Bisalloy

Technical Guide

bisalloy.com.au

DISCLAIMER

This technical guide provides guidance on the proper handling and use of our range of BISALLOY® quenched & tempered steel plates.

Please note that this information is intended solely for BISALLOY® products manufactured by Bisalloy Steels Group Limited.

BISALLOY® products manufactured by Bisalloy Steels Group Limited can only be purchased through Bisalloy Steels Group or through an authorised distributor. You can locate our authorised distributors on our website. Products purchased through any other business may not be BISALLOY® products.

Users are advised to not rely upon this guide for similar steel plates supplied or manufactured by other manufacturers. Users should always request the technical information, guides or the original equipment manufacturer (OEM) manual for the specific product purchased from the supplier or manufacturer.

Any attempt to apply the information contained in this guide to similar steel plates produced elsewhere may carry significant risks, including the potential for substantial harm.

We emphasise the need for users to exercise caution and take care to ensure that they are satisfied the information provided is appropriate for their needs before relying on the guide. We emphasise the need for users to ensure that they are appropriately qualified and skilled to perform the activities contemplated in this guide and to seek clarification where necessary before proceeding with any work.

We remind all readers and users that there are obligations under Work Health and Safety legislation to ensure that you do not put others or yourselves at risk of harm or serious injury. If you do not understand how to perform the activities in this guide or understand the information provided, do not proceed with the activity.

Please be aware that any specifications or technical data mentioned in this publication are subject to potential changes without prior notice and no warranty as to their suitability for any use is made.

Unless required by law, Bisalloy Steels Group Ltd does not accept any responsibility for any loss, damage or consequence resulting from the use of this publication.

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INTRODUCTION

Bisalloy Steels, located at Unanderra, NSW is Australia's only manufacturer of high-strength, wear-resistant and armour grade steel plate produced by the continuous roller quenching and tempering process.

Quenching and tempering, defined as a combination of heating and cooling of a metal or alloy, changes the microstructure of the steel and improves the strength, hardness and toughness of the materials being treated.

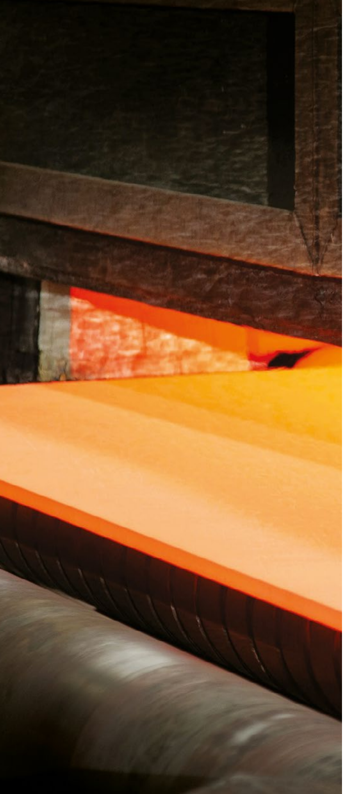
Utilising advanced heat treatment technology, furnace temperatures and quenching rates are scientifically controlled using PLC's to obtain the optimum quality grades of steel with low-alloy content. The resulting products of low-alloy quenched and tempered steel offer designers the strength-to-weight advantages and wear-resistant properties not available in conventional steels.

High-strength steel has a strength-to-weight ratio of approximately three times that of mild steel. Principal applications are in mining equipment, transport, telescopic cranes, materials handling equipment, high-rise construction and forestry. High-hardness grades offer improved wear-life making it ideal for applications such as liners for chutes, buckets, dump trucks etc. BISALLOY® Armour grades are suitable for armoured personnel carriers and ballistic protection of military and civilian fixed plant and transport equipment.

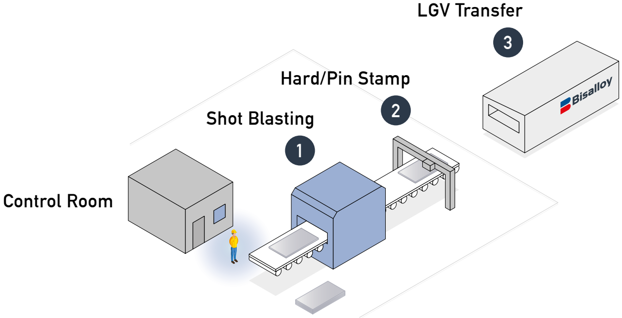
BISALLOY® grades can be readily cut, welded, formed and drilled using similar techniques to mild steel.

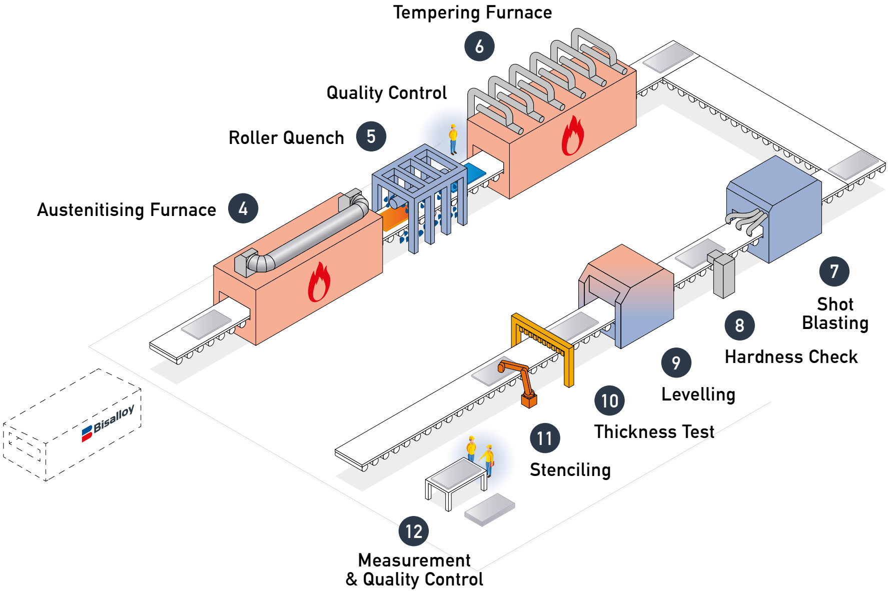
Bisalloy operates an approved mechanical testing laboratory registered and monitored by the Australian National Association of Testing Authorities (NATA). The company's quality control and management system is assessed and accredited to ISO9001, ISO45001 and ISO14001.

The capacity, quality and versatility of our heat treatment line enables us to compete in both domestic and international markets; including New Zealand, Asia, the Middle East, Europe, North America and South America.



PROCESS ROUTE




Tempering Furnace
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Quality Control
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Bisalloy

BISALLOY'S FEED PLATE

The technology used in the manufacture of BISALLOY® steel is not only world-class, but the demands of high-strength and high-hardness steels dictate the need for one of the most stringent process routes utilised in the manufacture of steel plate, anywhere in the world.

Hot metal desulphurisation ensures low levels of sulphur and other impurities in steelmaking. Vacuum degassing is carried out to reduce the Hydrogen content of the steel, whilst also decreasing the amount of undesirable oxygen and nitrogen in the steel. Control of impurities is additionally assisted through the use of hot metal injection and conditioning of the slag during the Basic Oxygen Steelmaking process.

Close control of chemical composition and final microstructure is maintained through the use of ladle refining with calcium injection, argon bubbling through the heat during steelmaking and alloying additions made under vacuum.

Following steelmaking, integrity of slab product is ensured by the use of electromagnetic stirring, continuous casting and controlled cooling of slabs prior to plate rolling.

Finally, plate rolling is carried out in a computer controlled four high rolling mill, in which each draft is modified during rolling for optimisation of final properties. All plate is supplied with a trimmed edge to ensure uniform material properties.

The net result is steel that provides improved toughness, structural integrity and fatigue resistance, providing consistent product performance in service.

BISALLOY'S HEAT TREATMENT

Plate is heated in our natural gas fired furnace, prior to quenching in the roller quench unit. Complete PLC control allows tight and consistent control of all furnace and quench operations, including water flow rates and pressure, furnace temperatures and residence times.

Pre and post-heat treatment shot blasting removes scale and presents an attractive plate. This improves product properties, welding and cutting, as well as simplification during fabrication.

The final operation at Bisalloy is plate levelling, through our plate leveller, for material up to

32mm thick. This has resulted in significant improvements in flatness of plate to market, much tighter than the Australian Standard and other International Standards.

Our quality assurance system ensures that full traceability exists from initial steelmaking right through the process to the final plate. Each plate is individually hard stamped with a unique identification, this links to the overall traceability.

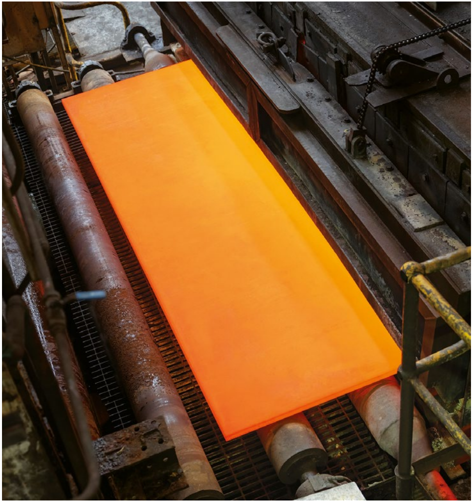
All plates are tested for hardness, whilst all structural grades are tested in Bisalloy's NATA approved mechanical testing laboratory. Plates of all grades are certified. The entire process is carried out in compliance with ISO9001.

BISALLOY'S TECHNICAL DEVELOPMENT

Each of the grades outlined in this brochure have been developed to optimise chemistry and mechanical properties in conjunction with Bisalloy's heat treatment process.

Our world-class steel grades ensure that properties such as ductility, weldability and toughness are maximised, whilst complying with the requisite hardness and strength requirements.

Ongoing R&D at Bisalloy keeps our product range at the leading edge of available quenched and tempered steels. We are developing steel to meet requirements for stronger structural grades and will release to the market as demand dictates.



RANGE OF GRADES

BISALLOY® products can be summarised to three major categories, Structural grade, Wear grade and Armour grade. Our world-class structural grades comply with Australian national standard AS3597 and international standards for quenched and tempered steel plate.

Each of the grades has specific mechanical and chemical properties detailed in the following tables.

Note: This guide covers BISALLOY® Structural and Wear grades only. Please see separate brochures for Bisalloy Armour grades, or contact our Technical team for more information.

Table 3.a:

SUMMARY TABLE FOR STRUCTURAL GRADES (CONFORM TO AS3597 -STRUCTURAL AND PRESSURE VESSEL GRADES)

BISALLOY® Grade	Thickness (mm)	CEQ/CET (Typical)	Hardness (Typical) (HB)	Tensile (Guaranteed)			Charpy Impact (Guaranteed) Specimen Size: 10x10mm		
				0.2P.S. (MPa)	UTS (MPa)	Elongation %	Energy (J)*	Test Temp. (ºC)	Direction
Structural 60	6 - 20 25 - 50 >50 - 100	0.44 / 0.26 0.54 / 0.32 0.58 / 0.34	210	500 (min)	590 - 730	20	80	-40	Longitudinal
Structural 70	6 - 20 25 - 50 >50 - 100	0.44 / 0.26 0.54 / 0.32 0.58 / 0.34	230	600 (min)	690 - 830	20	75	-40	Longitudinal
Structural 80	6 - 20 25 - 50 >50 - 65 >65 - 100 >100 - 120	0.44 / 0.26 0.54 / 0.32 0.58 / 0.34 0.58 / 0.34 0.62 / 0.38	255	690 (min) 690 (min) 690 (min) 620 (min) 620 (min)	790 - 930 790 - 930 790 - 930 720 - 900 720 - 900	18 18 18 16 16	40 40 40	-40 -20 -20	Longitudinal
Structural 100	6 - 20 25 - 50	0.44 / 0.26 0.54 / 0.32	310	890 (min)	940 - 1100	13	40	-20	Longitudinal
Structural 110	6 - 20 25 - 50	0.44 / 0.26 0.54 / 0.32	330	960 (min)	980 - 1150	12	40	-20	Longitudinal
Structural 80PV	6 - 20 25 - 50 >50 - 65 >65 - 100	0.44 / 0.26 0.54 / 0.32 0.58 / 0.34 0.58 / 0.34	255	690 (min) 690 (min) 690 (min) 620 (min)	790 - 930 790 - 930 790 - 930 720 - 900	18 18 18 16	Lateral expansion 0.38mm	< 0	Transverse

*Note:
5x10mm and 7.5x10mm Charpy specimens are used for plate less than 12mm thick. Impact Energy values are proportional to the cross-section area of the specimen according to AS3597.

