel company pioneered the production and sale of abrasion resistant steel plate in Japan in the mid-1950s, and JFE abrasion-resistant steel plate (JFE EVERHARD) enjoyed widespread use as a vital material for construction, mining, civil engineering and farming equipment. Furthermore, JFE Steel Co. has succeeded in developing super abrasion-resistant steel plate EH-SP with higher abrasion resistance than that of the Brinell 500 grade, and EH360LE, EH400LE, EH500LE with excellent toughness through the leading edge of production technology.

2.0 EHSP SPECIFICATION

Table 1. Manufacturing Process and Available Thickness

Grade	Thickness	Heat treatment
EHSP	6-65 mm	Controlled heat treatment

Table 2. Chemical Composition (mass %)

C	Si	Mn	P	S	Cr	Others	CE**
≤0.35	≤0.55	≤1.60	≤0.030	≤0.030	0.50-1.50	*	0.62

*Other alloying elements are added for enhancing the abrasion resistant property;

**Carbon Equivalent $CE = C + \frac{Mn}{6} + \frac{(Cr+Mo+V)}{5} + \frac{(Ni+Cu)}{15}$

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

TECHNICAL INFORMATION BULLETIN

TIB 125 03/11

Table 3. Hardness

Grade	Thickness	Hardness-HB-3000
EHSP	6-65 mm	401 min

Table 4. Tensile, Charpy Impact and Brinell Hardness Tests

Plate thickness mm	Specimen	Position	Direction	0.2% Proof Stress MPa	Tensile strength MPa	Elongation %	Charpy Impact Absorbed Energy J@0°C*	Brinell Hardness (surface)
9.5	JIS No.5	Full	T	1298	1401	13.3	15** (1/2t)	409
12	JIS No.5	Full	L	1270	1489	13.2	24 (1/2t)	461
			T	1274	1476	15.6		
25.4	JIS No.5	Full	T	1279	1471	16.6	18** (1/4t)	448
35	JIS No.5	Full	L	1098	1349	11.3	18 (1/4t)	455
			T	1104	1352	10.7		
50.8	JIS No.4	1/4t	T	1037	1204	10.4	15** (1/4t)	434
		1/2t	T	903	1145	10.7	16** (1/2t)	
63.5	JIS No.4	1/4t	T	867	1070	11.6	13** (1/4t)	442
		1/2t	T	677	951	13.8	15** (1/2t)	

*JIS No.4; **Longitudinal direction

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

3.0 WELDING

3.1 General Rules for good welding practice with EHSP Steel

- Use controlled hydrogen process.
- For highly restrained joints use low hydrogen consumables such as **Outershield®81Ni1-H**, **81Ni2C-H** for Flux cored wires, **Kryo®1** and **Jetweld LH-70** for stick electrodes or **LAC -Ni2** for SAW.
- Select consumables per Tables 7-13
- Consumables must be correctly stored in order to maintain their controlled hydrogen properties. See current editions of Lincoln Customer Application Bulletins 5, 55, 58 and 60 for information on storage and redrying of welding consumables.
- Clean joint area and up to approximately 12 mm on either side to remove oil, grease, paint, rust and scale before welding.
- Remove 1-2 mm from flame cut or gouged surfaces by grinding.
- Ensure that preheat and interpass temperatures, and heat input limitations specified in Tables 5 and 6 are followed closely.
- Position job for downhand welding where possible.
- Always use stringer beads, never wide weave beads.
- Deposit root runs with **Conarc®51**, **Conarc®49C** or **Jetweld®LH-70**. These will have the least likelihood of hot tearing in joints in thicker and more highly restrained sections, due to the high ductility of the weld metal.
- Tempering beads with low hydrogen consumables such as **Jetweld®LH-70** or **Conarc®49C** may be deposited as extra weld reinforcement or to refine the final passes of full strength welds and heat affected zones at the top of the joint. These are normally deposited partially over the final full strength runs and partially on the plate surface adjacent to the weld.
- When required, back gouge using the arc-air process and remove scale by grinding. Do not use oxy-acetylene for back gouging.
- Arc strikes outside the weld zone can result in cracks, particularly in dynamically loaded structures. All arc strikes should therefore be made within the joint preparation.
- Grinding toes of fillet welds is particularly important in fatigue applications.

