

SSAB OX

TechSupport

Information from
SSAB Oxelösund.

#60

Consumables for the welding of WELDOX and HARDOX steels

In this TechSupport, SSAB Oxelösund offers suggestions for suitable consumables for the welding of WELDOX structural steel plate and HARDOX wear plate. Note that the consumables listed are only examples. In addition to these, there are numerous suitable products that also meet the SSAB Oxelösund recommendations. The consumables are classified into two main groups – unalloyed and lowalloyed grades which are the most common, and also stainless steel consumables.

Unalloyed and lowalloyed consumables

General

Unalloyed and lowalloyed consumables must meet the specified strength criteria, and their hydrogen contents must be kept at a suitably low level, which is ≤ 5 ml/100 g of weld metal.

Strength

Suitable strength levels for consumables used for the welding of WELDOX and HARDOX are given in the chart on the next page.

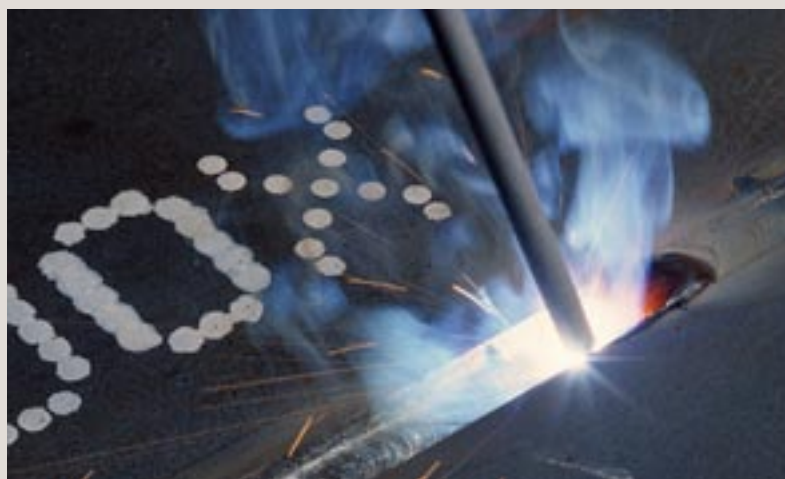
Hydrogen content

The hydrogen content of consumables depends on factors such as the welding method used. Solid wires for MAG with solid wire and TIG welding can meet the hydrogen content criteria for all types of consumables. Flux cored wires for MAG welding, which fulfil the hydrogen content criteria, are available for both basic and rutile types of consumables.

Metal cored wires used in MAG welding can have suitable hydrogen contents for certain grades.

Among consumables for the submerged arc welding, the combination of solid wire/ basic flux can produce sufficiently low hydrogen contents in the weld metal.

Manufacturers of consumables can provide information on the hydrogen content of a specific consumable. In addition, SSAB Oxelösund has specified

