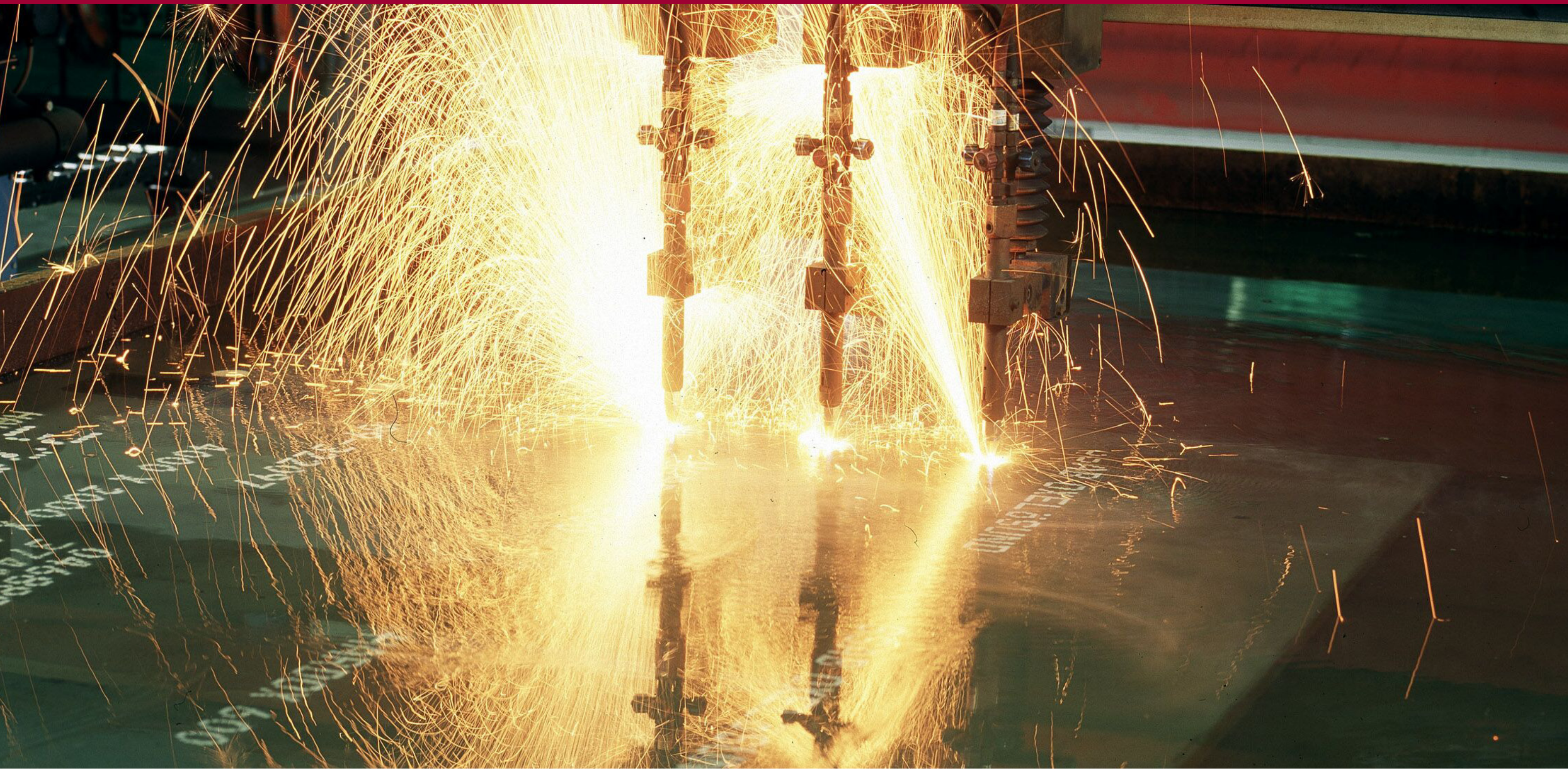
HARDOX®
WEAR PLATE

TECHSUPPORT #23

Hardox® 600 In Workshop



Hardox® 600 can be fabricated by using conventional work shop methods, if being performed according to the recommendations and guide lines given in this document. Recommendations for: welding, cutting, stud welding and drilling/milling.