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

- When preheating, follow the guidelines illustrated in Figure 1.
- Prior to welding a soaking time of 1 hour is required at prescribed preheating temperature.
- Slow cooling after welding by wrapping in refractory blankets or immersing in vermiculite is recommended for defect free joints.
- In order to control shrinkage, distortion and restraint joint cracking use back-step welding as illustrated in Figure 2.
- Convex fillet welds (Figure 3a & 3b) are desired in order to avoid shrinkage stresses cracking of the weld. For multiple pass fillet welds, the convex bead shape is usually applies on the first weld.
- If undercut defect is present it may be caused by:
    - Excessive welding current
    - Arc voltage too high
    - Excessive travel speed
    - Erratic feeding of wire
    - Incorrect electrode angle
- In case of crater cracking slightly reveres the travel of the electrode back into the weld bead, gradually reducing the welding current at the end of the weld, or by stopping the travel before breaking the arc.
- Centreline cracking may be caused by:
    - A weld bead too small for the thickness of the base metal
    - Poor fit-up
    - High restraint joint
    - Extension of crater crack
- Porosity of the weld can be eliminated by:
    - Decreasing voltage
    - Increasing drag angle
    - Decreasing travel speed
    - Increasing current
- When required, back gouge using the air-arc process and remove scale by grinding. Do not use oxy-acetylene for back gouging.
- Grinding toes of fillet welds is particularly important in fatigue applications

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

Table 5. Preheat Recommendations

CJT (mm) *	≤40	50	60	70	80	90	100	≥110
Preheat Temp °C**	110	130	150	160	175	185	195	200
Max ITP °C	150	170	190	200	215	225	235	240

* CJT- Combined joint thickness $t_1+t_2+t_3$ see Figure 1. **Calculation based on heat input [Heat Input (kJ/mm) = (V×A × 0.06)/ TS (mm/min)] of **1.7kJ**/mm and maximum hydrogen level of **5**ml/100g.

Table 6. Permissible heat input (kJ/mm*) for Welding of EHSP

	Plate thickness			
	3-10 (mm)	**12-20 (mm)**	**25-32 (mm)**	**40-100 (mm)**
MMAW	1.25-2.5	1.25-3.5	1.25-4.5	1.5-5.0
GMAW	1.0-2.5	1.0-3.5	1.25-4.5	1.5-5.0
FCAW	0.8-2.5	0.8-3.5	1.5-4.5	1.5-5.0
SAW	1.0-2.5	1.0-3.5	1.5-4.5	1.5-5.0

*Heat Input (kJ/mm) = (V × A × 0.06)/TS(mm/min)

3.2 Welding EHSP to Mild, Stainless and Manganese Steels

Welding EHSP to mild steel is straightforward. It is recommended to employ similar consumables to those materials recommended for fillet welding (see Tables 7 thru 13). Higher strength consumables may be used but admixture from the mild steel will lower the deposit strength to something between that of the EHSP being welded and the mild steel, and the mild steel fusion zone will still be the weakest part of the joint. It is most important to observe all the precautions regarding process, arc energy input and preheat of the EHSP.

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

When welding EHSP to austenitic stainless steel, **Lincoln®E309 or E312** consumables are recommended to ensure an austenitic weld metal microstructure. Any necessary preheat/arc energy input requirements for the EHSP grade must be observed.

Again **Lincoln®E309 and E312** consumables are also suitable for welding EHSP to austenitic manganese steels, with the correct preheat and arc energy input for both steel types. The manganese steel requires a maximum interpass temperature of 250°C (controlled as per Figure 1.) and fast cooling from welding temperature to avoid cracking of the manganese steel component.

