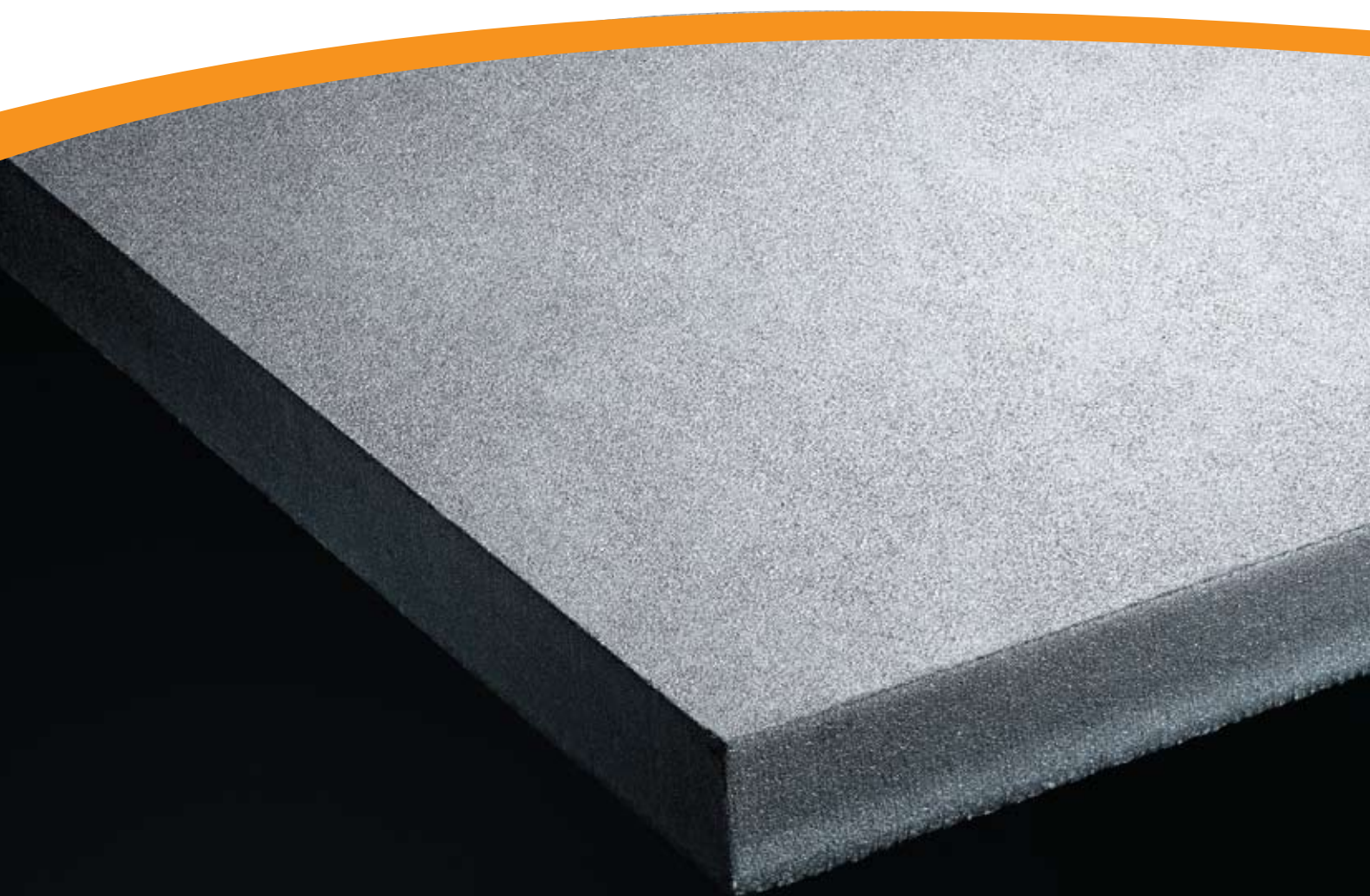


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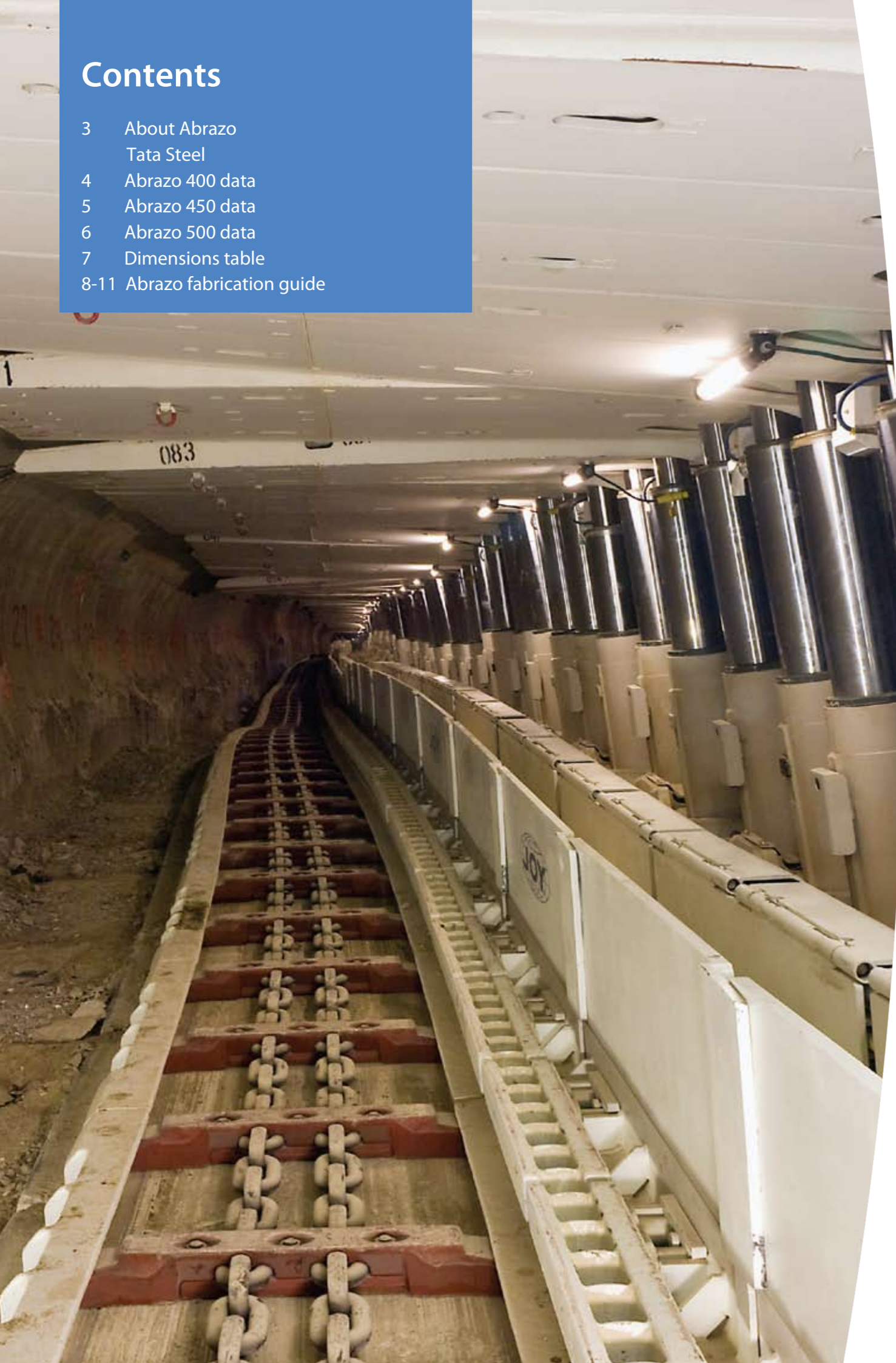
Abrazo[®] technical guide

Wear resistant roller quenched steel.



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ABRAZO®

Tata Steel's Abrazo steel plate products have been developed for long service life in abrasive conditions, providing our customers with a range of options suitable for most wear situations.

Abrazo products are suitable for a variety of applications, such as mining and quarrying, process industries, material handling, construction and earthmoving.

Designers and plant operators strive to extend the service life of critical components and reduce the effect of unscheduled maintenance. There are substantial benefits to be achieved by employing Abrazo wear resistant steel in harsh operating environments involving impact or sliding contact with abrasive material.

Tata Steel works in partnership with our customers, tailoring products and services to suit their applications, delivering value improvement through the use of Tata Steel plate.

The Abrazo product range is available in 400, 450 and 500 BHN wear plate grades.

This technical guide provides data for our Abrazo range of steels, Abrazo 400, Abrazo 450 and Abrazo 500. The fabrication guide provides all the essential operating parameters for use of Abrazo steels in the manufacturing process.