SSAB

Welding Hardox 600

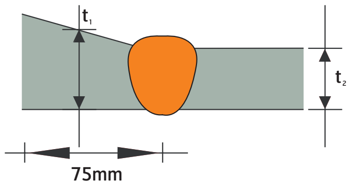
GENERAL WELDING INFORMATION

Hardox 600 can be welded with all conventional methods and to all other weldable steels. Cold cracking can most easily be avoided by choosing stainless austenitic consumables and/or by preheating the plate prior to welding. Also note that soft zones will occur in areas heated to a temperature >200°C, thus softening may arise when welding small components.

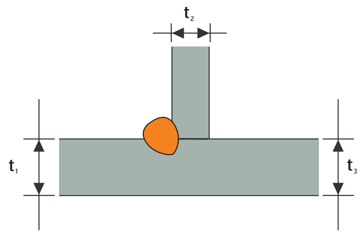
If welding is to be performed on oxygen fuel or plasma cut edges, joint preparation is recommended to be performed by machining.

PREHEATING

The preheat temperature is determined by the combined plate thickness. Preheating is most important when tack welding and welding of the root pass. The tack welds should be at least 50 mm long to reduce the stresses in the weld joint.



COMBINED PLATE THICKNESS: $t_1+t_2+t_3 = t_{COMB}$ [MM]



COMBINED PLATE THICKNESS: $t_1+t_2+t_3 = t_{COMB}$ [MM]

CONSUMABLES

Use stainless austenitic consumables or soft ferritic consumables, basic flux. Weld metal strength Re < 500 N / mm2 hydrogen content < 5 ml / 100 g.

RECOMMENDED PREHEATING TEMPERATURES (MIN. INTERPASS TEMPERATURE)

Combined plate thickness [mm]	10	20	30	40	50	60	70	80	90	100
Austenitic consumables	Room temp			100°C			125°C			
Ferritic consumables	150°C	175°C		Use austenitic consumables						

CONSUMABLES SUITABLE FOR WELDING HARDOX 600

	Electrodes	Wires	
Manufacturer	Austenitic	Austenitic (solid wire)	Ferritic (solid wire / flux-cored wire)
ESAB	OK 67.45	OK Autrod 16.95	OK Autrod 12.51 / OK Tubrod 15.00
LINCOLN	Jungo 307	LNM 307	LNM/LNT Ni1 / Outershield T55-H
OERLIKON	Citochromax N	Interfil 18 8 6	Carbofil 1 / Fluxofil 40
SAF	Safinox R 307	Nertalic 51	Nertalic 70S / Safdual 31
T-	Thermanit X	THERMANIT X	UNION K52 / Thyssen TG 50B

Cutting Hardox 600

OXYGEN FUEL CUTTING

The best way to avoid cut edge cracking when oxygen fuel cutting is to use preheating. The preheating can be performed by the use of burner lances, electrical heating mats or by furnace tempering. The recommended preheat temperatures for Hardox 600 are given in table 1. No restriction in cutting speed is required.

PREHEATING RECOMMENDATIONS WHEN OXYGEN FUEL OF CUTTING HARDOX 600

Thickness [mm]	Temperature [°C]
< 15	No preheating
15–30	150
30.1–50	175

SLOW CUTTING SPEED WHEN OXY FUEL CUTTING

An alternative to preheating prior to cutting is to reduce the cutting speed. The heat accumulated in the plate during the cutting process will then act as a kind of preheating. Cutting at a low cutting speed has, however, shown to be less reliable compared to the use of preheating for preventing cut edge cracking. If preheating is not employed the maximum permissible cutting speed is given in table 2.The lower the cutting speed used, the less risk of cut edge cracking.

MAX CUTTING SPEED WHEN OXYGEN FUEL CUTTING OF HARDOX 600 IF NO PREHEATING IS EMPLOYED. SLOW CUTTING / SUBMERGED CUTTING

Thickness [mm]	Maximum cutting speed [mm/min]
15	300
20	200
25	180
30	150
35	140
40*	120
50*	110

*When using cutting speeds < 140 mm/min the tendency of developing a poor of cut edge quality becomes evident, therefore attention must be paid when 1) selecting the cutting nozzle and 2) selecting the cutting gas pressure.

1. The nozzle should be selected according to the platethickness. The use of high efficiency or high speed nozzles has proven to give a better edge quality then standard nozzles.
2. Try to reach a state of best performance by adjusting the cutting gas pressure.