Carbon Equivalent Formula:

$$CEQ = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

$$CET = C + \frac{Mn + Mo}{10} + \frac{Cr + Cu}{20} + \frac{Ni}{40}$$

Table 3.b: SUMMARY TABLE FOR WEAR GRADES

BISALLOY® Grade	Thickness (mm)	CEQ/CET (Typical)	Hardness (HB)	Tensile (Typical)			Charpy Impact (Typical)		
				0.2P.S. (MPa)	UTS (MPa)	Elongation % 50 mm GL	Energy (J)	Test Temp. (ºC)	Direction
Wear 320	6 - 25	0.44 / 0.26	320 - 360	970	1070	16	35	-40	Longitudinal
	>25 - 80	0.54 / 0.32							
	>80-100	0.58 / 0.34							
Wear 400	6 - 25	0.44 / 0.26	370 - 430	1070	1320	14	35	-40	Longitudinal
	>25 - 80	0.54 / 0.32							
	>80-100	0.58 / 0.34							
Wear 450	6 - 20	0.46 / 0.30	425 - 475	1150	1400	12	30	-40	Longitudinal
	25 - 50	0.58 / 0.36							
	>50 -100	0.62 / 0.40							
Wear 500	8 - 100	0.62 / 0.40	470 - 530	1400	1640	10	25	-40	Longitudinal
Wear 600	12 - 60	0.75 / 0.52	570 - 640	-	-	-	12	-40	Longitudinal

Table 3.c: SUMMARY TABLE FOR WEAR PLUS & XT GRADES

BISALLOY® Grade	Thickness (mm)	CEW/CET (Typical)	Hardness (HB)	Tensile (Typical)			Charpy Impact (Guaranteed)		
				0.2P.S. (MPa)	UTS (MPa)	Elongation %	Energy (J)	Test Temp. (ºC)	Direction
Wear 320 Plus	25 - 40	0.62 / 0.35	310 - 370	970	1070	16	40	-40	Transverse
	>40 - 100	0.73 / 0.42							
Wear 450 Plus	6 – 20	0.46 / 0.30	425 - 475	1050	1400	12	27	-40	Transverse
	25- <50	0.62 / 0.35							
	50 - 100	0.73 / 0.42	410 - 475				27	-20	
Wear 500 Plus	6 - <50	0.60 / 0.40	470 - 530	1350	1640	10	20	-40	Longitudinal
	50 - 100	0.77 / 0.48	450 - 530						
Wear 500XT	8 - 50	0.62 / 0.40	470 - 520	1400	1640	10	25	-40	Longitudinal

*Note: Typical – Typical average values for reference information only.

Table 3.d:
GRADE EQUIVALENTS

BISALLOY® Grade	Country of Origin	Steel Standard	Comments
Structural 60	Australia	AS3597 Grade 500	Min. yield 500 MPa
	ISO	ISO4950-3 AMD 1	Min. yield 500 MPa
	Japan	JIS G3106 SM570	Min. yield 420 MPa
	USA	ASTM A572/A572M Grade 60	Min. yield 415 MPa
	USA	ASTM A537/A537M	Min. yield 485 MPa
	Europe	EN10025 S460	Min. yield 460 MPa
Structural 70	Australia	AS3597 Grade 600	Min. yield 600 MPa
	ISO	ISO4950-3 AMD 1	Min. yield 620 MPa
	USA	ASTM A533/A533M Cl.1	Min. yield 550 MPa
	Europe	EN10025 S600	Min. yield 620 MPa
Structural 80	Australia	AS3597 Grade 700	Min. yield 690 MPa
	ISO	ISO4950-3 AMD 1	Min. yield 690 MPa
	USA	ASTM A514/A514M	Min. yield 690 MPa
	Europe	EN10025 S690	Min. yield 620 MPa
	Japan	JIS G3128	Min. yield 685 MPa
Structural 80PV	Australia	AS3597 Grade 700PV	Min. yield 690 MPa
	USA	ASTM A517/A517M	Min. yield 690 MPa
	Europe	EN10028 P690	Min. yield 690 MPa
Structural 100	Australia	AS3597 Grade 900	Min. yield 890 MPa
	Europe	EN10025 S890	Min. yield 890 MPa
Structural 110	Australia	AS3597 Grade 1000	Min. yield 960 MPa
	Europe	EN10025 S960	Min. yield 960 MPa

Table 3.e:
APPLICATIONS OF BISALLOY PRODUCTS

BISALLOY® Grades	Applications
Structural 60, 70 and 80	Transport equipment, Mining equipment (Dump truck trays, Long wall roof support), Lifting equipment, Bridge and high-rise building, Storage tanks, Excavator buckets and arms, Induced draft fans
Structural 80PV	Transport road tankers, Storage tanks, Railroad tankers, Refinery and petrochemical equipment, Pipe line for high pressure water (Hydro project)
Structural 100 and 110	Transport equipment (low loaders), Lifting equipment (Mobile cranes), Mining equipment (Longwall roof supports)
Wear 320/320 Plus/400	Dump truck wear liners, Cyclones and Chutes, Deflector plate, Ground engaging tools, Storage bins, Cutting edges, Earthmoving buckets
Wear 450/450 Plus	Dump truck bodies and wear liners, Mining buckets, Tipper bodies, Cutting edges, Waste bins, Liner plate for chutes
Wear 500/500 Plus	Wear liners for truck bodies and chutes, Earthmoving buckets, Cutting edges, Ground engaging tools, Shredders
Wear 500 XT	Dump truck bodies, Chutes
Wear 600	Wear liners, Chute liners, Mining bucket, Ground engaging tools, Cutter and Cutting edges, Shredders

SAFETY CONSIDERATIONS AND ADVICE FOR HANDLING BISALLOY® WEAR 600 PLATE:

BISALLOY® Wear 600 is designed for wear applications and should not be used in any structural applications. It is recommended that all fabrication of BISALLOY® Wear 600 should be undertaken in strict accordance with these recommendations to avoid personal and/or equipment damage.

Recommendation for the processing and handling of BISALLOY® Wear 600 are provided to prevent any harm or injury which may result from the inappropriate unsafe use and handling of very high-hardness steels. All appropriate and/or necessary safety measures are the responsibility of the buyer and/or user in order to prevent personal injury or equipment damage during handling and/or processing of BISALLOY® Wear 600. Due to the very high-hardness of this product, the plant and equipment used for lifting and loading must be suitable for the job. In particular, the following should be noted:

- If using vertical lifting dogs/clamps, ensure they are suitable for lifting such high-hardness plate
- Avoid shock loading/dropping and other sudden impact during plate lifting/handling

BISALLOY® SIZE RANGE

BISALLOY® products are available in a thickness range of 6 – 120mm with various sizes, including standard sizes and non-standard sizes. The details of thickness and sizes for each grade are displayed in the following tables.

Table 4.a:

STANDARD SIZE SCHEDULE
(a) Structural and Wear grades

Plate Mass in Tonnes																			
Grades	**BISALLOY® Structural 60, 70, 80, 80PV 100, 110* WEAR 320, 400**							**BISALLOY® Wear 450**						**BISALLOY® Wear 500/500XT**				**BISALLOY® Wear 600**	
Width (mm)	**1525+**	**2485**	**3100**	**2485**	**2000**	**2000**	**2000**	**1525**	**1900**	**2485**	**2485**	**3100**	**3100**	**1525**	**1900**	**2485**	**2485**	**2400**	**2400**
Length (mm)	**8000**	**8000**	**8000**	**6000**	**6000**	**7000**	**5900**	**6000**	**6000**	**8000**	**8500**	**8000**	**8800**	**6000**	**6000**	**6000**	**8000**	**6000**	**8000**
Thickness (mm)																			
6	0.575	0.936																	
8		1.248								1.248							1.248		
10		1.561	1.947							1.561		1.947					1.561		1.507
12		1.873	2.336							1.873		2.336					1.873		1.809
16		2.497	3.115							2.497		3.115					2.497		2.412
20		3.121	3.894							3.121		3.894					3.121		3.014
25		3.901	4.867							3.901			5.354				3.901		3.768
32		4.994									5.306						4.994		4.823
40		6.242								6.242							6.242		6.029
50		7.803								7.803							7.803	5.626	
60				7.023						9.363						7.023			
70					6.594				6.264						6.264				
75					7.065				6.712						6.712				
80					7.536				7.159						7.159				
90					8.478	9.891													
100					9.420	10.99		7.183						7.183					
120							11.116												

* BISALLOY® Structural 80PV, 100 and 110 sizes by agreement. +1525mm wide 6mm thick is supplied with untrimmed edge.

Table 4.b:

(b) Wear 320 Plus/450 Plus/500 Plus

Plate Mass in Tonnes												
Grades	BISALLOY® Wear 320 Plus				BISALLOY® Wear 450 Plus				BISALLOY® Wear 500 Plus			
Width (mm)	2485	2485	3100	2000	2485	2485	3100	2000	2485	2485	2000	1800
Length (mm)	8000	8000	8000	6000	8000	8500	8000	6000	8000	6000	6000	6000
Thickness (mm)												
6												
8					1.248				1.248			
10	1.561		1.947		1.561		1.947		1.561			
12	1.873		2.336		1.873		2.336		1.873			
16	2.497		3.115		2.497		3.115		2.497			
20	3.121		3.894		3.121		3.894		3.121			
25	3.901				3.901				3.901			
32	4.994				4.994				4.994			
40	6.242				6.242				6.242			
50	7.803				7.803				7.803			
60	9.363				9.363					7.023		
70				6.594				6.594			6.594	
75				7.065				7.065			7.065	
80				7.536				7.536			7.536	
90											8.478	
100												8.478

NON STANDARD SIZES

- Available subject to sales enquiry
- Minimum order quantities may apply

Plate mass (tonnes) calculation = 7.85 x W x T x L (m)


0 10 20 30 40 50 60 70 80 90 100 110 120
0 1 2 3 4 5 6 7 8 9 10
0.05 mm

MANUFACTURING TOLERANCES

All manufacturing tolerances for BISALLOY® products comply with AS/NZS 1365.

