



STEP UP TO THE NEXT LEVEL IN WEAR PLATE PERFORMANCE

By upgrading your products from Hardox[®] 450 to Hardox[®] 500 Tuf, you can use a thinner material to increase the load capacity and still have the same outstanding service life. Or stay with the same thickness and increase service life by up to 40%.

Mechanical properties	Hardox [®] 500 Tuf	Hardox [®] 450
Hardness	475-505 HBW	425-475 HBW
Yield strength*	1300 MPa (189 ksi)	1200 MPa (174 ksi)
Tensile strength*	1600 MPa (232 ksi)	1400 MPa (203 ksi)
Elongation A5*	10%	10%
Impact toughness at -40 °C (-40 °F)*	45 J (33 ft-lb)	50 J (37 ft-lb)

*Typical value for 20 mm (0.787") plate thickness.

Material	Thickness range mm (in.)	Maximum width mm (in.)
Hardox [®] 500 Tuf sheet	3-6 (0.118-0.236)	1600 (63)
Hardox [®] 500 Tuf plate	4-25.4 (0.156-1)	3350 (132)
Hardox [®] 450 sheet	2-8 (0.079-0.315)	1650 (65)
Hardox [®] 450 plate	3.2-130 (0.126-5.118)	3350 (132)

The data in these tables may be subject to change without notice. Please download the latest version of the respective Hardox[®] wear plate product data sheet at www.ssab.com.

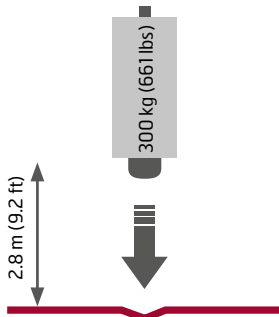
Upgrading benefits with Hardox® 500 Tuf

40% LONGER WEAR LIFE

Hardox® 500 Tuf adds around 50 HBW of hardness compared to Hardox® 450. Case studies show that the extra hardness can deliver up to 40% longer wear life, and even more in some applications. This naturally makes a dumper body, container, mining tray, excavator bucket or any other wear-affected equipment more cost-effective.

THINNER MAKES LIGHTER

You can use thinner wear steel when designing with Hardox® 500 Tuf instead of Hardox® 450, with the same or better service life. Thinner steel means lighter structures that can take more payload and increase your profitability. A 5 mm plate of Hardox® 500 Tuf is 17% lighter than a 6 mm plate of Hardox® 450. New design solutions naturally need to take buckling, deflection and fatigue strength into consideration.



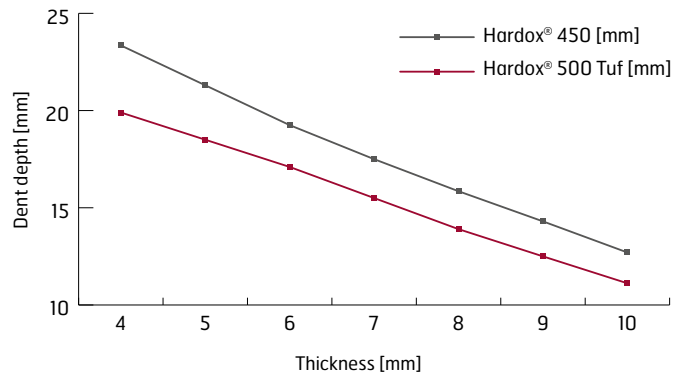
Results from impact drop tests of Hardox® 500 Tuf and Hardox® 450.

Basalt	Granite	Steel scrap
38%	40%	27%

Examples of increased wear life by upgrading from Hardox® 450 to Hardox® 500 Tuf for different materials and sliding wear, according to Hardox® WearCalc™.

IMPROVED DENT RESISTANCE

Higher hardness equals higher yield strength. This in turn translates into higher dent resistance. Upgrading from Hardox® 450 to Hardox® 500 Tuf improves the dent resistance as shown in the figure. In this test, a 300 kg (661 lbs.) weight is dropped from 2.8 m (9.2 ft.) onto a 600 x 600 mm (23 x 23") test plate.



Hardox® 500 Tuf in the workshop

WELDING

Hardox® 500 Tuf can be welded with all conventional arc welding methods for ordinary and high-strength steel. Use welding consumables with a yield strength of max. 500 MPa (72 ksi) and a sufficiently low hydrogen content of max. 5ml/100 g of weld metal. Welding materials with these properties reduce residual stress levels in the joint and its sensitivity to cold cracking. The following consumables fulfill the hydrogen criteria:

- All solid wires applied at MAG (GMAW) and TIG welding
- MAG welding with flux cored wires (FCAW):
Certain types
- MAG welding with metal cored wires (MCAW):
Certain types
- SAW: Basic types of fluxes in combination with solid wires

More detailed information regarding the hydrogen content of a certain brand can be attained from its manufacturer. In addition, SSAB provides examples of suitable welding consumables, please contact techsupport@ssab.com.

Single plate thickness mm (in.)	Hardox® 500 Tuf °C (°F)
< 16 (0.630)	Room temperature
16-25.4 (0.630-1)	75 (167)

Single plate thickness mm (in.)	Hardox® 450 °C (°F)
< 25 (0.984)	Room temperature
25-39.9 (0.984-1.571)	125 (257)

The tables show recommended preheating temperature using a heat input of 1.7 kJ/mm (43.2 kJ/inch) and a weld metal hydrogen content of maximum 5 ml/100 g of weld deposit. For heat inputs between 1.0-1.69 kJ/mm (25.4-42.9 kJ/inch), the min. preheat temperature is raised by 25 °C (77 °F) in comparison to the values in the tables, except when no preheating is required. For heat inputs below 1.0 kJ/mm (25.4 kJ/inch) the preheating temperatures can be calculated by SSAB's software WeldCalc. A user license of this software can be attained through www.ssab.com, or by contacting SSAB.