SLOW COOLING WHEN OXY FUEL CUTTING

Regardless of whether preheating or slow cutting speeds are employed, a slow cooling rate of the cut part will reduce the risk of cut edge cracking. Slow cooling rate can be achieved if the parts are stacked together while still warm and covered with an insulating blanket. Allow the parts to cool slowly down to room temperature.

CUTTING OF SMALL COMPONENTS WITH OXY FUEL CUTTING

To gain full benefit from the plate hardness it is important to consider the hardness reduction due to the heat generated from the cutting. In figure 1 the reduction in hardness due to tempering temperature is shown. The smaller the size of the cut part, the greater the probability of it softening, figure 3.

SURFACE HARDNES VS TEMPERING TEMPERATURE HARDOX 600

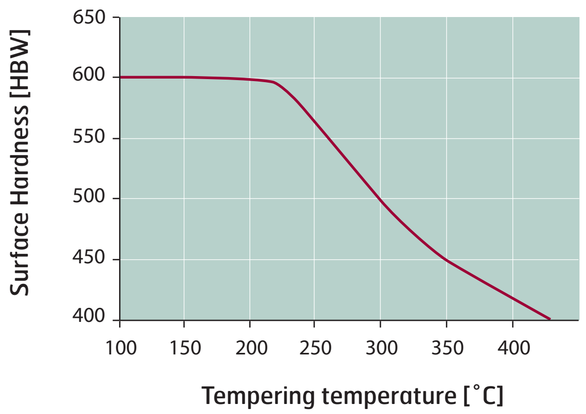


FIGURE 3.

Size of component: 25 x 120 x 75 mm

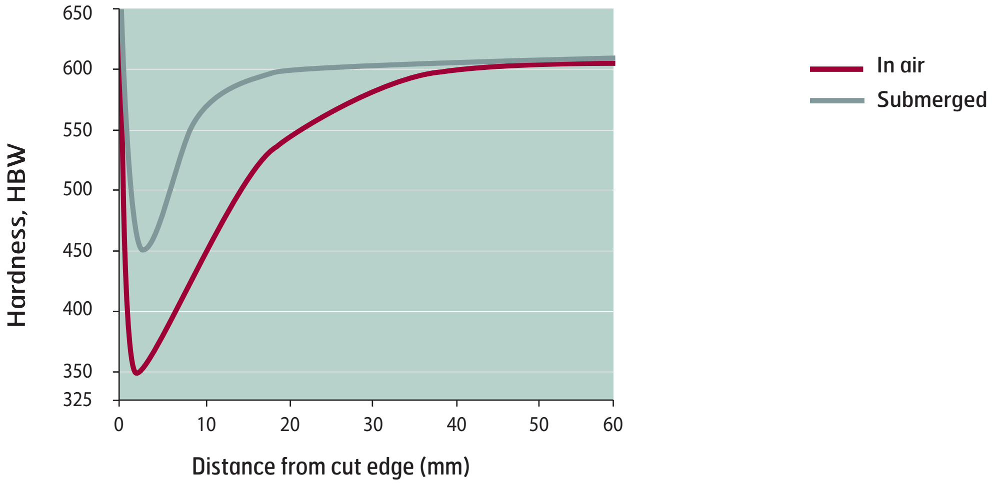
MINIMIZE SOFTENING OF SMALL COMPONENTS

To prevent softening when oxygen fuel cutting or plasma cutting small components, the cutting should be performed under water. Figure 2 displays the extension of the heat affected zone (HAZ) from oxy fuel cutting in air and submerged. By “small components” we mean when the distance between two individual cuts is less then 200 mm.

The best way to prevent softening of small components is to choose another cutting method where the amount of heat generated is limited, like laser or abrasive water jet cutting.

Cutting speeds for submerged oxy-fuel cutting are the same as for slow cutting, table 2.

FIGURE 2. SURFACE HARDNESS WHEN OXY FUEL CUTTING t=50 MM/CUTTING SPEED 110 MM/MIN



ABRASIVE WATER JET CUTTING
Abrasive water jet cutting (AWJ) is an excellent way of cutting HARDOX 600. The method is highly recommended when cutting thicker gauges. The use of AWJ produces narrow tolerances, no heat affected zone and an excellent cut edge quality.