Table 5.a:
THICKNESS TOLERANCE

Width		Thickness (+/- mm)									
		≤6	>6 ≤8	>8 ≤10	>10 ≤13	>13 ≤18	>18 ≤22	>22 ≤30	>30 ≤42	>42 ≤63	>63
	<1600	0.53	0.60	0.60	0.68	0.83	0.90	1.05	1.28	1.73	2.55
≥1600	<2100	0.60	0.68	0.68	0.75	0.90	0.98	1.13	1.35	1.80	2.63
≥2100	<2700	0.75	0.75	0.83	0.90	0.98	1.125	1.28	1.50	1.95	–
≥2700		–	0.98	1.05	1.13	1.20	1.35	1.43	–	–	–

Notes:
1. Measurement can be conducted anywhere on plate
2. All dimensions are in millimetres

Table 5.b:
WIDTH TOLERANCE TRIMMED EDGE PLATE

Thickness	<16mm		≥16 <50mm		≥50mm	
Width	Plus	Minus	Plus	Minus	Plus	Minus
<1520	20	0	25	0	25	0
≥1520	20	0	25	0	30	0

Note:
All dimensions are in millimetres

Table 5.c:
UNTRIMMED EDGE PLATE

Width (All Thickness)		PLUS	MINUS
Coil Plate	≤1525	40	0

Note:
All dimensions are in millimetres

Table 5.d:
LENGTH TOLERANCE

All Thickness	<25mm		≥25mm	
Length	Plus	Minus	Plus	Minus
<6000	25	0	30	0
≥6000 <12000	30	0	40	0
≥12000	50	0	65	0

Note:
All dimensions are in millimetres

Table 5.e:
EDGE CAMBER TOLERANCE

Specified Width	Trimmed Edge	Trimmed Edge
All	4	6

Note:
All dimensions are in millimetres

Figure 1:
Measurement of Camber

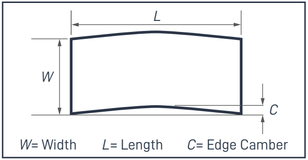


Figure 2a:
Measurement of Flatness Waviness

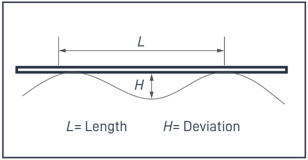
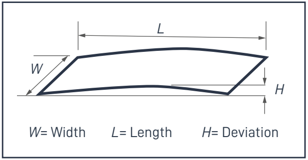


Figure 2b:
Measurement of Flatness Bowing



Note:
All dimensions are in millimetres. The measurement method conforms to AS 1365

Edge Camber shall be limited so that it shall be possible to inscribe the dimensions of the ordered plate within the delivered size.

Measurement of flatness tolerance should be made when the product, resting under its own mass, is placed on a flat horizontal surface. A straight edge shall be placed on the plate and the maximum vertical distance from the plate shall be measured (H).

Table 5.f:
MANUFACTURING TOLERANCES FOR FLATNESS

Specified Thickness Plate (mm)	Distance Between Points of Contact (mm)	Specified Width of Plate (mm)				
		<1500	≥1500 <1800	≥1800 <2400	≥2400 <3000	≥3000
<8	1000	5	5	5	5	-
	2000	6	6	6	6	-
8-<50	1000	5	5	5	5	5
	2000	6	6	6	6	6
50-120	1000	4	4	4	4	-
	2000	6	6	6	6	-

Notes:

1. The tolerances apply when measured at least 20mm from the longitudinal edges and 100mm from the transverse edges
2. Where the distance between the points of contact is between 500mm and 1000mm, the permissible deviation is obtained as follows:

$$\frac{\text{DISTANT BETWEEN POINTS OF CONTACT x H}}{10000}$$

Where H = allowable deviation for 1000mm

3. The method for measuring the flatness should refer to AS1365
4. This table only applies to Wear and Structural grades with hardness under 530HB. Flatness tolerance for other products are supplied by agreement.

PLATE CUTTING

All grades of BISALLOY® steel can be cut by either thermal cutting, laser cutting, waterjet cutting or power saw operations. The cutting operations can be carried out either in the workshop or, in the case of flame cutting, in field conditions. Both the high-strength structural grades and the wear (abrasion) resistant grades can be cut using the same type of equipment employed in cutting plain carbon steels.

Dependant on the grade and thickness being cut, the following operations can be used on BISALLOY® steel.

-Flame Cutting (Oxy-LPG and Oxy-acetylene)

-Plasma Cutting

-Laser Cutting

-Waterjet Cutting

-Power Sawing

FLAME CUTTING

Both Oxy-LPG and Oxy-acetylene processes are acceptable for sectioning all thicknesses of BISALLOY® steel. With these processes, the following techniques are recommended:

- **Gas pressure** to be the same as for cutting the equivalent thickness in plain carbon steel.
- Reduce **travel speeds** by 30% when compared to the equivalent thickness plain carbon steels when using a standard cutting nozzle.
- **Nozzle size** to be the same as for equivalent thickness plain carbon steel. Correct selection of nozzle size for the plate thickness being cut is important to ensure efficient cutting and to minimise the width of the heat affected zone (HAZ).

As with all plate steels, the smoothness of the cut is affected by surface scale. If this is present, it is advisable to remove it prior to cutting. (BISALLOY® steel is normally supplied in the shotblasted condition).

Under normal Oxy cutting conditions, the total heat affected zone adjacent to the flame-cut edge will extend into the plate more than 2mm. The thicker the plate, the wider the heat affected zone. It should be noted that the heat affected zone produces a 'hard' layer adjacent to the flame-cut edge, with a 'soft' layer inside this. The original plate hardness returns after a certain distance from the cut edge.

Preheating BISALLOY® steel prior to flame cutting will minimise the hardness of the flame-cut edge and will also reduce the risk of delayed cracking from the cut edge. Preheating is particularly important in cold environments where plate temperature is less than 20ºC and for the high hardenability grades of BISALLOY® Wear 450, 500 and 600 steels.

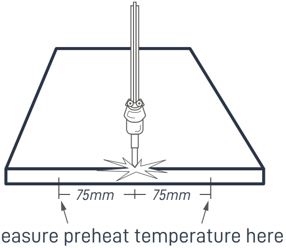
Table 6.a, gives guidance on the preheat requirements. It is recommended that the zone to be preheated should extend at least 75mm either side of the line of cut, with the temperature being measured on the opposite surface and at a distance of 75mm, as shown in Figure 1.

A slow cool can reduce the risk of cracking after cutting on 500 & 600 grade. When stripping plates, the use of multiple cutting heads will help to minimise distortion of the cut pieces.

Table 6.a:
RECOMMENDED MINIMUM PREHEAT TEMPERATURES FOR FLAME CUTTING OF BISALLOY® GRADES

BISALLOY® Grade	Plate Thickness (mm)	Minimum Preheat Temperature (ºC)
Structural 60/70/80/80PV/100/110	≤25mm	20 ºC
	>25 – 50mm	75 ºC
	>50 – 100mm	100 ºC
	>100 – 120mm	120 ºC
Wear 320/320 Plus/400	≤25mm	20 ºC
	>25 – 50mm	75 ºC
	>50 – 100mm	120 ºC
Wear450/450Plus/500XT	≤25mm	20 ºC
	>25 – 50mm	100 ºC
	>50 – 100mm	150 ºC
Wear 500/500 Plus	8 - 20mm	50 ºC
	>20 – 50mm	100 ºC
	>50 – 100mm	150 ºC
Wear 600	8-20mm	100 ºC
	>20 – 50mm	150 ºC

Figure 1:
Recommended preheat zone and location of preheat measurement.



If the flame-cut surface is to be the face of a welded joint, the heat affected zone from the flame cutting need not be removed. However, all slag and loose scale should be removed by light grinding, and prior to welding, the cut surface should be dry and free from organic matter such as oil, grease, etc (as directed by good workshop practice).

When stripping plates, the use of multiple cutting heads will help to minimise distortion of the cut pieces. Correct nozzle size, gas pressure and travel speed will also minimise distortion during cutting. Softening on edges can also occur when flame cutting small strips or parts.

Quench cutting of BISALLOY® steel to minimise distortion is not recommended, cooling in still air is preferred. The technique of stacking plates during profile cutting can reduce the cooling rate and help to diffuse the hydrogen.

Post-heating can be applied to cut plate or parts. Post-heating can reduce cooling rate, therefore reduce the risk of cold cracking. The operation of post-heating is the same as preheating.

SUMMARY OF FLAME CUTTING RECOMMENDATIONS

– For oxy processes use gas pressures and nozzle sizes as for an equivalent thickness of plain carbon steel
– For oxy processes use cutting speeds two thirds of that recommended for an equivalent thickness of plain carbon steel
– Flame cutting produces a heat affected zone on all grades. The risk of delayed cracking is reduced by using preheat especially for thick plate and for BISALLOY® Wear 500 and Wear 600 grades.
– Use multiple cutting heads when stripping plates
– Still air cooling after cutting
– Do not quench cut plates
– Use thermal crayons or surface thermometers to measure preheat temperatures

REFERENCES/FURTHER READING

Weld Australia Technical Note 5 “Flame Cutting of Steels.”

PLASMA CUTTING

Plasma cutting is an acceptable method of sectioning all grades of BISALLOY® steel. The process offers particular advantages of productivity over flame cutting in thicknesses up to 50mm using currently available equipment. For instance, the cutting speed of 6mm BISALLOY® Wear 400 may be up to 9 times that recommended for conventional flame cutting techniques.

The cut quality may be inferior, however, due to rounding of the top edges and difficulty in obtaining a square cut face of both edges. Guidance on the optimum settings for nozzle size, gas pressure, gas composition and cutting speeds will be provided by the equipment manufacturer. Bisalloy products contain low-alloy contents and should be treated similarly to conventional steels.

The heat affected zone from a plasma cut is narrower than that produced from flame cutting but peak hardnesses are generally higher. General recommendations for the removal of this hardened zone are outlined below in table 6.b.

Table 6.b:
HARDNESS PROFILE CHARACTERISTICS FOR PLASMA CUTTING

Plate Thickness (mm)	Recommended Depth of Removal (mm)	Peak Hardness (HB)			
		BISALLOY® Structural 60, 70, 80, 80PV, 100, 110/ BISALLOY® Wear 320, 400	BISALLOY® Wear 450	BISALLOY® Wear 500	BISALLOY® Wear 600
5 – 8	0.4 – 0.5	430	480	540	640
>8 – 12	0.6 – 0.8	430	480	540	640
>12 – 20	1.0 – 1.2	450	480	540	640

The plasma cut HAZ typically extends 0.5 - 1.0mm into the plate under normal conditions. As is the case for flame cutting, complete removal by grinding is recommended if cold forming of the cut plate is contemplated.

All other comments for flame cutting regarding preheating, removal of the HAZ, stripping and stack cutting of plates would apply to plasma cutting.

LASER CUTTING

Laser cutting is a productive method for sectioning all grades of BISALLOY® steel up to 12mm thickness, particularly where high levels of accuracy and minimal distortion is required. Currently, with thicknesses above 12mm, productivity levels drop when compared with other processes.

The laser cutting process is unlike other thermal cutting in so far as the material is essentially vapourised from the kerf rather than melting and removal by kinetic energy.

The laser concentrates its energy into a focused beam resulting in low levels of excess heat. This results in very small HAZ areas (0.05 – 0.15mm) and small kerfs (0.3mm) as shown in table 6.c.

Table 6.c:
COMPARISON OF FLAME, PLASMA AND LASER CUTTING ON 6mm BISALLOY® WEAR 400

Process	Kerf Width (mm)	Haz Width (mm)
Flame Cutting	0.9	1.5
Plasma Cutting	3.2	0.5
Laser Cutting	0.3	0.2

Cutting speeds are typically 3000mm/min and the edge is generally square, burr-free and minimal dross.

Peak hardness levels are lower than those obtained from alternate cutting methods previously described. Removal of the HAZ is generally not considered necessary for most applications, however, for forming operations it is advised that Bisalloy are contacted for guidance.

