TECHNICAL GUIDE
CUTTING

INTRODUCING OUR NEW PRODUCT NOMENCLATURE

Bisalloy Steels has recently introduced a new product nomenclature. The following table details the grade equivalents.

Note: Only the designation has changed – not the product

Previous Name	New Name
BISPLATE® 60	BISALLOY® Structural 60 steel
BISPLATE® 70	BISALLOY® Structural 70 steel
BISPLATE® 80	BISALLOY® Structural 80 steel
BISPLATE® 100	BISALLOY® Structural 100 steel
BISPLATE® 80PV	BISALLOY® Structural 80 Pressure Vessel steel
BISPLATE® 320	BISALLOY® Wear 320 steel
BISPLATE® 400	BISALLOY® Wear 400 steel
BISPLATE® 450	BISALLOY® Wear 450 steel
BISPLATE® 500	BISALLOY® Wear 500 steel
BISPLATE® 600	BISALLOY® Wear 600 steel
BISPLATE® HIA - Class 2	BISALLOY® Armour RHA300 steel
BISPLATE® HIA - Class 1	BISALLOY® Armour RHA360 steel
BISPLATE® HTA	BISALLOY® Armour HTA400 steel
BISPLATE® UHT	BISALLOY® Armour UHT440 steel
BISPLATE® HHA	BISALLOY® Armour HHA500 steel
BISPLATE® UHH	BISALLOY® Armour UHH600 steel

FLAME CUTTING, PLASMA CUTTING, LASER CUTTING, WATERJET CUTTING AND SAWING RECOMMENDATIONS

All grades of BISALLOY® quenched and tempered 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 and 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 grades.

- 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.

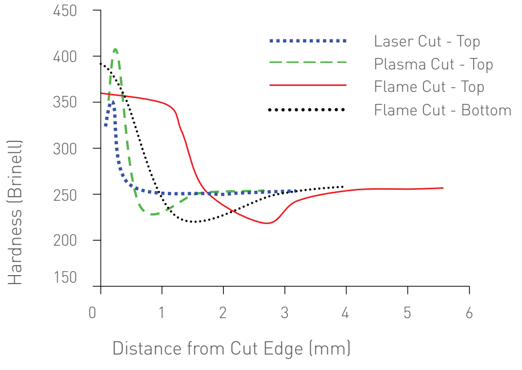
Correct selection of nozzle size for the plate thickness being cut is important to ensure efficient cutting and to minimise the width of the heat affected zone (HAZ).

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).

FLAME CUTTING, PLASMA CUTTING, LASER CUTTING, WATERJET CUTTING AND SAWING RECOMMENDATIONS continued...

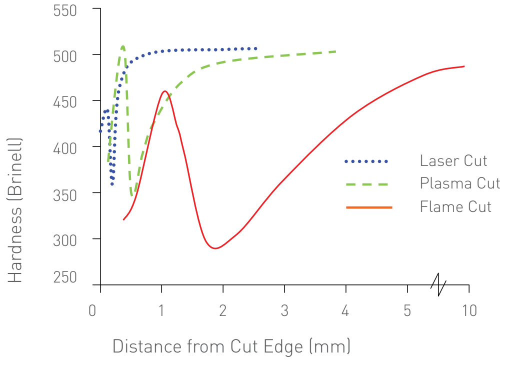
HAZ for 6mm BISALLOY® Structural 80 steel and BISALLOY® Wear 500 steel using different cutting methods.

Fig 2a:



Effects of flame, plasma and laser cutting on plate hardness for a 6 mm AS3597 Grade 700 steel (BISALLOY Structural 80 steel). Hardness tests were conducted using the Vickers method and converted to Brinell hardness values (HB).