Tata Steel offer a range of specialist technical support which is available to assist with any specific application or process. For further details please contact our technical advice service listed at the back of this brochure.

TATA STEEL

Tata Steel is one of Europe's largest steel producers. We serve many different and demanding markets worldwide, including lifting and excavating, aerospace, automotive, construction, energy & power, and packaging. Our primary steelmaking operations in the UK and the Netherlands are supported by a global sales and distribution network.

Innovation and continuous improvement are at the heart of our performance culture. We aim to create value by offering a sustainable and value-added steel product range supported by unrivalled customer service. By working in partnership with you, we find the best solutions to meet your needs and help your business to perform.

Our European operations are a subsidiary of Tata Steel Group, one of the world's top ten steel producers. With a combined presence in nearly 50 countries, the Tata Steel Group, including the Europe operations, Tata Steel Thailand and NatSteel Asia, has approximately 80,000 employees across five continents and a aggregate crude steel production capacity of over 28 million tonnes.

ABRAZO[®] 400

Wear resistant Abrazo 400 is a roller quenched steel, combining high strength, toughness, good weldability, and excellent wear resistance.

Chemical composition

Thickness (mm)	C (%)	Si (%)	Mn (%)	S (%)	P (%)	Cr (%)	Mo (%)	Nb (%)	V (%)	Ni (%)	Cu (%)	B (%)	
8 ≤ t ≤ 80	max.	0.20	0.50	1.60	0.010	0.025	1.00	0.70	0.06	0.10	1.50	0.40	0.004

Abrazo 400 is offered with the following CEV:

Thickness* (mm)	Maximum ladle CEV (%)
8 ≤ t ≤ 19	0.43
19 < t ≤ 40	0.55
40 < t ≤ 80	0.59

Mechanical properties

Abrazo 400 is supplied subject to hardness testing only. Any additional testing and / or guarantee is by special arrangement.

Thickness (mm)	Minimum hardness (H _{BN})	Typical hardness (H _{BN})
8 ≤ t ≤ 80	360	400

Typical mechanical properties for 25mm thick plate.

Yield strength (MPa)	Tensile strength (MPa)	Proportional elongation (%)	Average impact energy*
1100	1250	10	27 J at -40°C

* Longitudinal Charpy V notch 2mm sub surface

Testing in accordance with EN ISO 6892, EN 10045 and EN ISO 6506.

Dimensions

Abrazo 400 is available in thicknesses 8mm to 80mm. Width and length availability is given in the table on page 7 of this guide.

Tolerances

The manufacturing tolerances for Abrazo 400 are in compliance with EN10029:2010.

Surface quality of Abrazo 400 is compliant with EN10163:2004 class A subclass 1.

Other tolerances are available by agreement.

Supply Condition

Quenched or Quenched and Tempered at the discretion of the supplier.

ABRAZO[®] 450

Abrazo 450 is a roller quenched steel, combining excellent wear resistance, high strength, durability and toughness.

Chemical composition

Thickness (mm)	C (%)	Si (%)	Mn (%)	S (%)	P (%)	Cr (%)	Mo (%)	Ni (%)	B (%)	
12 ≤ t ≤ 50	max.	0.25	0.50	1.50	0.010	0.025	1.50	0.70	1.50	0.005

Abrazo 450 is offered with the following CEV:

Thickness (mm)	Maximum ladle CEV* (%)
12 ≤ t ≤ 50	0.68

Mechanical properties

Abrazo 450 is supplied subject to hardness testing only. Any additional testing and / or guarantee is by special arrangement.

Thickness (mm)	Minimum hardness (H _{BN})	Typical hardness (H _{BN})
12 ≤ t ≤ 50	415	450

Typical mechanical properties for 25mm thick plate.

Yield strength (MPa)	Tensile strength (MPa)	Proportional elongation (%)	Average impact energy*
1200	1450	10	27 J at -40°C

* Longitudinal Charpy V notch 2mm sub surface

Testing in accordance with EN ISO 6892, EN 10045 and EN ISO 6506.

Dimensions

Abrazo 450 is available in thicknesses 12mm to 50mm. Width and length availability is given in the table on page 7 of this guide.

Tolerances

The manufacturing tolerances for Abrazo 450 are in compliance with EN10029:2010.

Surface quality of Abrazo 450 is compliant with EN10163:2004 class A subclass 1.

Other tolerances are available by agreement.

Supply Condition

Quenched or Quenched and Tempered at the discretion of the supplier.