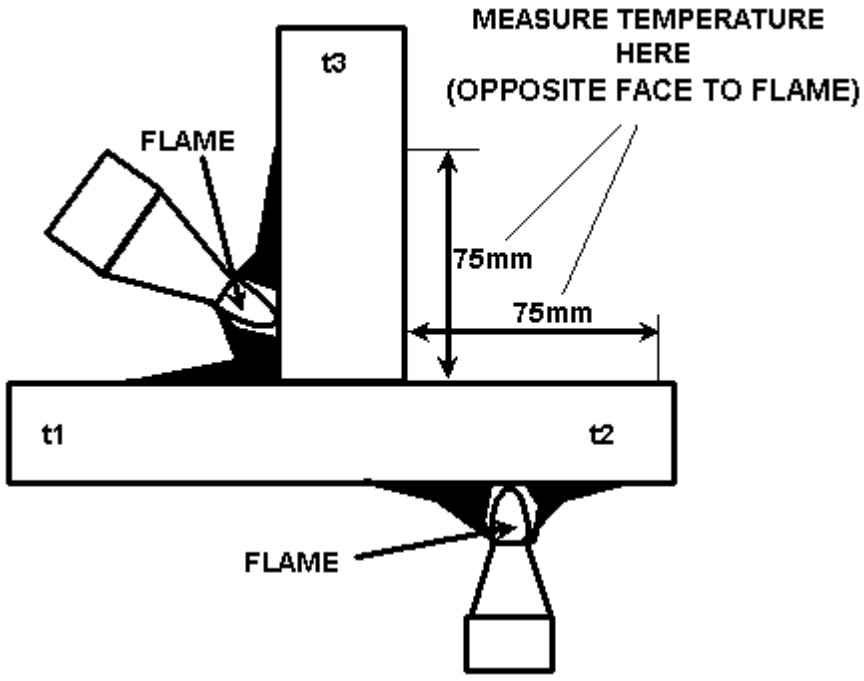

Fig 1. Recommended preheat zone and location of preheat temperature measurement

For more information please refer to AS ISO 13916-2003

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

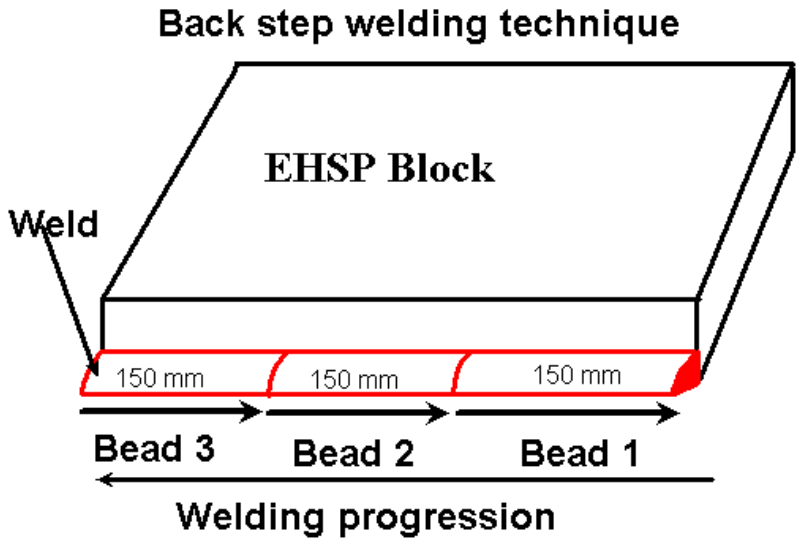

Fig 2. Back step technique to avoid shrinkage, distortion and restraint joint cracking