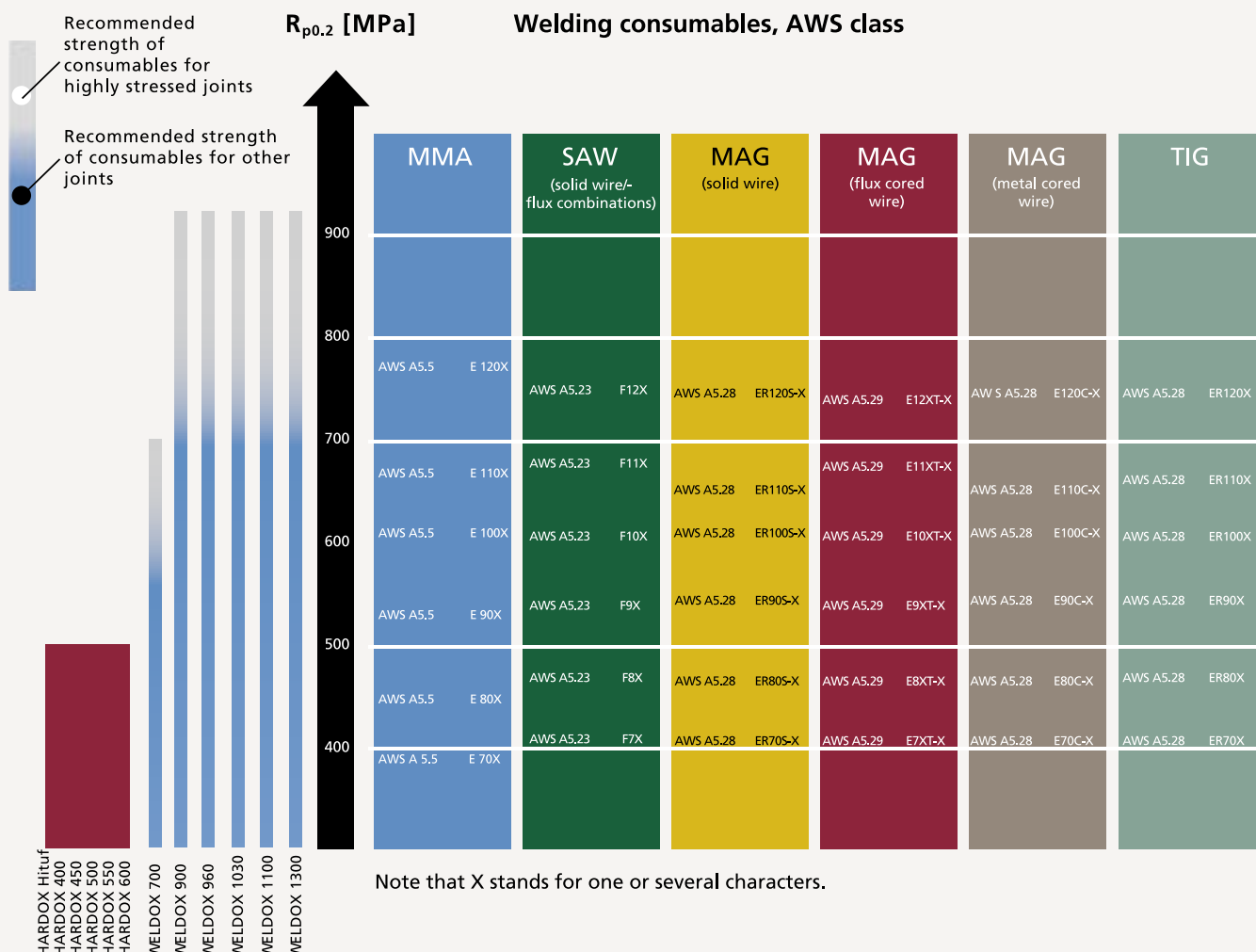
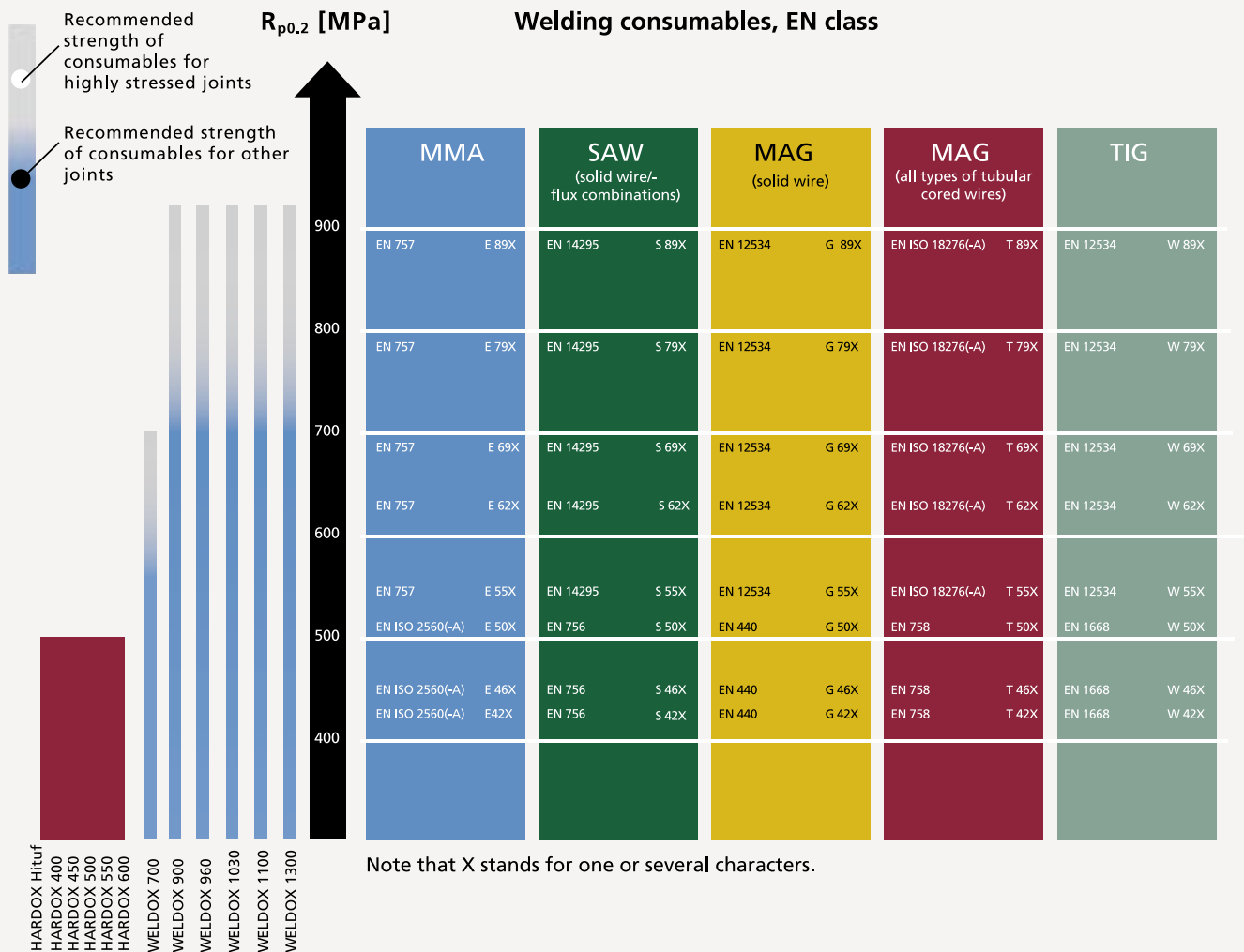