DISTORTION AFTER CUTTING

BISALLOY® Wear 500 and 600 have very high-hardness and may contain high residual stresses. Distortion of the cut part can happen due to releasing of the internal stress after cutting. It is recommended that the following practices to be used to minimise distortion after cutting:

- Use multiple cutting heads when stripping plates
- Use stitch cutting technique, leaving small tabs along the cutting line to restrain the component from moving due to distortion.
- Use a cutting sequence which minimises heat concentration.

Should distortion/springback occur after cutting/profiling into small parts, pressing/levelling either by bend press or roller leveller can be used. Such practise will not affect mechanical properties.

Preheat can be used when pressing/levelling parts however do not exceed 200ºC. When the part needs to be pressed, refer to the recommended bending procedures (in the Technical Guide for Bending).

POWER SAWING

All BISALLOY® grades can be cut with power saws, provided lower blade speeds and blade pressures up to 50% higher than those used for cutting plain carbon steel are used. Best results have been achieved using power saw blades normally recommended for cutting stainless steel (generally, blades having 4 - 6 teeth per 25mm). Sawing directly onto a flame-cut surface should be avoided where possible.

WATERJET CUTTING

Waterjet cutting can be performed on all BISALLOY® grades, although its widespread use is limited due to the current machines available in Australia and their low cutting speeds.

A key advantage of water jet cutting is that it leaves the surface free of HAZ. Cutting without heat protects against metallurgical changes in the plate, ensuring original plate mechanical properties are maintained.

Testing performed by the CSIRO Division of Manufacturing Technology on waterjet cutting 8mm BISALLOY® Wear 500 at 40mm/min resulting in near-perfect cut edges. Speeds to 75mm/min are possible but with reduced smoothness of the cut edge.

The waterjet cut shows no change in material structure at the edge of the cut. The laser cut edge shows a distinct change in structure to a depth of 0.2mm.

Both laser cutting and waterjet cutting are industrial processes which should be considered by structural designers and fabricators as alternate means to avoiding problems associated with fit up, cut edge squareness, shape precision, dross and gross HAZ's which can occur with conventional thermal cutting processes.

WELDING OF BISALLOY® STEEL

All grades of BISALLOY® steel can be readily welded using any of the conventional low hydrogen welding processes. Their low carbon content combined with selective addition of alloying elements (Mn, Cr, Mo, B) ensures good weldability, in addition to the advantages of higher strength, hardness and impact toughness.

To ensure ideal welding of BISALLOY® steel, it is necessary to be more mindful of the levels of hydrogen, preheat temperatures and arc energy inputs in order to minimise the hardening and maintain the properties of the weld Heat Affected Zone (HAZ).

HYDROGEN CONTROL

Particular attention must be paid to the control of hydrogen content to minimise the risk of weld and HAZ cracking. Weld hydrogen content is minimised by careful attention to the cleanliness and dryness of the joint preparation and the use of hydrogen controlled welding consumables. Recommendations on the correct storage and handling of consumables may be obtained from welding consumable manufacturers, for instance the use of "Hot Boxes" for storage and reconditioning are required when using manual metal arc welding electrodes. Refer Weld Australia Tech. Note 3 for further guidance.

HEAT AFFECTED ZONE PROPERTY CONTROL

The HAZ, a region directly adjacent to the weld, experiences a thermal gradient ranging from unaffected parent plate to near melting at the fusion boundary. The properties of this HAZ are determined by the steel composition as well as the cooling rate.

COOLING RATE

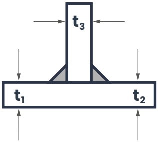
Limitations on both preheat and heat input are necessary to ensure that the HAZ cools at an appropriate rate and that the correct hardness and microstructure is achieved. A cooling rate that is too slow can result in a soft HAZ and thus a loss of tensile and fracture toughness properties. Too rapid a cooling rate produces a hard HAZ which may cause loss of ductility. Cooling is controlled by a balance between preheat and heat input for a particular plate thickness and joint configuration.

PREHEAT/HEAT INPUT

The preheat/heat input recommendations outlined in tables 7.a and 7.b will ensure that the cooling rate of the HAZ is satisfactory.

Table 7.a:
RECOMMENDED PREHEAT/INTERPASS TEMPERATURES (°C)

BISALLOY® Grade	Joint Combined Thickness (t1 + t2 + t3) (mm)				
	<30	≥30≤40	>40<50	≥50<100	≥100
Minimum Preheat Temp°C BISALLOY® Structural Grades					
60 (AS3597 Grade 500)	Nil*	50	50	75	140
70 (AS3597 Grade 600)	Nil*	50	50	75	140
80 (AS3597 Grade 700)/80PV	Nil*	50	50	75	140
100 (AS3597 Grade 900)/110	Nil*	50	50	75	140
Minimum Preheat Temp°C BISALLOY® Wear Grades					
320/320 Plus	Nil*	50	75	125	150
400	Nil*	50	75	125	150
450/450 Plus/500XT	Nil*	75	100	150	175
500/500 Plus	100	150	150	150	175
600	150	150	150	175	200
Maximum Interpass Temp°C					
60 - 450 Grades	150	150	175	200	220
500 Grade	150	175	175	200	220
600 Grade	150	175	175	220	220



*Chill must be removed from plates prior to welding

Note that under rigid weld joint restraint or high ambient humidity conditions preheating temperature should be increased by 25°C

Table 7.b:
PERMISSIBLE HEAT INPUT (KJ/mm) FOR BISALLOY® PLATE

Welding Process	Joint Combined Thickness (t1 + t2 + t3) (mm)			
	≤40	>40 ≤60	>60 ≤100	>100
MMAW	1.25 - 2.5	1.25 - 3.5	1.5 - 4.5	1.5 - 5.0
GMAW	1.0 - 2.5	1.0 - 3.5	1.5 - 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

$$\text{Heat input (kJ/mm)} = \frac{\text{Volts x Amps x 0.06}}{\text{Travel Speed (mm/minute)}}$$

Note: For thicknesses up to 12mm in structural grades, the maximum arc energy may need to be limited to 1.5 KJ/mm maximum in specific applications such as structural beams.

Table 7.c:
WELDING CONSUMABLE SELECTION GUIDE (AS CLASSIFICATIONS)

		Structural 60	Structural 70	Structural 80/80PV	Structural 100, 110 and Wear 320/320Plus, 400, 450/450Plus, 500/500Plus, 500XT
MMAW Consumables* Warning: Only use Hydrogen Controlled consumables					
Strength Level	Matching	E55XX/E62XX[+]	E69XX[~]	E76XX	N.R.
	Lower	E49XX	E55XX	E55XX/E62XX[+]	E55XX
	Lower	E49XX	E49XX	E49XX	E49XX
Hardness	Matching	N.R.	N.R.	N.R.	1430-AX, 1855-AX[^]
GMAW Consumables**					
Strength Level	Matching	W55XX/W62XX[+]	W69XX[+]	W76XX	N.R.
	Lower	W50XX	W55XX	W62XX/W69XX	W55XX
	Lower	W50XX	W50XX	W55XX.X	W50XX
Hardness	Matching	N.R.	N.R.	N.R.	1855-BX[^]
FCAW Consumables***					
Strength Level	Matching	B T 55X/B T 62X[+]	B T 69X[~]	B T 76X	N.R.
	Lower	B T 49X	B T 62X	B T 62X	B T 55X
	Lower	B T 49X	B T 55X	B T 55X	B T 49X
Hardness	Matching	N.R.	N.R.	N.R.	1430-BX, 1855-BX, 1860-BX[^]
FCAW Consumables***					
Strength Level	Matching	W55XX/W62XX[+]	W69XX[~]	W76XX	N.R.
	Lower	W50XX	W50XX	W50XX	W50XX
	Lower	W40XX	W40XX	W40XX	W40XX
Hardness	Matching	N.R.	N.R.	N.R.	1855-BX[^]

Table 7.c courtesy of Weld Australia (Tech Note 15)

Notes:
* MMAW - AS/NZS 4855 consumable classification
** GMAW - AS2717.1 consumable classification
*** FCAW - AS/NZS17632 and AS/NZS18276 consumable classification
**** SAW - AS1858.1 and AS1858.2 consumable classification
[X] A Variable - any value allowed by the relevant standard may be acceptable provided that the consumable is hydrogen controlled (ie low hydrogen)
[+] E62XX and W62XX type consumables overmatch the strength requirements but may be used
[~] These Consumables may be difficult to obtain. In some cases E62XX, W62XX or B T 62X consumables may be substituted, otherwise use E76XX, W76XX or B T 76X types
[^] AS2576 and Weld Australia TN 4 Classifications
N.R. Not Recommended

Table 7.d:

WELDING CONSUMABLE SELECTION GUIDE (AWS CLASSIFICATIONS)

		Structural 60	Structural 70	Structural 80	Structural 100, 110 and Wear 320/320Plus, 400, 450/450Plus, 500/500Plus, 500XT
MMAW Consumables* Warning: Only use Hydrogen Controlled consumables					
Strength Level	Matching	E80XX/E90XX+	E100XX~	E110XX	N.R.
	Lower	E70XX	E80XX	E80XX/E90XX	E80XX
	Lower	E70XX	E70XX	E70XX	E70XX
Hardness	Matching	N.R.	N.R.	N.R.	1430-AX, 1855-AX^
GMAW Consumables**					
Strength Level	Matching	ER80S-X/ER90S-X+	ER100S-X~	ER110S-X	N.R.
	Lower	ER70S-X	ER80S-X	ER90S-X/ ER100S-X	ER80S-X
	Lower	ER70S-X	ER70S-X	ER80S-X	ER70S-X
Hardness	Matching	N.R.	N.R.	N.R.	1855-BX^
FCAW Consumables***					
Strength Level	Matching	E8XTX-X/E9XTX-X+	E10XTX-X~	E11XTX-X	N.R.
	Lower	E7XTX-X	E9XTX-X	E9XTX-X	E8XTX-X
	Lower	E7XTX-X	E8XTX-X	E8XTX-X	E7XTX-X
Hardness	Matching	N.R.	N.R.	N.R.	1430-BX, 1855-BX, 1860-BX^
FCAW Consumables***					
Strength Level	Matching	F8XX/F9XX+	F10XX~	F11XX	N.R.
	Lower	F7XX	F7XX	F7XX	F7XX
	Lower	F6XX	F6XX	F6XX	F6XX
Hardness	Matching	N.R.	N.R.	N.R.	1855-BX^

Table 7.d courtesy of Weld Australia (Tech. Note 15)

Notes:
* MMAW – AWS A5.1-2004 and AWS A5.5 consumable classification
** GMAW – AWS A5.18-2005 and AWS A5.28 consumable classification
*** FCAW – AWS A5.20-2005 and AWS A5.29 consumable classification
**** SAW – AWS A5.17-1997 and AWS A5.23 consumable classification
X A Variable - any value allowed by the relevant standard may be acceptable provided that the consumable is hydrogen controlled (ie low hydrogen)
+ E90XX, ER90S, E9XTX and F9XX type consumables overmatch the strength requirements but may be used
~ These Consumables may be difficult to obtain. In some cases E90XX, ER90S, E9XTX or F9XX type consumables may be substituted, otherwise use E110XX, ER110S, E11XTX or F11XX types
^ AS2576 Weld Australia TN 4 Classifications
N.R. Not Recommended

WELDING PROCEDURES

The specific effects of welding on weld joint properties in any practical situation will depend on many factors including the choice of consumables, total weld heat input, level of restraint, weld geometry and proximity of adjacent welds.