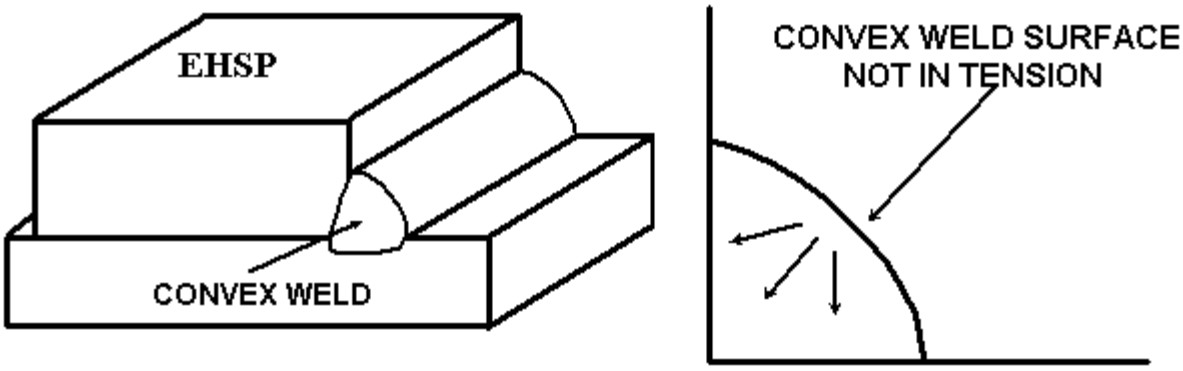

Fig 3a & 3b. Convex fillet welds are recommended in order to eliminate weld shrinkage cracking

LINCOLN ELECTRIC
THE WELDING EXPERTS®
The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

Table 7. Lincoln consumables for welding EH-SP

Manual Metal Arc Welding					
Consumable	**Size Range mm**	**Classification**	**General description**	**Applicable Joint Types/ Positions**	**Evolved Hydrogen mL/100g Deposited Weld Metal**
Conarc®51	2.5, 3.2, 4.0	AS/NZS ISO 4855-B-E4916-1-A-UH5 AWS A5.1- E7016-1 H4R	Low hydrogen electrode with excellent impact properties at low temperature, all position, 2.5 and 3.2 mm dia excellent root pass electrodes,	Root passes. Butts/Fillets Temper beads	≤ 5
Conarc®49C	2.5, 3.2, 4.0	AS/NZS ISO 4855-B-E4918-1-A-H5 AWS A5.1- E7018-1 H4R	Basic and very low hydrogen electrode, 120% efficiency, Very good notch toughness at low temperatures	Root passes. Butts/Fillets Temper beads	≤ 5
Jetweld®LH-70	2.4, 3.2, 4.0, 4.8	AS/NZS ISO 4855-B-E4918-A-UH5 AWS A5.1-E7018 H4R	Low iron powder low hydrogen manual arc electrode. Good for thick sections.	All position except vertical down	≤ 5
Conarc®V250	4.0,5.0	AS/NZS ISO 4855-B-E4928-1-A-H5 AWS A5.1- E7028 H4R	Low hydrogen electrode, 250% recovery, High deposition rate, excellent x-ray quality,	Downhand	≤ 5
Conarc®80	3.2,4.0	AS/NZS ISO 4856-B-E7618-G-A-UH5 AWS A5.5- E11018M H4	Low iron powder extremely low hydrogen, capable of producing 785 MPa tensile strength deposit,	All position	≤ 5
Kryo®1	2.5,3.2,4.0	AS/NZS ISO 4855-B-E6218-2C1M H5 AWS A5.5:E7018-G-H4R, E8018-G-H4R	Basic all position electrode with 1% Ni, Excellent mechanical properties -60°C, Extremely low hydrogen content, 110 - 120% recovery.	All position	≤ 5

Table 8

Gas Metal Arc Welding					
Consumable	**Size Range mm**	**Classification**	**General description**	**Applicable Joint Types/ Positions**	**Evolved Hydrogen mL/100g Deposited Weld Metal**
UltraMag® S4	0.9, 1.0, 1.2, 1.6	AS / NZS 2717.1-ES4-GM-W503AH AWS A5.18- ER70S-4	High quality general purposes all positional mild steel solid wire.	Butts/Fillets	≤ 5
UltraMag™ S6	0.8, 0.9, 1.0, 1.2, 1.6	AS / NZS 2717.1-ES6-GM/C-W503AH AWS A5.18- ER70S-6	High quality general purposes all positional mild steel solid wire with higher manganese and silicon levels.	Butts/Fillets	≤ 5
SuperArc®LA-100	1.2	AWS A5.28- ER100S-G, ER110S-G/EM-2	Capable of producing welds with 690 MPa tensile strength, excellent for welding quenched and tempered steels	Butts/Fillets	≤ 5