suggestions for suitable consumables. The types suggested in this TechSupport are sorted according to welding method and strength class.

Preheat/Interpass temperature

Consumables with yield strengths ($R_{p0.2}$) up to 700 MPa normally have carbon equivalents that are lower than the steels in the joint. In these cases, the preheat/interpass temperature during the welding is determined by the plates included in the joint.

For high strength consumables with yield strengths higher than 700 MPa, the carbon equivalent in the vast majority of cases is higher in the consumables than in the steels included in the joint. The preheat/interpass temperature of the consumables must therefore also be taken into account in these situations. Use the highest preheat/interpass temperature either for the plates included in the joint or for the relevant consumables. Consumables with yield strengths higher than 700 MPa make special demands on factors such as preheat and interpass temperatures during the welding, and these are therefore discussed in more detail under a separate heading.



High strength, lowalloy consumables with yield strengths ($R_{p0.2}$) higher than 700 MPa

WELDOX 900-1300 steel types are frequently welded with consumables that have yield strengths of about 750-900 MPa in the all-weld metal. The consumables used are of the highest strength available on the market.

The manufacturers of consumables do not normally specify preheat/interpass temperatures for these types of consumables. The actual temperature can be determined in accordance with the European Standard EN 1011-2, Method B, for example. In addition, SSAB Oxelösund has made its own general estimates of the lowest suitable preheat/interpass temperature in accordance with the table below. This is possible since the alloying concepts are similar for the relevant consumables.

Consumables are sensitive to high interpass temperatures. All recommended consumables will achieve high strengths due to the high strength microstructures, such as martensite, in the weld metal. Due to the high content of alloy elements, martensite transformation takes place at low temperatures. This is

Single plate thickness, welded joint (mm)	Minimum working temperature (°C)
< 10	100
10 - 20	125
> 20	150

The minimum recommended preheat/interpass temperatures.

High strength consumables are normally sensitive to high heat inputs. Excessively high heat input will impair the mechanical properties of the joint. However, the permissible heat input follows our normal recommendations for the relevant steel grade. Ordinary welding conditions are otherwise applicable to WELDOX steels.

Examples of suitable lowalloy consumables

Examples of suitable lowalloyed consumables

Suggestions for various suitable consumables are given in the following tables. Note that the consumables are arranged according to the yield strength ($R_{p0.2}$) for which they are classified. In reality, a given consumable normally has a higher yield strength than its standard designation. The mechanical properties of a given consumable can be obtained from its manufacturer.