Guidance on weld procedures for specific applications may be sought from Bisalloy technical staff or consumable suppliers.

ARC STRIKES

Arc strikes outside the welded zone can result in cracks, particularly on dynamically loaded structures. All strikes should be made within the joint preparation.

TACK WELDING

Tack welds require special care due to the abnormal stresses and high cooling rates experienced by the adjacent material. The same preheat, heat input requirements should be employed and lower strength welding consumables considered.

AUSTENITIC STAINLESS STEEL CONSUMABLE

Due to the fact that the hydrogen diffusion rate is very low in austenitic steel than in ferritic steel, a austenitic steel consumable has advantages over a ferritic consumable when it is used for welding Q&T steel, especially for welding those high-hardness, high-carbon equivalent Q&T steels such as BISALLOY® Wear 500 & 600 steel.

For welding BISALLOY® Structural 80 steel and even BISALLOY® Wear 450 steel, no preheat is required if austenitic stainless steel consumable is used. For welding BISALLOY® Wear 600 steel grade, preheat temperature is much lower than the temperature required for ferritic consumables.

The following austenitic consumables are recommended for welding BISALLOY® grades.

Table 7.e:
RECOMMENDED AUSTENITIC STAINLESS STEEL CONSUMABLES

Welding Method	AS Classification	AWS Classification
MMAW	ES308L, ES309L, ES316L	E308L, E309L, E316L
GMAW	SS308L, SS309L, SS316L	ER308L, ER309L, ER316L
FCAW	TS308LT, TS309LT, TS316LT	E308LT, E309LT, E316LT
SAW	ER308L, ER309L, ER316L	ER308L, ER309L, ER316L

FILLET WELDING

Good fillet welding techniques are important in welding Q&T steels because often very high stresses are applied in service. It is essential that welds have good root penetration, be smooth, correctly contoured and well flared into the legs of the joined pieces. Lower strength consumables are suggested when design permits.

Weld Australia Tech. Note 15 provides guidance on correct procedures for fillet welding.

REPAIR WORK

It is good practice to weld repair with lower strength consumables (low hydrogen type), since plate materials which have been highly stressed in service may tend to warp or distort slightly during welding and improved ductility may be required. In some situations, such as joints under restraint, joints subjected to impact/fatigue stresses, etc, special welding consumables may be necessary.

WELDING STRESSES

It should be emphasised that the recommended values of preheat and heat input are based on low to moderate levels of restraint. For conditions of high-restraint it is important to minimise the degree to which free contraction is hampered and it may be necessary to use higher preheats. Proper welding sequence and small joint configurations would be considered important in high-restraint situations and it is advisable to establish welding parameters with simulated full-scale weld tests.

Care should also be exercised at the assembly stage to avoid offset and angular distortion at the plate edge, undercutting and bad appearance.

STRESS RELIEF

Stress relief may be conducted on Structural 60, 70, 80 and 80PV grades but is advisable only if absolutely necessary (eg. to comply with AS1210 in the case of road tankers). Stress relief is recommended within a 540 - 570°C temperature range for one hour per 25mm of thickness. Thermal cycling is generally performed in accordance with AS1210 Code requirements for Q&T steels. The toes of weld beads should be dressed by grinding prior to any stress relief treatment in order to prevent stress relief cracking.

When stress relieving plate ≤12mm (typically 0.40 CE(IIW)) and matching strength across the weld is a requirement, it is recommended to weld with minimum permissible preheat/interpass temperatures (Table 7.a) and heat input (Table 7.b) conditions to minimise the degree of softening or any loss of strength which may occur in the HAZ.

Consult Bisalloy Steels for further information if required.

POST-WELD HEATING

Post-weld heating at 200°C may be conducted as an effective hydrogen dissolution treatment particularly when consumables other than H5 or H10 are used.

HELPFUL HINTS

General rules for good quality welding of BISALLOY® steel:

- Use a low hydrogen process, eg. GMAW (MIG), FCAW (gas shielded)
- Adhere to the correct rules for storage and handling of low hydrogen consumables per the manufacturers' recommendations, or Weld Australia Tech. Note 3
- Clean joint area of all contaminants prior to welding
- Remove 1 - 2mm from flame-cut or gouged surfaces by grinding
- Select the recommended preheat, interpass and heat input parameters
- Position for downhand welding where possible
- Always use stringer beads, never wide weaves
- Use lower strength consumables on root runs and fillet welds (when the design permits)
- Use temper beads when necessary
- Arc strikes to be made in the joint preparation
- Particular attention should be given to tack welds re preheat, heat input and joint cleanliness requirements
- Grinding toes of fillet welds is particularly important in fatigue applications

REFERENCES/FURTHER READING

- AS1554 Part 4 Welding of Q&T Steels
- AS1554 Part 5 Welding of Steel Structures Subject to High Levels of Fatigue Loading
- Weld Australia Technical Note 15
- Weld Australia Technical Note 3
- Weld Australia Technical Note 1

Photo courtesy of QSM Fabrication

FORMIMG, SHEARING AND PUNCHING BISALLOY® STEEL

BISALLOY® products can be processed by using conventional fabrication methods, including cold forming such as bending and rolling, shearing and punching. However, due to their high-strength and high-hardness, special care should be taken during fabrications of both Structural and Wear grade plate. The following information are recommendations for cold forming, shearing and punching BISALLOY® products.

The forming, shearing & punching recommendations are designed for use in relation to BISALLOY® products only. Users must ensure that they are using genuine BISALLOY® products and be aware that steel being referred to as 'Bisalloy' does not necessarily mean it is a BISALLOY® product.

COLD FORMING

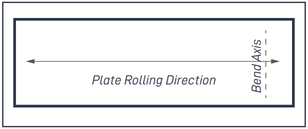
All BISALLOY® products can be cold-formed, using brake press bending or plate rolling techniques.

However, with an increase in both hardness and yield stress compared to plain carbon steel grades, suitable consideration of sufficient machine power, plate bending direction and former radii must be made.

In addition, springback allowances should be greater than for plain carbon steel and will depend on the type of forming. Plate edges should be ground smooth, and for thick plates and high-hardness grades, the plate edges should be rounded prior to forming.

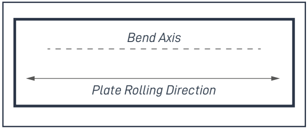
It is recommended for the high-hardness grades that where possible the bend axis be at right angles to the plate rolling direction (transverse bending). For plate 16mm and above in Wear 500 grade, it is suggested bending be done in the transverse direction only (refer to figure 1a).

Figure 1a:



Schematic of transverse bend direction.

Figure 1b:



Schematic of longitudinal bend direction.

Any cold forming work should be completed by an appropriately skilled and qualified tradesman with experience in cold forming in accordance with relevant professional standards and regulations.

Table 8.a:

MINIMUM FORMER RADII (R) IN MM FOR COLD FORMING

The minimum former radii for cold rolling or bending of BISALLOY® grades (where possible a larger former radii should be used).

Before relying on the information in this table, users are advised to confirm that they are using genuine BISALLOY® steel. There is a possibility that other products have different properties, performance characteristics, and quality standards compared to BISALLOY®, which could make this information unsafe or not applicable.

BISALLOY® Grade	Structural 60		Structural 70		Structural 80		Structural 100		Structural 110		Wear 320/400		Wear 450		Wear 500XT		Wear 500		Wear 600*	
Bend Direction	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L	T	L
Plate Thickness (t) (mm)	Bending Forming radius R / Plate Thickness t, (R/t)																			
4	–	–	–	–	2.0	2.5	–	–	–	–	2.5	3.0	3.0	3.5	–	–	4.0	4.5	Not generally recommended. Please contact Bisalloy Technical if bending is required.	
5	1.0	1.5	1.5	2.0	2.0	2.5	2.5	3.0	2.5	3.0	2.5	3.0	3.0	3.5	–	–	4.0	4.5		
6	1.0	1.5	1.5	2.0	2.0	2.5	2.5	3.0	2.5	3.0	3.0	3.5	3.5	4.0	3.5	4.0	4.0	4.5		
8	1.0	1.5	1.5	2.0	2.0	2.5	2.5	3.0	2.5	3.0	3.0	4.0	3.5	4.5	4.0	4.5	4.5	5.0		
10	1.0	1.5	1.5	2.0	2.0	2.5	2.5	3.0	2.5	3.0	3.0	4.0	4.0	5.0	4.0	5.0	4.5	5.5		
12	1.0	1.5	1.5	2.0	2.0	2.5	2.5	3.0	2.5	3.0	3.0	4.0	4.0	5.0	4.0	5.0	4.5	5.5		
16	1.5	2.0	1.5	2.0	2.0	2.5	2.5	3.0	2.5	3.0	3.5	4.5	4.5	5.5	4.5	5.5	5.0	6.0		
20	1.5	2.0	2.0	2.5	2.5	3.0	3.0	3.5	3.0	3.5	4.0	5.0	4.5	5.5	4.5	5.5	5.5	6.5		
25	1.5	2.0	2.0	2.5	2.5	3.0	3.0	4.0	3.0	4.0	4.5	5.5	5.0	6.0	5.0	6.0	5.5	6.5		
32	1.5	2.0	2.5	3.0	3.0	3.5	3.5	4.0	3.5	4.0	4.5	5.5	5.0	6.0	5.0	6.5	6.0	7.0		
40	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	3.5	4.0	4.5	5.5	5.0	6.0	–	–	–	–		
50	2.0	2.5	2.5	3.0	3.0	3.5	3.5	4.0	3.5	4.0	4.5	5.5	5.0	6.0	–	–	–	–		

T: Transverse Bending Direction (refer to Figure 1a).
L: Longitudinal Bending Direction (refer to Figure 1b).
R/t for wear Plus grades is 0.5 less than the wear grade

Notes re Table 8.a:

1. Above values were determined for plate at a temperature of 20°C. If minimum former radii values are to be used, plate temperature should be at least 20°C, maximum 100°C. If forming at a temperature less than 20°C, an increase in former radii is recommended.
2. When pressing is being done in a single pass operation, an increase in former radii of minimum 50% must be made.
3. When forming using these minimum former radii, flame-cut hardened edge (heat affected zone of 1-2mm) should be removed.
4. The use of smaller former radii than in the table is not recommended.
5. For best cold forming results, ensure adequate lubrication between the plate, die and former.
6. Die openings refer to table 8.b.

CAPACITY OF PRESS

All BISALLOY® steel has higher yield and tensile strengths than plain carbon steel.

It is important that the capacity of the machine is suitable, bending press manufacturers provide information on bending loads in relation to V-block opening, plate thickness and steel strength.

Table 8.c gives an indication of the approximate bending force required when forming BISALLOY® steel, compared to plain carbon steel (e.g. AS3678-Grade 250).

Table 8.b:
APPROXIMATE DIE OPENINGS (REFER FIGURE 2)

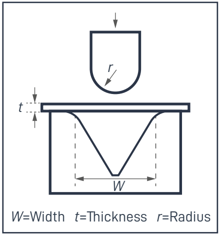
BISALLOY® Grade	Die Opening Width (W/t) Range
Structural 60	10 - 12
Structural 70	10 - 12
Structural 80/80PV	10 - 12
Structural 100	12 - 16
Structural 110	12 - 16
Wear 320/320 Plus	12 - 16
Wear 400	12 - 16
Wear 450/450 Plus	12 - 16
Wear 500/500 Plus/Wear 500XT	14 - 18

These recommendations are based on single step to 90 degree bending.