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

TECHNICAL INFORMATION BULLETIN

TIB 125 03/11

Table 9

Gas Shielded Flux Cored Arc Welding

Consumable	Size Range mm	Classification	General description	Applicable Joint Types/ Positions	Evolved Hydrogen mL/100g Deposited Weld Metal
Outershield®71MX	1.2 1.6 2.0	AS/NZS ISO 17632-B-T492T1-1MA-K- UH10 AWS A5.20- E71T-12M	Positional welding with CO2 or 25% CO2 in Argon shielding only, deposition rate to appr. 8 kg/hr.	Butts/Fillets All positional	≤ 10
Outershield®71CX	1.2 1.6	AS/NZS ISO 17632-B-T493T1-1CA-K-UH10 AWS A 5.20- E71T-1C H8 Also meets E71T-9C H8, E71T-12C H8z	All positional micro alloyed flux cored wire, extremely smooth arc transfer, clean surface finish, 100% CO_2 shielding gas	Butts/Fillets All positional	≤ 5 ≤ 10
Primacore®LW-71	1.2, 1.6	AS/NZS ISO 17632-B –T493T1-1CA-K-UH10 AWS A5.20-E71T-1C, E71T-9C	Micro alloyed flux cored wire, all position welding of mild steel, very good notch toughness, 100% CO_2 shielding gas	Butts/Fillets All positional	≤ 10
Outershield®MC-715H	1.2, 1.6	AS/NZS ISO 17632-B-T492T15-0MA-UH5 AWS A5.18-E70C-6M	Metal cored wire, little slag and spatter, fast travel speed excellent impact value, very low hydrogen, 5-25% CO_2 in Argon shielding gas	Butts/Fillets Downhand & horizontal	≤ 5
Outershield®690-H	1.2, 1.6	AS/NZS ISO18276-B-T762T2-1MA-N3M2-H5 AWS A5.20-E111T1-K3MJ	All position high strength low hydrogen flux cored wire, excellent feadability, superb mechanical properties, good impact value at -40°C, excellent wire for high strength and QT steel, 5-25% CO_2 in Argon shielding gas	Butts/Fillets All positional	≤ 5
Outershield®81Ni1-H	1.2, 1.6, 2.0	AS/NZS ISO17632-B-T555T1-1MA-N2-UH5 AWS A5.29-E81T1-Ni1M	Low alloy with high deposition rate wire, x-ray weld quality and good impact properties a t -50°C, typical tensile 600 MPa, 15-25% CO_2 in Argon shielding gas	Butts/Fillets All positional	≤ 5
Ultracore®81Ni2C-H	1.2, 1.6	AWS A5.29-E81T1-Ni2C-JH4	Capable of producing weld deposits with impact toughness exceeding 54 - 84 J at -51°C, Designed for welding with 100% CO2 shielding gas, very low hydrogen	Butts/Fillets All positional	≤ 5
Outershield®91Ni1-HSR	1.2	AWS A5.29-E91T1-GM	A low alloy (1%Ni, 0.4%Mo) with excellent impact properties at -50°C, weldablity with high heat input, typical weld tensile 740 MPa, 5-25% CO_2 in Argon shielding gas	Butts/Fillets All positional	≤ 5

The Lincoln Electric Company Pty Ltd
35 Bryant Street, Padstow, NSW, 2211 Australia
Tel: +61 (2) 9772 7222 Fax: +61 (2) 9772 7208