MAG solid wire

Min. yield strength (MPa)	400	470	540	610	680	745
AWS class	ER 70S-X*	ER 80S-X*	ER 90S-X*	ER 100S-X*	ER 110S-X*	ER 120S-X*
ELGA	Elgamatic 100 Elgamatic 103	Elgamatic 162	Elgamatic 163	Elgamatic 135 Elgamatic 147		Elgamatic 138
ESAB	OK Autrod 12.51 OK Autrod 12.64	OK Autrod 13.09		OK Autrod 13.13	OK Autrod 13.29	OK Autrod 13.31
LINCOLN	SUPRA MIG SUPRA MIG ULTRA LNM 27	LNT/LNM Ni1 LNT/LNM Ni2,5		LNM Moniva LA-100	LA 100	
OERLIKON	Carbofil 1 Carbofil 1a	Carbofil 2,5 Ni	Carbofil NiMo1	Carbofil NiMoCr		
SAF	NERTALIC 70S NERTALIC 70A	NERTALIC 86		NERTALIC 86		
BÖHLER	EMK 7 EMK 8	NiCu-1G	NiMo 1-IG		NiCrMo 2.5-IG X 70-IG	X 90-IG
THYSSEN	Union K52 Union K56	Union K5 Ni	Union MoNi	Union NiMoCr	Union X 85	Union X90 Union X96

* Note that X can stand for one or several code characters

MAG flux cored wire

Min. yield strength (MPa)	400	470	540	610	680	745
AWS class	E7XT-X*	E8XT-X*	E9XT-X*	E10XT-X*	E11XT-X*	E12XT-X*
ELGA	DWA 51B				Elgacore 110B	
ESAB	OK Tubrod 15.00 OK Tubrod 15.25				OK Tubrod 15.27	Filarc PZ 6149
LINCOLN	Outershield T55-H					
OERLIKON	Fluxofil 30 Fluxofil 31	Fluxofil 40 Fluxofil 48	Fluxofil 41		Fluxofil 42	Fluxofil 45
SAF	Saf dual 31 Saf dual 400					
BÖHLER	Kb 52-FD					
THYSSEN	Thyssen TG50B					

* Note that X can stand for one or several code characters

MAG metal cored wire

Min. yield strength (MPa)	400	470	540	610	680	745
AWS class	E7XT-X*	E8XT-X*	E9XT-X*	E10XT-X*	E11XT-X*	E12XT-X*
ELGA	MXA 100 MX 100T	MXA 55T				
ESAB	Filarc PZ 6102 Filarc PZ 6105R				OK Tubrod 14.03	
LINCOLN	Outershield MC710-H Outershield MC715-H				Outershield MC1100	
OERLIKON	Fluxofil M8 Fluxofil M10				Fluxofil M42	
SAF	Saf dual 200 Saf dual 206	Saf dual 202	Saf dual 255		Saf dual 270	
BÖHLER	HL 50-FD HL 52-FD					
THYSSEN	Thyssen TG55Fe Thyssen MV70					

* Note that X can stand for one or several code characters

MMA

Min. yield strength (MPa)	399	399	460	530	600	670	740
AWS class	E 7016 E 7018	E 7028	E 8016 E 8018	E 9018	E 10018	E 11018	E 12018
ELGA	P48S P51 P62MR	Maxeta 21	P48K P65MR	P70		P110MR Maxeta 110	
ESAB	OK 48.00 OK 48.08 OK 53.68	OK Femax 38.65	OK 73.68 OK 73.15	OK 74.78 FILARC 98S		OK 75.75	OK 75.78
LINCOLN	Baso 100 Conarc 48 Conarc 49 Kryo 1	Conarc V180 Conarc V250 Conarc L150	Kryo 1-180 Kryo 1N Kryo 3	Kryo 2 Conarc 60G Conarc 70G		Conarc 80	Conarc 85 Conarc 85-150
OERLIKON	Tenacito Tenacito 38 R	Febacito 160S Ferrocord B250	Tenacito 70 Tenacito 70B	Tenacito 65 Tenacito 65R	Tenacito 75	Tenacito 80	Tenacito 100
SAF	Safer MF48 Safer NF59A Safer Prestige	Safer NF52 Safer NF53	Safer NF59 Safer MD56	Safer ND65	Safer MD70	Safer ND80	Safer ND100
BÖHLER	FOX EV 47 FOX EV 50-W		FOX EV 60 FOX EV 63 FOX EV 65	FOX EV 70 FOX U 80 N	FOX EV 75	FOX EV 85	
THYSSEN	SH Grün K50W SH Grün K52W Phoenix 120K		SH V 370 SH V 1 SH Ni 2 K70	SH Schwarz 3 K Ni	SH Ni2 K90 ThyssenNiMo100	SH Ni2 K100	SH Ni2 K130