Table 8.c:
APPROXIMATE BENDING FORCE (P) REQUIRED FOR BISALLOY® STEEL, COMPARED TO PLAIN CARBON STEEL, FOR A GIVEN FORMING GEOMETRY (REFER FIGURE 2)

BISALLOY® Grade	Bending Force (P)
AS3678 – Grade 250	P
Structural 60	2.0P
Structural 70	2.4P
Structural 80/80PV	2.8P
Structural 100	3.0P
Structural 110	3.0P
Wear 320/320 Plus	4.0P
Wear 400	5.0P
Wear 450/450 Plus	5.2P
Wear 500/500 Plus/Wear 500XT	6.4P

Figure 2:



Schematic diagram of brake press bending.

HOT FORMING

Hot forming can be done on BISALLOY® Structural steel grades, however the temperature for these grades must not exceed 570°C.

Hot forming is not recommended for BISALLOY® Wear and BISALLOY® Armour steel grades.

The mechanical properties of BISALLOY® Wear steel will reduce if the steel is heated above 250°C.

SHEARING AND PUNCHING

Shearing and punching of the lower hardness BISALLOY® grades can be done successfully, provided a machine of sufficient power and stability is used.

BISALLOY® Structural 60, 70 and 80 steel grades can normally be cold sheared up to 25mm thickness. However, the necessary shearing force is in the order of 2-3 times that required for plain carbon steel grades. The grades of BISALLOY® Wear 400, 450, 500 and 600 steel should not be considered for shearing.

These tasks should only be undertaken by an appropriately qualified and skilled tradesman, with experience in shearing and punching, in accordance with relevant professional standards and regulations.

The guillotine blades should be very sharp and set with a clearance of 0.25 to 0.40mm. Note, the maximum limiting thickness for cold punching are approximately half the cold shearing values.

Table 8.d:
MAXIMUM THICKNESS FOR COLD SHEARING AND PUNCHING

BISALLOY® Grade	Cold Shearing	Cold Punching
Structural 60	25mm	12mm
Structural 70	25mm	12mm
Structural 80/80PV	25mm	12mm
Structural 100 and 110	10mm	6mm
Wear 320/320 Plus	10mm	6mm
Wear 400	Not Recommended	
Wear 450	Not Recommended	
Wear 500 and 500XT	Not Recommended	

DRILLING, COUNTERSINKING AND TAPPING BISALLOY® STEEL

All grades of BISALLOY® steel are able to be drilled, countersunk and tapped although, as with most fabrication aspects, care should be taken with these grades of steel.

In all cases, suitable high powered and rigid drilling equipment should be used.

DRILLING OF HIGH-STRENGTH STRUCTURAL GRADES

When drilling the BISALLOY® Structural grades 60, 70, 80 and 100 the use of cobalt type high speed steel drills is recommended. Drills equipped with replaceable carbide inserts can also be used.

DRILLING OF WEAR/ABRASION RESISTANT GRADES

BISALLOY® Wear 320, 400 and 450 grades may be drilled with either cobalt type high speed steel drills or drills equipped with replaceable carbide inserts.

With regards to the drilling of Wear 500 and 600 grades, we recommend only the use of drills equipped with replaceable carbide inserts.

RECOMMENDATIONS FOR IMPROVED RESULTS

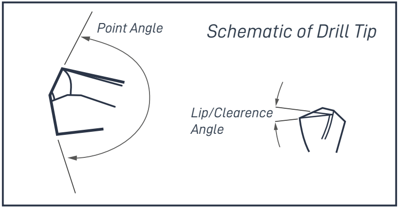
- The supporting bars under the plate should be placed as close to the hole as possible
- If possible, use a plain carbon steel backing plate under the BISALLOY® steel plate
- The drilling head should be placed as close as possible to the main support
- Short length drills are preferred
- The last part of the hole to be drilled should be done with manual feed
- Usage of adequate coolant (water and oil emulsion mixture)

Table 9.a:
RECOMMENDED FEEDS AND SPEEDS USING COBALT TYPE HIGH SPEED STEEL DRILLS

BISALLOY® Grade	Peripheral Speed (m/min)	R.P.M. (Upper Figures) and Feed per Revolution (mm) for Given Drill Size						Hardness (HB)
		5mm	10mm	15mm	20mm	25mm	30mm	
AS3678-Grade 250	~23	1465 0.10	735 0.15	490 0.20	370 0.25	295 0.35	245 0.4	~120
Structural 60	~20	1280 0.10	640 0.10	425 0.16	320 0.23	255 0.30	210 0.35	~220
Structural 70	~19	1210 0.10	610 0.10	410 0.16	300 0.23	240 0.30	200 0.35	~240
Structural 80/80PV	~18	1150 0.10	575 0.10	390 0.16	290 0.23	230 0.30	190 0.35	~260
Structual 100/110 / Wear 320/320 Plus	~12	760 0.07	380 0.10	250 0.16	190 0.23	150 0.30	130 0.35	320 (min)
Wear 400	~9	570 0.05	285 0.10	190 0.16	150 0.23	110 0.30	90 0.35	370 (min)
Wear 450/450Plus	~7	440 0.05	220 0.09	150 0.15	110 0.20	90 0.25	75 0.30	425 (min)

Note:
This table applies when cobalt type high speed drills are used with a cutting fluid, if no fluid is used the speeds shown above must be reduced

Figure 1:
Drill Tip Configuration for Cobalt Type High Speed Drills



Approximate Feeds and Speeds Using Drills With Replaceable Carbide Inserts

Table 9.b:
RECOMMENDED DRILL TIP CONFIGURATION FOR COBALT TYPE HIGH SPEED DRILLS

BISALLOY® Grade	Point Angle	Lip/Clearance Angle
Structural 60	118 deg.	10 deg.
Structural 70	118 deg.	10 deg.
Structural 80/80PV	118 deg.	10 deg.
Structural 100/110, Wear 320/320Plus	125 deg.	7.5 deg.
Wear 400, 450/450Plus	150 deg.	5 deg.

Table 9.c:

RECOMMENDED FEEDS AND SPEEDS USING DRILLS WITH REPLACEABLE CARBIDE INSERTS

BISALLOY® Grade	ISCAR Insert Grade	Surface Speed (m/min)	Feed Rate (mm/rev)	Hardness (HB)
Structural 60	IC908 or IC808	150 - 250	0.08 - 0.25	~220
Structural 70	IC908 or IC808	150 - 220	0.08 - 0.25	~240
Structural 80/80PV	IC908 or IC808	120 - 190	0.08 - 0.25	~260
Structural 100/110 / Wear 320/320 Plus	IC908 or IC808	120 - 180	0.08 - 0.20	320 - 360
Wear 400	IC908 or IC808	100 - 160	0.06 - 0.18	370 - 430
Wear 450/450 Plus	IC908 or IC808	80 - 100	0.06 - 0.18	425 - 475
Wear 500/500 Plus/500XT	IC908 or IC808	70 - 90	0.06 - 0.14	500 (avg)
Wear 600	IC908 or IC808	50 - 70	0.06 - 0.12	600 (avg)

Note:
Above drilling recommendations are based on using a ISCAR "DR DRILL" and is based on hole sizes of 12.0 -70.0 mm diameter. Through the tool coolant must be used. Feed rates are governed by the insert size related to the diameter of the drill.

COUNTERSINKING AND COUNTERBORING

Countersinking and counterboring of holes is possible in all BISALLOY® grades with best performance obtained using tools with a revolving pilot. The pilot increases the stability and allows tools with replaceable carbide inserts to be used.

Cobalt type high speed steel drills with a pilot can be used for the BISALLOY® Structural 60, 70, 80, 100 and BISALLOY® Wear 320/320 Plus, 400 and 450/450 Plus. The cutting data will vary from machine to machine. A coolant should be used. Replaceable carbide insert tools should be used on BISALLOY® Wear 500 and 600 grades.

Table 9.d:
CUTTING SPEEDS AND FEEDS WITH COBALT TYPE TOOLS

BISALLOY® Grade	Cutting Speed (m/min)	ø16		ø20		ø25		ø32		ø40		ø60	
		RPM	Feed (mm/r)	RPM	Feed (mm/r)	RPM	Feed (mm/r)	RPM	Feed (mm/r)	RPM	Feed (mm/r)	RPM	Feed (mm/r)
Structural 60	10 - 12	250	0.05 - 0.2	200	0.05 - 0.2	160	0.07 - 0.3	110	0.07 - 0.3	90	0.07 - 0.3	70	0.07 - 0.3
Structural 70	9 - 11	210	0.05 - 0.2	170	0.05 - 0.2	130	0.07 - 0.3	90	0.07 - 0.3	60	0.07 - 0.3	60	0.07 - 0.3
Structural 80/80PV	7 - 9	170	0.05 - 0.2	130	0.05 - 0.2	100	0.07 - 0.3	70	0.07 - 0.3	60	0.07 - 0.3	40	0.07 - 0.3
Structural 100/110 Wear 320/320 Plus	6 - 8	150	0.05 - 0.2	120	0.05 - 0.2	90	0.07 - 0.3	60	0.07 - 0.3	50	0.07 - 0.3	40	0.07 - 0.3
Wear 400 Wear 450/450 Plus	4 - 6	130	0.05 - 0.2	105	0.05 - 0.2	75	0.07 - 0.3	50	0.07 - 0.3	40	0.07 - 0.3	30	0.07 - 0.3

Table 9.e:
TAPPING SPEEDS AND TYPES RECOMMENDED FOR BISALLOY® GRADES

BISALLOY® Grade	Tap Type (Prototyp)	Tapping Speed (m/min)	Size Range	Lubrication
Structural 60	Paradur 20360	15	M3 - M56	Cutting Oil
Structural 70	Paradur 20360	15	M3 - M56	Cutting Oil
Structural 80/80PV	Prototex Inox 202135	6 - 15*	M1.6 - M36	Cutting Oil
Structural 100/110 Wear 320/320 Plus	Prototex Inox 202135	6 - 15*	M1.6 - M36	Cutting Oil
Wear 400	Prototex Inox 202135	6 - 15*	M1.6 - M36	Cutting Oil
Wear 450/450 Plus	Prototex Ni 202602	3	M1.6 - M24	Cutting Oil
Wear 500/500 Plus/500XT	Paradur H/C 80311	1.6	M3 - M12**	Cutting Oil

*6m/min using steam tempered taps and 15m/min using tin coated tips
**For larger size threads, thread milling is recommended.