Preheating can be avoided by welding with austenitic stainless consumables according to type AWS 307 or AWS 309. Hydrogen content is not relevant when welding with stainless consumables.

CUTTING

Oxy-fuel, plasma, laser and abrasive water jet (AWJ) are all suitable methods for cutting Hardox® wear plate.

Recommendations for oxy-fuel cutting of Hardox® 500 Tuf and Hardox® 450. Preheating is usually not required.

Grade	Plate thickness mm (in.)	Minimum preheating temp. °C (°F)	Max. allowable temp. °C (°F)
Hardox® 500 Tuf	≤ 25.4 (1)	No preheating	225 (437)
Hardox® 450	< 40 (1.576)	No preheating	225 (437)

*Maximum allowable temperature is the temperature which must not be exceeded by preheating or cutting, or a combination of these two processes, otherwise the hardness of the cut part will be reduced.

Recommended maximum cutting speed without preheating.

Max. plate thickness mm (in.)	≤ 25.4 (1)
Hardox® 500 Tuf	No restriction*

Max. plate thickness mm (in.)	< 40 (1.576)
Hardox® 450	No restriction*

*Please follow recommendations from the cutting equipment manufacturer.

BENDING

Minimum recommended tool radius (R) and die opening width (W) when the bend line is perpendicular or parallel to the rolling direction.

Thickness (t) mm (in.)		Transverse to rolling direction minimum R / t	Along rolling direction minimum R / t	Die opening width (W) minimum W / t
Hardox® 500 Tuf & Hardox® 450		Hardox® 500 Tuf & Hardox® 450	Hardox® 500 Tuf & Hardox® 450	Hardox® 500 Tuf & Hardox® 450
Plate	t < 8 (0.315)	3.0	3.5	12
	8 (0.315) ≤ t < 20 (0.787)	3.5	4.5	14
	t ≥ 20 (0.787)	4.5	5.0	16
Sheet	3 (0.118") ≤ t < 4 (0.157)	3.0	4.0	12
	4 (0.157) ≤ t ≤ 6 (0.236")	3.0	3.5	12

To estimate the force needed during bending, all factors should be considered: Bending length, plate thickness, die width, tensile strength, and the changing moment arm during bending. The peak load is assumed to be reached at a bend opening angle of 120° with normal friction (no lubrication). Trial tests are always recommended.

$$P = \frac{b \cdot t^2 \cdot R_m}{(W - R_d - R_p) \cdot 9\,800}$$

The SSAB Bending Formula® is verified by tests for 90° bends.

P = Bending force, tonnes (metric)
t = Plate thickness, mm
W = Die width, mm
b = Bend length, mm
R_m = Tensile strength, MPa
R_d = Die entry radius, mm
R_p = Punch radius, mm

Since the tensile strength is higher for Hardox® 500 Tuf, the required bending force is about 14% higher than for a Hardox® 450 plate of the same thickness. A Hardox® 500 Tuf plate that

is 6% thinner than a Hardox® 450 plate is bent with the same force. A 5 mm (0.197") plate of Hardox® 500 Tuf requires a lower bending force than a 6 mm (0.236") Hardox® 450 plate.

DRILLING

Drill	HSS-8% Co		
	Drill Ø mm	Hardox® 500 Tuf	Hardox® 450
Vc [m/min]		3-5	5-7
fn [mm/rev]	10	0.08	0.10
	15	0.12	0.15
	20	0.16	0.20
	25	0.20	0.25
	30	0.24	0.30

Drill	Solid cemented carbide		
	Drill Ø mm	Hardox® 500 Tuf	Hardox® 450
Vc [m/min]		35-50	40-60
fn [mm/rev]		Min-max	Min-max
	3.0-5.0	0.03-0.05	0.03-0.05
	5.01-10.0	0.05-0.10	0.05-0.11
	10.01-15.0	0.10-0.14	0.11-0.15
	15.01-20.0	0.14-0.18	0.15-0.20

Drill	Exchangeable drill head		
	Drill Ø mm	Hardox® 500 Tuf	Hardox® 450
Vc [m/min]		35-50	40-60
fn [mm/rev]		Min-max	Min-max
	7.5-12.0	0.06-0.10	0.07-0.11
	12.01-20.0	0.10-0.14	0.11-0.15
	20.01-25.0	0.14-0.18	0.15-0.20
	25.01-33.0	0.18-0.24	0.20-0.28

Drill	Indexable inserts		
	Drill Ø mm	Hardox® 500 Tuf	Hardox® 450
Vc [m/min]		40-70	50-90
fn [mm/rev]		Min-max	Min-max
	12.0-20.0	0.04-0.08	0.04-0.10
	20.01-30.0	0.04-0.10	0.06-0.12
	30.01-44.0	0.06-0.12	0.06-0.14
	44.01-63.5	0.08-0.14	0.08-0.16

Use as short drill as possible, when drilling with indexable inserts. The recommendations are for 2xØ.



CUSTOMER SUPPORT

For more information about the benefits of upgrading from Hardox® 450 to Hardox® 500 Tuf, please contact your local SSAB sales representative. You will find contacts for all markets at www.ssab.com

SSAB is a Nordic and US-based steel company. SSAB offers value added products and services developed in close cooperation with its customers to create a stronger, lighter and more sustainable world. SSAB has employees in over 50 countries. SSAB has production facilities in Sweden, Finland and the US. SSAB is listed on Nasdaq Stockholm and has a secondary listing on Nasdaq Helsinki.

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