SAW wire/powder combinations

Min. yield strength (MPa)	400	470	540	610	680	745
AWS class	ER 70S-X*	ER 80S-X*	ER 90S-X*	ER 100S-X*	ER 110S-X*	ER 120S-X*
ELGA	Elgaflux 251B/ Elgasaw 102					
ESAB	OK Flux 10.71/ OK Autrod 12.20 OK Flux 10.71/ OK Autrod 12.22	OK Flux 10.62/ OK Autrod 12.24			OK Flux 10.62/ OK Autrod 13.43	
LINCOLN	P 230/L-61 P 230/LNS 133 U	P 230/LNS140A Lincolnweld 8500/ L-70	P240/LNS151	P230/LNS 168		
OERLIKON	Lincolnweld 860/L61 OP121TT/	OP121TT/	OP121TT/		UV421TT/	
SAF	OE-SD3 AS589/AS37**	OE-S2Mo	OE-S3NiMo1 AS589/AS 40A**		Union S3NiMoCr	
BÖHLER	BB24/ EMS2		BB24/ 3NiMo 1-UP	BB24/		
THYSSEN	UV 420TT / Union S2	UV421TT/ Union S2NiMo	UV421TT/ Union S3NiMo	3 NiCrMo 2.5-UP		

* Note that X can stand for one or several code characters

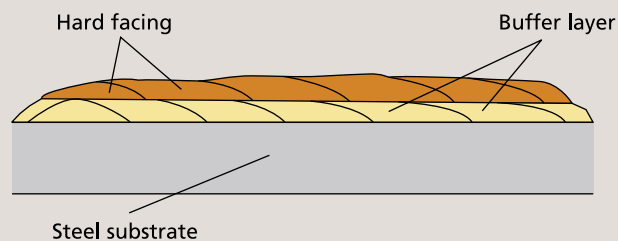
** No information on classification of flux/wire combination according to the relevant AWS standard

Stainless steel consumables

HARDOX and WELDOX steels can always be welded with austenitic stainless steel consumables of type AWS 307. The typical basic chemical composition for this grade is 18% Cr, 8% Ni, 6% Mn. After welding, high resistance is achieved to both hydrogen cracks and hot cracks in the welded joint. The structure of the weld metal will contain austenite, which contributes to high toughness of the weld metal. The yield strength ($R_{p0.2}$) of this type of consumables is around 450 – 500 MPa.

Other important benefits of welding with this type of consumables are:

- Preheat/Interpass temperatures, i.e. a temperature above +20°C in the joint as well as in the surrounding air, can be avoided on all HARDOX and WELDOX steels, with the exception of HARDOX 600. Further information is available in the welding brochure from SSAB Oxelösund.
- Welding operations can be performed for the welding of HARDOX and WELDOX grades to other kinds of steels, such as:
 - Stainless steels
 - Manganese steels (Hadfield steel)
 - Steels that are difficult to weld, such as spring steels



- This type of consumable is suitable as the buffer layer in hard facing

An alternative to the welding consumable AWS 307 is an austenitic stainless steel consumable according to AWS 309. However, the risk of hot cracking is somewhat higher when using consumables of type AWS 309 compared to ones according to AWS 307. Consumables according to AWS 307 are listed in the table on the next page.

Examples of suitable stainless steel consumables

Welding method	MMA	MAG, solid wire	MAG, fluxcored tubular wire	MAG, metal cored wire
AWS class	A5.4: E307-X*	A5.9: ER307		A5.22: E307T-X*
ELGA	Cromarod 307B	Cromamig 307Si		
ESAB	OK 67.45 OK 67.52	OK Autrod 16.95	OK Tubrod 15.34	OK Tubrod 14.71
LINCOLN	Jungo 307 Arosta 307	LNM 307		
AVESTA WELDING	307	307-Si		
SAF	Safinox R 307	Nertalic 51	Safdual 651	
OERLIKON	Citochromax N Citochromax R Citochromax RS	Inertfil 18 8 6	Fluxinox 307 Fluxinox 307-PF	Fluxinox M 307
SANDVIK	18.8.MnR	Sandvik 18.8.Mn Sandvik 18.8.CMn		
BÖHLER	FOX A 7	A 7-IG	A 7-FD	
THYSSEN	Thermanit X Thermanit XW	Thermanit X		

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