CARBIDE TIPPED CUTTERS

There is a range of Indexable Carbide Tipped Cutters available from ISCAR. Countersink Tools available as standard in 60, 82, 90 and 120 degrees. Counterbore (Flat Bottom) Drill Heads available from 8.0mm - 25.5mm and Indexable Carbide Tipped Cutters with the ability to generate Counter Bores. For the best solution and cutting conditions contact your local representative or ISCAR Australia on Toll free phone: 1800 806 016 or email: iscaraus@iscar.com.au

TAPPING

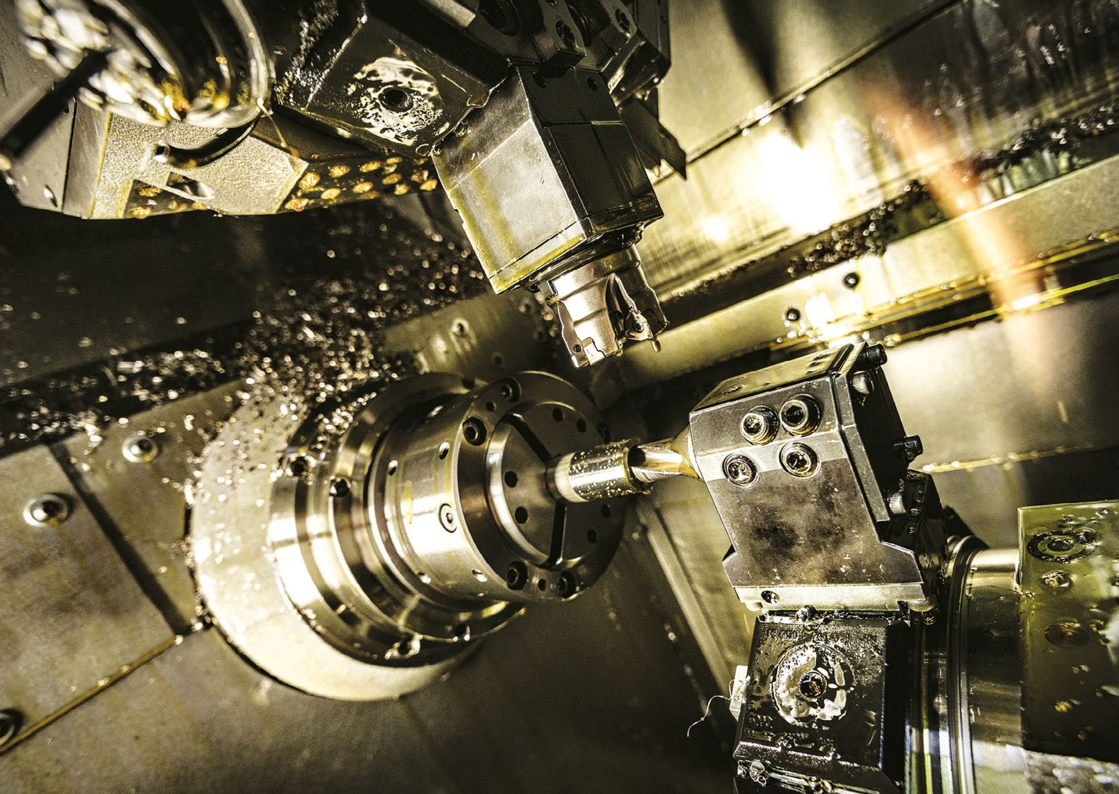
With the correct tools and cutting speeds, tapping can be performed on all BISALLOY® grades of steel. Higher alloyed taps must be used for high-hardness BISALLOY® Wear 400, 450, 500 and 600.

Difficulties that commonly arise when thread cutting higher tensile strength steels include tap sticking, torn threads and the short life of taps. The Prototyp brand tools have been specifically developed for tapping in BISALLOY® grades of steel.

With all tapping it is recommended that the cutting speed is accurately controlled.

For best results, cutting oil or grease should be used. For through-holes of up to 2 times diameter in thread depth, in metric sizes, the following tapping tools are recommended.

Note: The introduction of stress concentrations (as a result of tapping) is an important consideration in fatigue applications



MILLING AND TURNING BISALLOY®

Due to their high-strength and high-hardness, special tools and operation parameters are required for milling or turning BISALLOY® products. The following contents are intended as guides and recommendations for how to achieve best result in milling and turning.

MILLING

Milling operations can be performed satisfactorily on all BISALLOY® grades; utilisation of indexable carbide cutters is recommended.

In many situations, the milling operation entails the dressing of a flame-cut edge, and then subsequent bulk milling of material to the desired surface finish and dimensional tolerance.

Care must be taken to make a first cut sufficiently deep to remove the heat affected zone of the flame-cut edge. Cutters must be sufficiently robust to take this heavy loading. In such circumstances it is desirable that, due to the high-hardness adjacent to the flame-cut surfaces, cutter speeds and feed rates for initial milling should be reduced to 40 - 50% of the speed normally used when milling plain carbon steel. The importance of adequate preheating prior to flame cutting and slow cooling after cutting to minimise edge hardening is again emphasised. Speed and feed rates may be increased somewhat for subsequent bulk milling to 50 - 75% of the settings used for plain carbon steel.

AVOID VIBRATIONS

Indexable inserts are sensitive to vibrations. These can be avoided or reduced by observing the following.

When turning or milling gas cut edges, the cutting depth should be at least 2mm to cope with the hardness and unevenness of the edge.

OTHER MILLING REQUIREMENTS

- Firm clamping of the workpiece
- Use cutters with the smallest possible gap between the teeth
- Machine stability permitting, unidirectional milling is preferable (see figure 1)
- If a large cutter is used for the milling of small areas, place the milling cutter eccentrically to get as many teeth as possible operating (see figure 2)
- Avoid, if possible, the use of a universal cutterhead which generally causes weakening of the power transmission and the tool holder

Table 10.a:
MILLING RECOMMENDATIONS

Bisalloy® Grade	ISCAR Insert Grade	Surface Speed Vc m/min	Feed/Tooth Fz
Structural 60	IC830	200 - 300	0.15 - 0.25
Structural 70	IC830	200 - 300	0.15 - 0.25
Structural 80/80PV	IC830	180 - 240	0.15 - 0.25
Structural 100/110 Wear 320/320 Plus	IC830	120- 140	0.15 - 0.25
Wear 400	IC808	80 - 120	0.15 - 0.25
Wear 450/450 Plus	IC808	70 - 100	0.15 - 0.25
Wear 500/500 Plus/500XT	IC808	60 - 80	0.15 - 0.25
Wear 600	IC808	40 - 60	0.15 - 0.25

Note:
These recommendations are given as a guide only, and are based on stable working conditions. It is suggested a 45 degree approach angle or a round insert facemill be used. For quick metal removal a very successful cutting method is the use of FF Fast Feed Milling Cutters by ISCAR. Feed rates are dependent on geometry selected.

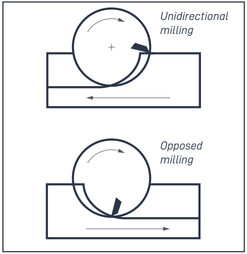


Figure 1:
Showing the direction of milling.

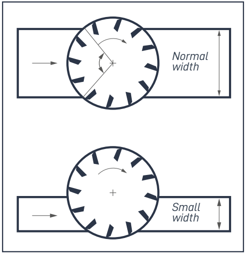


Figure 2:
Showing the eccentricity milling cutter.

TURNING

All BISALLOY® grades, including those with hardness in excess of 360 HB can be turned satisfactorily with carbide tooling, provided spindle speeds and feed rates are reduced from those normally employed when carrying out similar machining operations on plain carbon steel. Reductions of 50 - 70% in spindle speed and up to 50% in feed rate may be necessary, depending on the hardness of the component being machined. High speed tools are not recommended.

As an example, the following settings in Table 10.b have been found to give satisfactory results when turning cylindrical workpieces of 25mm diameter from the various BISALLOY® grades. With increases in stock diameter, spindle speeds will obviously need to be decreased.

Table 10.b:
TURNING RECOMMENDATIONS

BISALLOY® Grade	ISCAR Insert Grade	Surface Speed m/min
Structural 60	IC8150	180 - 340
Structural 70	IC8150	180 - 330
Structural 80/80PV	IC8150	180 - 320
Structural 100/110 Wear 320/320 Plus	IC8150/IC807	120 - 220
Wear 400	IC8150/IC807	100 - 150
Wear 450/450 Plus	IC807	60 - 120
Wear 500/ 500 Plus/500XT	IC807	40 - 80
Wear 600	IC807	30 - 60

Note:
These recommendations are given as a guide only and are based on stable working conditions. The geometry of the inserts used will be dependent on the operation. Insert Geometry, Nose Radius and Chipbreaker will determine the depth of cut and feed rate.

FORMULA FOR THE CALCULATION OF SPEEDS AND FEEDS FOR GENERAL MILLING AND TURNING OPERATIONS

To calculate spindle speed:

318 x m/min ÷ Ø = RPM
eg: 318 x 150 ÷ 25 = 1908 RPM

To calculate table feed:

Fz x Z x RPM = Vf
eg: 0.22 x 2 x 1908 = 839.5mm/min

Legend:

318 = Constant (1000 ÷ π)
m/min = Surface Speed (Vc)
Ø = Dia. of Cutter / Work Piece
Fz = Feed per Tooth
Z = Number of Teeth
Vf = Table Feed in mm/min

Note:
Bisalloy wish to thank ISCAR Australia Pty Ltd for information pertaining to drilling, tapping, countersinking, milling and turning contained in this publication.

Further information can be obtained from your local ISCAR Sales representative or ISCAR head office Sydney.

Toll free phone: 1800 806 016
Email: iscaraus@iscar.com.au

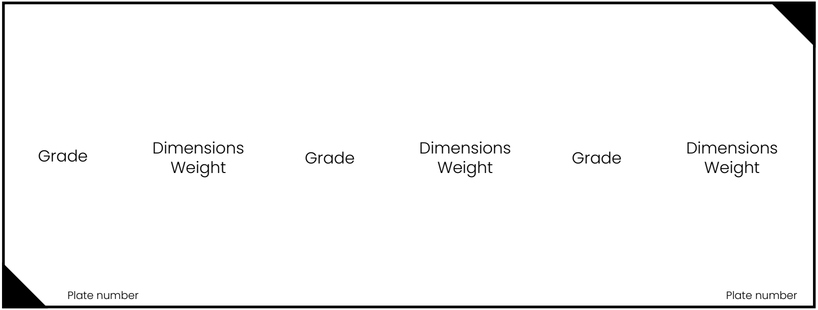

Bisalloy
BISALLOY WEAR
400 400 400
121247

BISALLOY® PLATE IDENTIFICATION MARKING AND COLOUR CODING

Bisalloy has a series of identification markings and colour codes to clearly identify the plate specifications and differentiate the grades from each other and other grades of steel. It is crucial that when plates are profiled that this identification is transferred to all cut parts and off-cuts to prevent loss of plate identity.

GRADE AND PLATE IDENTIFICATION STENCILS

There are two grade ID stencils on each plate located at opposite ends so that if plates are halved then each end remains identified. These stencils are colour matched to the grade colour coding.



Plates delivered via central stock will not have a customer name.

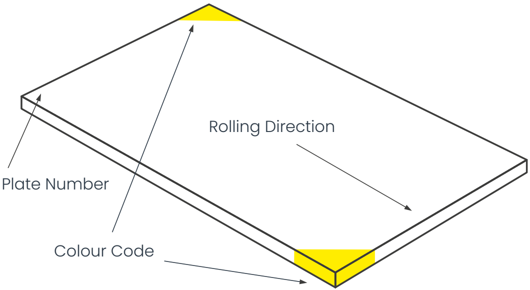
If specified for export orders, customer name and order number can be stenciled onto the plate by agreement.

Australian standards can also be added to the plate if applicable.

PLATE CORNERS

Two diagonal corners of the plate are coloured with the relevant grade colour code.

One plate corner is hard stamped with the plate number.



STRUCTURAL GRADE COLOUR CODES

Structural 60
White

Structural 70
Green

Structural 80
Pink

Structural 80PV
Pink/Red

Structural 100
Blue

Structural 110
Blue/Pink

WEAR GRADE COLOUR CODES

Wear 320
Brown

Wear 320 Plus
Brown/Pink

Wear 400
Orange

Wear 450
Yellow

Wear 450 Plus
Yellow/Pink

Wear 500
Black

Wear 500 Plus
Black/Pink

Wear 500XT
Black/Green

Wear 600
Red

TESTING AND CERTIFICATION

Bisalloy leverages an in-house NATA accredited testing facility to develop world-class steel grades that reinforce our reputation as an innovative steel manufacturer.

BISALLOY® products are stringently tested to meet Australian and International standards.