ABRAZO[®] 500

Abrazo 500 is a roller quenched steel, combining outstanding wear resistance, high strength and durability.

Chemical composition

Thickness (mm)		C (%)	Si (%)	Mn (%)	S (%)	P (%)	Cr (%)	Mo (%)	Ni (%)	B (%)
12 ≤ t ≤ 50	max.	0.30	0.50	1.50	0.010	0.025	1.50	0.70	1.50	0.005

Abrazo 500 is offered with the following CEV:

Thickness (mm)	Maximum ladle CEV* (%)
12 ≤ t < 25	0.62
25 ≤ t ≤ 50	0.68

Mechanical properties

Abrazo 500 is supplied subject to hardness testing only. Any additional testing and / or guarantee is by special arrangement.

Thickness (mm)	Minimum hardness (H _{BN})	Typical hardness (H _{BN})
12 ≤ t ≤ 50	460	500

Typical mechanical properties for 25mm thick plate.

Yield strength (MPa)	Tensile strength (MPa)	Proportional elongation (%)	Average impact energy*
1400	1550	10	27 J at -30°C

* Longitudinal Charpy V notch 2mm sub surface

Testing in accordance with EN ISO 6892, EN 10045 and EN ISO 6506.

Dimensions

Abrazo 500 is available in thicknesses 12mm to 50mm. Width and length availability is given in the table on page 7 of this guide.

Tolerances

The manufacturing tolerances for Abrazo 500 are in compliance with EN10029:2010.

Surface quality of Abrazo 500 is compliant with EN10163:2004 class A subclass 1.

Other tolerances are available by agreement.

Supply Condition

Quenched or Quenched and Tempered at the discretion of the supplier.

Dimensional range

The information in this table must be read in conjunction with the explanatory notes at the bottom of the table. Figures within the table are maximum lengths in metres.

Plate gauge (mm)	Plate width mm												
	≥1220 ≤1250	≥1250 ≤1300	≥1300 ≤1500	≥1500 ≤1600	≥1600 ≤1750	≥1750 ≤1800	≥1800 ≤2000	≥2000 ≤2100	≥2100 ≤2250	≥2250 ≤2500	≥2500 ≤2750	≥2750 ≤3000	≥3000 ≤3050
8	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
9	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
10	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
12	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0
12.5	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
15	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
20	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
25	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
30	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
35	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
40	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0	14.5	13.0
45	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.5
50	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.5	10.5
55	11.5	11.5	11.0	12.0	12.0	12.0	12.0	12.0	12.0	12.0	11.5	10.5	9.5
60	10.5	10.5	10.0	12.0	12.0	12.0	11.5	12.0	12.0	11.5	10.5	9.5	8.5
65	10.0	9.5	9.0	12.0	12.0	11.0	10.5	12.0	11.5	10.5	9.5	8.5	8.0
70	9.0	9.0	8.5	12.0	11.0	10.5	10.0	11.0	10.5	10.0	9.0	8.0	7.5
75	8.5	8.5	8.0	11.0	10.5	9.5	9.5	10.5	10.0	9.5	8.5	7.5	7.0
80	8.0	8.0	7.5	10.5	10.0	9.0	8.5	10.0	9.5	8.5	8.0	7.0	6.5

There will be occasions when sizes and grades may be manufactured which are not shown in the table. As a guide to the available plate sizes for an intermediate gauge (e.g. 18mm), please use the nearest gauge shown in the table (i.e. 20mm). For any specific requirement, please contact us.

Notes

- Plates > 80mm thick and/or > 12.6 tonnes, please contact us for confirmation of availability.
- Plates < 1500mm wide are available by arrangement, if ordered in even numbers.
- Please refer to the Abrazo data in this technical guide for maximum thickness.
- Plates can be designed by arrangement to meet specific customer requirements and to the requirements of other national and international standards.

FABRICATION GUIDE

Welding

Abrazo grades of plate can be readily welded using the MMA, MIG, FCAW and SAW arc welding processes, these are commonly found in fabrication shops.

Welding should only be carried out using low hydrogen consumables content of not more than scale 'C'. Refer to BS EN 1011-2:2001, Welding preheat – Recommendations for welding of metallic material - Part 2: Arc welding of ferritic steels.