TECHNICAL INFORMATION BULLETIN

TIB 125 03/11

Table 10

Self Shielded Flux Cored Arc Welding

Consumable	Size Range mm	Classification	General description	Applicable Joint Types/ Positions	Evolved Hydrogen mL/100g Deposited Weld Metal
Innershield®NR-232	1.7, 2.0	AS/NZS ISO17632-B-T492T8-1NA-H15 AWS A5.20- E71T-8	High deposition rates on out-of-position welding, for high productivity and good impact properties for single and multipass welding,	Butts/Fillets All positional	≤ 10
Innershield®NR-233	1.6, 1.8	AS/NZS ISO17632-B-T493T8-1NA-H15 AWS A5.20- E71T-8	High deposition rate, even in out of position welding, minimised gas marking, good impact properties at -29°C	Butts/Fillets All positional	≤ 10
Innershield®NR 311	2.0, 2.4	AS/NZS ISO17632-B-T49ZT7-0NA-H15 AWS A5.20- E70T-7	General purpose wire for high deposition rates, fast travel speeds and good penetration.	Butts/Fillets Flat and horizontal	≤ 15
Innershield®NS-3M	2.0, 2.4, 3.0	AS/NZS ISO17632-B-T49ZT4-0NA-H15 AWS A5.20- E70T-4	Very high deposition rates up to 18kg/h, suitable for thicker carbon steel and alloy steel, must be used with DC+	Butts/Fillets Flat and horizontal	≤ 15

Table 11

Submerged Arc Welding

Consumable	Size Range mm	Classification	General description	Applicable Joint Types/ Positions	Evolved Hydrogen mL/100g Deposited Weld Metal
Lincolnweld®LA-90/880	3.2	AWS A5.23- F9A4-EA3K-A4	This electrode/flux combination provides high strength welds of 620 MPa class	Downhand butts/ fillets.	≤ 10
Lincolnweld®LAC Ni2/880M	2.4	AWS A5.23- F7P10- ECNi2-Ni2-H8 and F7A10-ECNi2-Ni2-H8	2% nickel electrode good choice for restrained joints and low temperature impact resistance.	Downhand butts/ fillets.	≤ 10
Lincolnweld®LAC M2/880M	2.4, 4.0	AWS A5.23-ECM2-FBL-W769A.M2-H8	Cored SAW wire designed to produce weld deposits of 800 MPa class good impact properties at -50°C	Downhand butts/ fillets.	≤ 10
Lincolnweld®LC-72/980	2.4	AWS A5.17- F7A2-EC1-H8	Designed to increased deposition rate app 30%, in the tensile 540 MPa class	Downhand butts/ fillets.	≤ 10

Total Steel

Total Steel of Australia Pty Ltd
ABN 34 001 201 850

Administration
Suite 10, 35–37 Railway Parade
Engadine, New South Wales 2233
PO Box 70 Engadine NSW 2233
Telephone: (02) 8508 4800
Fax: (02) 9520 8628
Email: admin@totalsteel.com.au

Sydney
46 Anzac Avenue
Smeaton Grange, New South Wales 2567
Box 3205 Narellan DC NSW 2567
Telephone: (02) 4648 8111
Fax: (02) 4647 8011
Email: sydney@totalsteel.com.au

Melbourne
207-211 Fitzgerald Road
Laverton North, Victoria 3026
PO Box 477 Laverton VIC 3028
Telephone: (03) 9369 8855
Fax: (03) 9369 8866
Email: melbourne@totalsteel.com.au

Brisbane
106 Mica Street
Carole Park, Queensland 4300
PO Box 265 Carole Park QLD 4300
Telephone: (07) 3723 9200
Fax: (07) 3271 1699
Email: brisbane@totalsteel.com.au

Perth
53–75 McDowell Street
Welshpool, Western Australia 6106
PO Box 626 Welshpool DC WA 6986
Telephone: (08) 9351 6800
Fax: (08) 9351 6868
Email: perth@totalsteel.com.au

Darwin
48 Dawson Street
East Arm
NT 0822
Tel: (08) 8984 4324
Fax: (08) 8947 4615
Email: darwin@totalsteel.com.au

total quality total service **Total Steel**