PLASMA CUTTING
Plasma cutting can be performed up to plate thickness of 20 mm, under water as well as in air. There is also no need of preheating or a restricted cutting speed.

LASER CUTTING
Laser cutting can be performed up to a plate thickness of 15 mm, without restrictions in cutting speed.

GUIDELINES WHEN CUTTING HARDOX 600
Allow a cold plate to reach room temperature before thermal cutting. After cutting do not expose the plate to large temperature changes before it has reached room temperature.

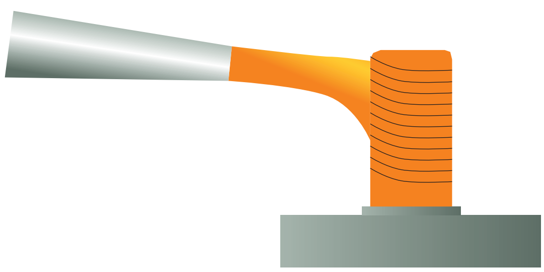
Cutting should always be performed indoors. For demanding applications, in 40 – 50 mm plate thickness, it is recommended to perform ultrasonic inspection , not less than two weeks after cutting.

Stud welding Hardox 600

GENERAL INFORMATION ABOUT STUD WELDING
The most important thing is to avoid hydrogen cracking. This can be done either by preheating, post heating, choice of bolt material or a combination of these.

BOLTS
Our recommendations are to use austenitic or acid–proof stainless steel bolts in combination with post heating. These bolts have a high solubility of hydrogen, which considerably reduces the risk of hydrogen cracking.

CHECK LIST FOR STUD WELDING
1. Weld the bolt on a ground and clean surface.
2. Directly after welding, heat the bolt in order to minimize the amount of hydrogen trapped in the weld.
3. When heating, make sure that the bolt is almost completely orange in colour (15-20 sec of heating for M12).
4. Measure the temperature according to the figure. The plate should not be warmer than 200°C.

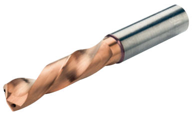


Due to many parameters there are a large number of weld setup combinations. Therefore, it is advisable to contact our Technical Customer Service Department for further information.

Drilling in Hardox 600

Hardox 600 can be machined in ordinary stable machines. It is important to avoid vibrations and to use proper tools made of cemented carbide. Use coolant!

SOLID CEMENTED CARBIDE



v_c = 20–32 m/min
f_n = 0.08–0.14 mm/rev
D_c > approx 3 mm
Good tolerance
Regrindable
Sensitive to vibrations

BRAZED CEMENTED CARBIDE

v_c = 20–35 m/min
f_n = 0.08–0.15 mm/rev
D_c > approx 10 mm
Good tolerance
Regrindable/exchangeable
Not as sensitive to vibrations as solid drills

INDEXABLE DRILLS

v_c = 30–50 m/min
f_n = 0.04–0.12 mm/rev
First choice is drill length 2x D_c
Centre insert ISO class P40
Periphery insert ISO class P40
D_c > approx 12 mm
Choose coated cemented carbide inserts
Not as good tolerance as the other two.

Counterboring

Counterboring can be performed by using tools with cemented carbide inserts. Use coolant!

v_c = 30–50 m/min
f_n = 0.10–0.20 mm/rev
D_c > approx 12 mm
When countersinking (conical) reduce cutting data with ~30%

Milling

Choose coated cemented carbide inserts ISO class K 20 or P10–30.

fz [mm/tooth]	0.07	0.1	0.12
v [mm/min]	80	75	70

Rough milling: Use round inserts

Finishing milling: Use 45 º insert angle

Thread Milling

Threads can be machined in Hardox 600. Use cemented carbide tools. Threads are best made by using a thread milling tool. To manage thread milling, a numerically controlled machine is necessary. The cutting speed should be approximately 30 m/min.

SSAB is a global leader in value added, high strength steel. SSAB offers products developed in close cooperation with its customers to reach a stronger, lighter and more sustainable world.

SSAB employs over 8 700 people in over 45 countries around the world and operates production facilities in Sweden and the US. SSAB is listed on the NASDAQ OMX Nordic Exchange, Stockholm.

For more information, contact us or visit **www.ssab.com**

TS-23-Hardox 600 In Workshop-uk-v2-2010

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