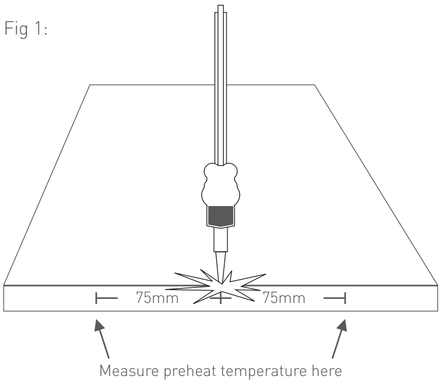
Fig 2b:



Effects of flame, plasma and laser cutting on plate hardness for a 6mm BISALLOY Wear 500 steel. Hardness tests were conducted using the Vickers method and converted to Brinell hardness values (HB).

Note: Some variations to the hardness profiles of Fig. 2a and b will occur with changes to cutting speed and plate thickness.

Fig 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).

Under normal Oxy cutting conditions, the total heat affected zone adjacent to the flame cut edge will extend into the plate approximately 2-3mm, as shown left in Figure 2a for BISALLOY® Structural 80 steel. 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 the 2-3mm distance from the cut edge. For BISALLOY® Wear 500 steel the HAZ may extend as much as 4-5mm into the plate as shown in Figure 2b.

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

Table 1 below, 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.

Recommended Minimum Preheat Temperatures for Flame Cutting of BISALLOY® steel Grades

When stripping plates, the use of multiple cutting heads will help to minimise distortion of the cut pieces.

Table 1:

BISALLOY® STEEL GRADE	PLATE THICKNESS (mm)	MINIMUM PRE-HEAT TEMPERATURE
Structural 60/70	8 – 32	20°C
Structural 80/80PV/100	5 – 31	20°C
	32 – 80	50°C
	81 – 100	100°C
Wear 320/400	5 – 31	20°C
	32 – 50	50°C
	51 – 100	100°C
Wear 450	6 – 20	20°C
	21 – 50	50°C
	51 – 100	100°C
Wear 500*	6 – 20	50°C
	21 – 50	100°C
	51 – 100	120°C
Wear 600*	≤12	50°C
	13 – 16	75°C
	17 – 20	100°C
	21 – 25	120°C
	>25	150°C

* A slow cool can reduce the risk of cracking after cutting on 500 & 600 grade.

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, eg. 50mm wide x 50mm thick plate.

Quench cutting of BISALLOY® steel grades to minimise distortion is not recommended, while cooling in still air is preferred. The technique of stacking plates and parts during profile cutting can slowdown 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 & 600 steel 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

WTIA 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 20mm using currently available equipment. For instance, the cutting speed of 6mm BISALLOY® Wear 400 steel 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® steel with low alloy contents should be treated similarly to conventional structural 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.

Hardness Profile Characteristics for Plasma Cutting.

Table 2:

<table>
<tr><th rowspan="2">PLATE THICKNESS (mm)</th><th rowspan="2">RECOMMENDED DEPTH OF REMOVAL (mm)</th><th colspan="4">PEAK HARDNESS (HB)</th></tr>
<tr><th>Structural 60/70/80 Wear 320/400</th><th>Wear 450</th><th>Wear 500</th><th>Wear 600</th></tr>
<tr><td>5 – 8</td><td>0.4 - 0.5</td><td>430</td><td rowspan="3">480</td><td rowspan="3">540</td><td rowspan="3">640</td></tr>
<tr><td>>8 - 12</td><td>0.6 - 0.8</td><td>450</td></tr>
<tr><td>>12 - 20</td><td>1.0 - 1.2</td><td>450</td></tr>
</table>

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).

Comparison of Flame, Plasma and Laser Cutting on 6mm BISALLOY® Wear 400 steel.

Table 3:

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 you contact Bisalloy Steels for guidance.

POWER SAWING

All BISALLOY® steel 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

WATER JET CUTTING

Water jet cutting can be performed on all grades of BISALLOY® steel.

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.

Water jet cutting does not introduce internal stress to the cut plate/parts like thernal cutting does, therefore it is an ideal method for cutting high hardness grade, such as Wear 600 plates.

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.

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