MECHANICAL TESTING

BRINELL HARDNESS TEST

Brinell hardness test is performed in accordance with the requirements of AS1816. All plates are individually hardness tested.

TENSILE TESTS

Structural steel grades are tensile tested in accordance with the requirements of AS1391 and these tensile tests are done on a batch basis, per requirement of AS3597.

CHARPY V-NOTCH IMPACT TESTS

Structural steel grades are impact tested. Charpy V-Notch tests are done on a batch basis, per requirement of AS3597.

Standard test direction is longitudinal and test temperature is -40˚C up to 60mm and -20˚C above 60mm in thickness.

Tests conducted in accordance with AS1544.2 requirements.

CERTIFICATION

A separate NATA certified test certificate will be issued for each full plate supplied. Tests are conducted in our NATA certified laboratory and chemical analysis, hardness and relevant mechanical test information dependent on the grade ordered is reported on the certificate.

Bisalloy

NATA ACCREDITED LABORATORY

THIS LABORATORY IS ACCREDITED FOR COMPLIANCE WITH ISO/IEC 17025 - TESTING.
THIS DOCUMENT SHALL NOT BE REPRODUCED EXCEPT IN FULL. LABORATORY No. 1553.

BISALLOY STEELS PTY. LTD.
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TEST CERTIFICATE

PAGE: 1 of 1
PRINT DATE:
DATE OF MANUFACTURE:
CERTIFICATE No:

CUSTOMER:	SPECIFICATION:
BISEXPRESS **EXAMPLE ONLY**	**STRUCTURAL 80 (AS3597-2008 GRADE 700)**

CHEMICAL ANALYSIS		LADLE ANALYSIS - PERCENTAGE OF ELEMENT BY MASS												
HEAT No	BATCH No	C	P	Mn	Si	S	Ni	Cr	Mo	Cu	Al	Sn	Ti	B
12345	12345	0.177	0.019	0.810	0.500	0.002	0.013	0.800	0.210	0.021	0.035	0.002	0.022	0.0017
		CA = 0.0013 N = 0.0047 NB = 0.0010 V = 0.0050												
		CE(IIW) = 0.5163												

MECHANICAL TESTS			TEST METHODS	AS 1391					AS 1816.1	AS1544 CHARPY V-NOTCH IMPACT TEST				
CUSTOMER O/No	ITEM No	SERIAL No	PLATE SIZE mm x mm x m WIDTH X THICKNESS X LENGTH	0.2% PROOF STRESS MPa	TENSILE STRENGTH MPa	ELON-GATION %	GAUGE LENGTH (mm)	PS/TS RATIO	Hardness HBW 10/3000	SPEC SIZE mm x mm	DIR	TEMP °C	ENERGY J	LATERAL EXPANSION (mm)
	12345	12345	2485 x 32 x 8.000	801	871	23	50	0.92	265	10 x 10	L	-40	163 120 153	
	12345	12345	2485 x 32 x 8.000											
										NOMINAL STRIKING ENERGY 300J NOMINAL IMPACT VELOCITY 5.24 m/s				

METRIC/IMPERIAL CONVERSION FACTORS PER ASTM E380

1inch	=	25.44mm
1ksi	=	6.894757 Mpa
°F	=	(°C x 1.8) + 32
1ft. lbf	=	1.355818 Joules

*****Plate No 12345 is a BATCH TEST plate only*****

THE ABOVE CHEMICAL ANALYSES ARE REPRODUCED FROM FEED SUPPLIER NATA OR EQUIVALENT INTERNATIONALLY ENDORSED LABORATORIES.

FEED LABORATORY No. NATA No: 0632

FEED CERTIFICATE No. 12345 DATED.

WE CERTIFY THE ABOVE INFORMATION IS IN ACCORDANCE WITH THE RECORDS OF THE COMPANY AND CONFORMS TO THE SPECIFICATION AS STATED.

Bisalloy

SIGNATORY

HARDNESS TESTING OF BISALLOY® STEEL

As a result of the heat treatment process used to produce Australian made BISALLOY® steel, proper test procedures need to be taken when performing hardness tests on the plate product.

In addition to the other steps detailed in this document particular care must be paid to the proper preparation of the test surface. Without this important step the results of any standard hardness test are likely to be inaccurate, generally delivering a lower result than the true hardness measure.

WHAT IS HARDNESS?

Hardness is the resistance of material to plastic deformation – usually by indentation or penetration. It also defines the ability of material to resist scratching, abrasion or cutting.

WHY TEST FOR IT?

Hardness testing is undertaken to:

1. Specify and certify a range of wear resistance products.
2. Double check the tensile strength of structural grade materials.
3. Assist in failure analyses and material identification.

Table 13.a:
HARDNESS TESTING METHOD COMPARISON

Method	Standard	Basis	Measurement	Accuracy Approx %	Max Temp
Brinell [4]	AS1816	10mm Tungsten Carbide ball [1] impressed under 3,000 kg load	Surface area for known load	± 2	50ºC
Vickers (HV)	AS1817	136º Diamond pyramid impressed under load	Surface area for known load	± 2	50ºC
Rockwell (HR) A,B,C	AS1815 ISO6517-1	120º Conical Diamond Steel ball used for soft metals	Depth of impression under known load (15 - 150 kg)	± 2	50ºC
Equotip [2]	–	“Rebound” Method	Height of rebound	Poor	–
Poldi [3]	–	10mm Ball impressed with hammered test bar	Comparative impression	Very Poor (± 20)	50ºC

WHERE TO TEST?

Testing can be carried out in the laboratory, workshop or on site. However, site testing with portable equipment can often have difficulties of access, surface preparation and vibration, which may reduce the accuracy of testing.

TESTING PROCEDURES AND EQUIPMENT

Table 13.a sets out the methods of identifying common indentation hardness, and other types of hardness tests.

It is absolutely vital to understand the specific uses, strengths and any weaknesses of – and correct requirements and procedures demanded by – each of these methods in order to ensure consistent, comparable results in testing.

INTERPRETING TABLE 13.A – SOME IMPORTANT CONSIDERATIONS

(1) Where the maximum hardness of the work exceed 450 HB, but doesn't exceed 650 HB, the standard says a tungsten carbide ball must be used.

(2) Equotip is a "rebound" method of hardness testing, which does NOT measure hardness (indentation or plastic deformation) but gives a result convertible within a restricted range into an indentation hardness figure. This method gives only indicative results. It is extremely dependent on the operator, test material and surface condition. It is NOT recommended on quenched and tempered steel, or surfaces that aren't bright and smoothly ground.

(3) The Poldi test is sometimes employed in the field. Even though it is an impression method, it displays very poor accuracy. It is not recommended for quenched and tempered steel.

(4) The Brinell test is strongly recommended for all BISALLOY® grades as it is widely accepted as the industry standard. (Brinell gives a more definite reading, by leaving a more definite impression on the plate). It is the standard employed at Bisalloy Steels and by other manufacturers, both on the production line and in the laboratory. The hardness rating on a certificate issued by Bisalloy Steels is measured in Brinell hardness. Converted values from other methods such as Rockwell or Vickers (more often used in laboratory testing small samples of steel, or in small-parts engineering, and not ideal for use in the production environment) can cause small discrepancies from the Brinell rating on the certificate.

PROPER PREPARATION OF THE TEST SURFACE

As BISALLOY® is a quenched and tempered steel product, some decarburisation will occur on the plate surface during the heat treatment process. The thickness of the decarburised layer (the very thin surface layer which has lost carbon during austenitising) will vary depending on the plate thickness. This decarburised layer will get thicker as the plate thickness increases.

To ensure testing accuracy, surface scale and the decarburised layer must always be removed by either grinding or machining from the areas where hardness measurements are taken. The minimum grinding or machining depths are listed in the Table 13.b.

Table 13.b:
GRINDING DEPTHS FOR SURFACE PREPARATION

Plate Thickness	Min Grinding or Machining Depths (mm)
≤6	0.2
>6 - 10	0.3
>10 - 20	0.5
>20 - 50	0.7
>50 - 80	1.0
>80	1.5

Without removing the entire decarburised layer by grinding or machining, the results of the hardness test will be invalid.

It should also be noted that the area tested should be a min. of 75mm from any thermally cut surface to avoid any heat-affected zone.

The tested area must represent the whole material, must be clean, free from unwanted scale, and must be flat, sufficiently thick and smooth. The test piece must be well supported and not subject to movement or vibration.

CALIBRATION

To further ensure accuracy and consistency, all testing equipment must be calibrated yearly and checked daily against calibration blocks.

PERSONNEL COMPETENCY

For all tests, the operator requires training in the correct methods and assessment acceptable to the employer. Preference is given to NATA registered laboratories for high-risk applications.

Table 13.c:
HARDNESS (HB): SPECIFIED VS. TYPICAL

BISALLOY® Grade	Specified Hardness	Typical Hardness
Structural 60	-	210
Structural 70	-	230
Structural 80/80PV	-	255
Structural 100	-	310
Structural 110	-	330
Wear 320	320 – 360	340
Wear 400	370 – 430	400
Wear 450	425 – 475	450
Wear 500XT	470 – 520	500
Wear 500	470 – 530	500
Wear 600	570 – 640	600

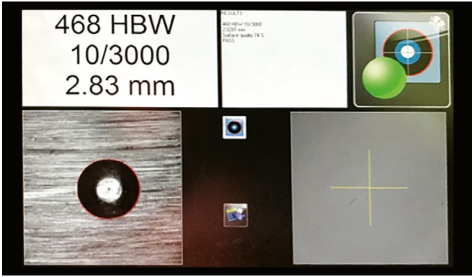
Bisalloy physically tests every plate produced - that is, each plate goes through the full process of grinding, test and measure. This is unique from other manufacturers.

This testing procedure is fully automated including automated grinding and indentation, guaranteeing an even greater and more consistent level of accuracy and repeatability. (Figure 1).

The size of the indentation is measured using the latest video imaging technology, which is interfaced with a dedicated computer to generate a HB number to within one point. (Figure 2).

Figure 1:

Figure 2:



GALVANISING OF BISALLOY® STRUCTURAL STEEL

Bisalloy recommendations should be followed to ensure sound and continuous galvanised coatings on BISALLOY® Structual steel grades.

PRECAUTIONS WHEN GALVANISING BISALLOY® STRUCTURAL STEEL

While BISALLOY® Structural steel can be readily galvanised there are some precautions & recommendations that should be taken into account:

- DO NOT ACID DESCALE to prepare the surface. Acid descaling can lead to hydrogen being absorbed into the steel, increasing the likelihood of hydrogen embrittlement.
- To prepare the surface it is recommended to use grit/shot blasting. This method not only ensures there is no hydrogen contamination it assists the galvanizing process by increasing the surface reactiveness to molten zinc.
- Care should be taken when galvanizing structures/components manufactured from BISALLOY® Structural steel that may contain severe internal stresses, such as those caused by large weldments, as liquid metal embrittlement may occur. In these cases, it may be appropriate to prototype test or attain the use of painted or sprayed coatings in place of galvanizing.

EFFECT ON PROPERTIES

Galvanising does not affect the mechanical properties of BISALLOY® Structural steel.

Registered Trade Marks

Bisalloy Steels® BISALLOY® BIS® BISPLATE® are all registered trade marks of Bisalloy Steels Pty Ltd.

AUSTRALIAN-MADE

BISALLOY® Steel is proudly Australian-made.

AUSTRALIAN MADE

ONLINE TECHNICAL GUIDE

If an updated version of the Bisalloy Steels technical guide is available, you will be able to read the most up-to-date version at the resource centre on the Bisalloy website.

FOR FURTHER ENQUIRIES

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