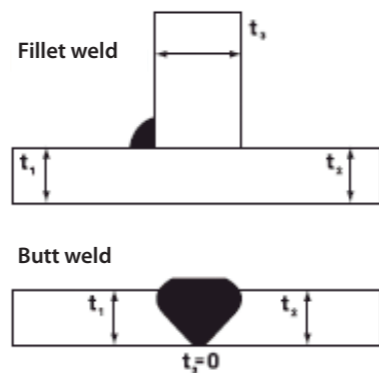
Guide for preheat requirements when welding Abrazo steels

Assumption: Arc energy = 1.5 kJ/mm. Hydrogen scale 'C' welding consumables is used.

	Combined plate thickness (mm) = $t_1 + t_2 + t_3$																											
	20	30	40	50	60	70	80	90	100	110	120	130	140	150	20	30	40	50	60	70	80	90	100	110	120	130	140	150
Abrazo400	20	20	20	20	20	125	125	125	125	150	150	150	150	200	200	200	200	200	200	200	200	200	200	200	200	200	200	200
Abrazo450		125	125	125	150	150	175	175	175	175	175	200	200	200	200	200												
Abrazo500			175	175	175	175	200	200	200	200	200	200	200	200	200	200												

Figures within table represent preheat temperature (°C)
This table should be used as a basis for the formulation and testing of a qualified welding procedure

For specific or unusual geometries, structural or welding conditions, please contact our technical advisory services on : +44 (0) 1724 402106



Suggested heat inputs

To obtain optimum properties in the weld zone it is important to control the cooling rate of the weld. To facilitate this the table opposite shows suggested maximum weld 'Arc Energies' for different combined plate thicknesses. The maximum recommended interpass temperatures for these steels is 225°C.

Please note that the recommended arc energies and interpass temperatures are also applicable to tack welds.

Abrazo Combined plate thickness (mm)	Arc energy (kJ/mm)
<20	1.0
>20 <30	1.5
>30 <40	2.0
>40 <50	2.25
>50	2.5

Maximum interpass 225 °C

Welding preheat

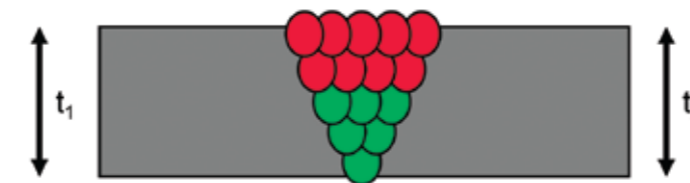
The following table gives guidance on the preheat levels that may be required to prevent hydrogen cracking. This table is based on a welding consumable giving a hydrogen analysis equating to a hydrogen scale C, an arc energy of 1.5 kJ/mm and the maximum CEV for grade of plate. A lower actual plate CEV may result in a lower preheat requirement.

The table should be used as a basis for the formulation and testing of a qualified welding procedure. In some cases, the weld metal may have a higher CEV than the parent plate. In this scenario, the preheat level should be based on the higher CEV.

Welding consumables

For many of the arc welding processes, wear resistant welding consumables that produce differing hardness levels are available from most manufacturers. See your preferred consumable manufacturer for their recommended electrode.

In multipass joints it can be beneficial to weld with different strength welding consumables.



- Welding consumables that produce a wear resistant weld metal should be used for capping passes and possibly the last few layers of the fill passes, depending upon how much wear the weldment will experience in service.
- Tack welds, root passes and the first few fill passes should be welded with lower strength weld metal.

Cutting and forming

Abrazo plate can be readily cut using plasma, conventional oxy-fuel gas flame cutting practices as well as abrasive water jet cutting.

Pre-heat temperatures for thermal cutting

Abrazo	Plate thickness (mm)	Preheating temp (°C)
400	≤ 20	20
	21 - 40	100
	41 - 80	150
450	12 - 50	100
500	12 - 50	100

Cutting

In the case of oxy-fuel gas cutting and plasma cutting there is the risk of a very hard edge, adjacent to the cut, forming. Associated with this hard edge there is the possibility of micro-cracks forming. It is important to reduce the possibility of these occurring. A way of doing this is to reduce the steel cooling rate after cutting.

This can be done by reducing the recommended cutting speed and/or applying a preheat prior to the commencement of cutting. Recommended preheating temperatures are given in the table.

The manufacturer's guidelines for your cutting machine should be followed when cutting Abrazo plate i.e. nozzle diameter for a given plate thickness, appropriate gas pressures for the nozzle diameter and cutting travel speed appropriate for the steel thickness. When a range of cutting speeds is given, the slowest speed should be employed. Adjust the cutting flame so that a neutral flame is employed.

Shearing

Abrazo 400 can be sheared, but as shear strength is a function of tensile strength, a proportional reduction in the capacity of plate shearing equipment should be anticipated in comparison with mild steel grades. The quality of a sheared edge can be heavily influenced by machine set-up. Shear blades should therefore be sharp and well maintained in order to decrease the forces required for the cutting action. Cutting angle and blade gap clearance should be monitored to avoid irregularities such

as burrs and lips. Sheared edges should be dressed and irregularities removed prior to any subsequent cold forming operation. Abrazo should not be sheared at temperatures lower than + 10°C .

Due to its high strength, shearing of Abrazo 450 and 500 is not recommended.

Drilling

Abrazo 400 should be drilled with care. Armour piercing HSS-Co drills with a point angle of 125°-130° may be used. In this case a rigid holding set up is essential in addition to the correct selection of cutting speed, feed rate, tool geometry and cutting fluid, which should be applied generously. A mild steel backing plate or supporting bars should be placed beneath the plate. The following cutting speeds and feeds are based on 1500mm wear life using PRESTO 11-211 armour piercing drills.

5mm Diameter		10mm Diameter		15mm Diameter		20mm Diameter	
rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed m/rev
570	0.05	290	0.10	190	0.16	150	0.20

Alternatively, indexable drills equipped with replaceable carbide inserts may be used for larger holes, but will require very rigid machines. The following recommendations for cutting speeds and feeds for such drills are based upon SECO SD 50 drills.

20mm Diameter		25mm Diameter		30mm Diameter	
rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed mm/rev
1040	0.10	830	0.10	700	0.12

Using:
Outer – Type SCMT F2 TP20 TiN/Al2O3 /coated carbide
Inner – Type SPMX S60M carbide (uncoated)

Both Abrazo 450 and 500 grades can be drilled, provided that care is taken. Indexable drills equipped with replaceable carbide inserts may be used, but drilling will require a very rigid set-up, and copious cutting fluid. The following speeds and feed rates apply (based on minimum 1500 mm wearlife).

20mm Diameter		25mm Diameter		30mm Diameter	
rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed mm/rev
590	0.10	470	0.10	390	0.10

Armour piercing HSS-Co drills are not recommended.

Punching

Abrazo 400 can be cold punched, but it may be a more difficult operation than with mild steel and punch wear will be greater. Punching is not recommended for Abrazo 450 and 500 grades

Milling

Abrazo grades can be machined by milling. The following recommendations are given for general guidance.

Milling can be affected by the rigidity of the machine tool and the workpiece clamping. Also, small variations in cutting speeds and feed rates can significantly affect tool life and these factors should be taken into account in any milling operation. Advice should be sought from tool manufacturers.

Please note the above data has been determined using dry milling with coated carbide inserts. The application of coolant may, in some cases, facilitate the use of faster cutting speeds and feeds. Advice should be sought from insert manufacturers.

Cold bending

Where possible, cold bending should be carried out with the bend axis perpendicular to the rolling direction, this being the more formable of the two directions. The following table contains guidelines for bending to a 90° angle. In general however, bending radii should be as generous as possible, at least 10 times the plate thickness.

Steel grade	Cutting speed mm/min	Feed mm/tooth
Abrazo 400/450/500	100	0.10 - 0.15

Bending direction (bend axis)	Minimum inside bending radius	Minimum die opening
Perpendicular to rolling direction	3t	8.5t
Parallel to rolling direction	4t	10t

Please note, when cold bending Abrazo 450 or 500, any flame-cut edges must be suitably prepared.

Should forming requirements be more onerous, detailed advice can be obtained from Tata Steel Technical advisory services.

Countersinking and counter boring

For countersinking and counterboring, it is recommended that water cooling should be used to improve chip breaking. To achieve a cutting speed of 25-30mm/min, the following speed and feeds are recommended.

19mm Diameter		24mm Diameter		34mm Diameter		42mm Diameter		57mm diameter	
rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed mm/rev	rpm	Feed mm/rev
450	0.15 - 0.20	360	0.15 - 0.20	250	0.10 - 0.15	205	0.10 - 0.17	150	0.10 - 0.15

Hot forming and stress relieving

Abrazo grades are not suitable for hot forming or for applications requiring stress relief.

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While care has been taken to ensure that the information contained in this brochure is accurate, neither Tata Steel Europe Limited nor its subsidiaries accept responsibility or liability for errors or information which is found to be misleading.

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