

### General welding information

SSAB Oxelösund AB, Sweden, produces armour plate with a lean chemical composition which simplifies welding.

ARMOX plates should be welded with a consumable which produces a low hydrogen content in the weld metal. Good results require that hydrogen, which can induce cold cracking is kept away from the weld area.

ARMOX plates can be welded by either manual metal-arc or gas metal-arc. All ARMOX grades can be welded to other weldable steel.

ARMOX plates have been developed to have as low a carbon equivalent as possible without loss in hardness, strength and ballistic properties. Typical carbon equivalents are shown in the table below.

### Edge preparation

A good fit between the work pieces is essential to minimize stresses and thereby the risk of cracking.

All types of impurities on and near the edges, such as mill scale, rust, oil, paint and moisture, should be removed before welding.

Steel grade	Thickness range	Carbon equivalent CEV (IIW) <sup>1</sup>
ARMOX 370 T	3–150 mm	0.67–0.75 <sup>2</sup>
ARMOX 440 T	4–30 mm	0.68–0.72
ARMOX 500 T	3–150 mm	0.67–0.75 <sup>2</sup>
ARMOX 560 T	5–100 mm	0.79–0.85 <sup>2</sup>
ARMOX 600 T	5–100 mm	0.85 <sup>2</sup>

1) Carbon equivalent (CEV) in accordance to IIW: 
$$C + \frac{Mn}{6} + \frac{Cr+Mo+V}{5} + \frac{Cu+Ni}{15}$$

2) For plate thicknesses > 80 mm, please contact SSAB Oxelösund.



### Tack welding

During tack welding the cooling rate is more rapid which increases the risk of cold cracking. In areas of high restraint the minimum length of each tack weld should be 50 mm to prevent this.

### Working temperature and heat input

If **ferritic** consumables are used preheating is necessary and the plate should be welded at a working temperature of 75–200°C, dependent on plate thickness and restraint conditions. The temperature should be maintained throughout the entire weld operation, tack welding and root passes included.

If **austenitic** consumables are used, the plate should be welded at least at room temperature (18–25°C), but when welding in plate thicknesses in excess of 30 mm in conjunction with high levels of restraint preheating to 100–150°C is recommended.

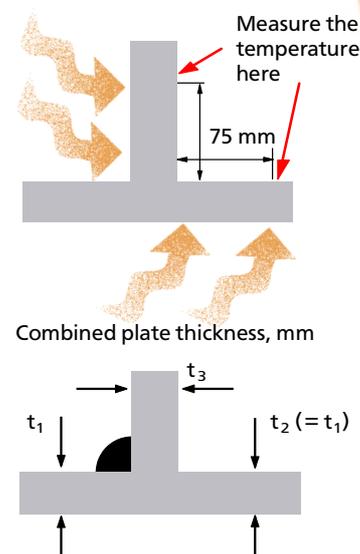
Do not preheat ARMOX plates above 200°C.

### Recommended working temperatures for welding with ferritic consumables

Steel grade	Heat input Q [kJ/mm] **	Combined plate thickness t <sub>1</sub> +t <sub>2</sub> +t <sub>3</sub> [mm]					
		20	30	40	50	60	70
ARMOX 440 T	1	100°C	125°C	150°C	175°C	200°C	200°C
	2	50°C	75°C	100°C	125°C	150°C	175°C
ARMOX 370 T/500 T	1	125°C	150°C	175°C	200°C	200°C	200°C
	2	75°C	100°C	125°C	150°C	175°C	200°C
ARMOX 560 T/600 T *	1	125°C	150°C	175°C	Use austenitic cons. Preheat 100–150°C		
	2	125°C	150°C	175°C			

\*\*) 
$$Q = \frac{U \cdot I \cdot 60}{v \cdot 1000} \text{ [kJ/mm]}$$

I = Weld current [A]  
 U = Weld voltage [V]  
 v = Weld speed [mm/min]



\*) ARMOX 560 T and ARMOX 600 T are recommended to be welded with austenitic consumables.

## Welding recommendations for ARMOX plate (cont.)

### Selection of consumables

Consumables should be selected on the basis of strength and toughness requirements in the welded joint as well as on the prevailing restraint conditions.

In order to achieve an optimum combination of strength and toughness in the welded joint, select a consumable with as lowest strength as possible, but which still fulfils the strength requirements for the joint. Overmatching should be avoided. Designers should attempt to position the welds in low stress areas. In most cases, undermatching consumables can then be used. The main advantages of a low-strength instead of a high-strength consumable are an increase in plastic deformation capacity (ductility), a reduced susceptibility to cracking and better toughness in the weld joint.

Basic consumables are most suitable for ARMOX plate.

### Handling of consumables

Select the weld process and consumables which produce the lowest possible level of hydrogen in the weld metal. Covered electrodes should be thoroughly dried to ensure that the hydrogen content does not exceed 5 ml per 100 g weld metal (the Hg method according to ISO 3690).

Consumables should be stored to ensure that moisture absorption is prevented. Always keep opened packages of electrodes dry and warm (at least 125°C).

Do not return unconsumed electrodes to dry cabinets if there is the slightest risk that they may have absorbed moisture. (Harmful absorption can take place in 30 to 60 minutes).

If there is any risk that moisture has been absorbed, the consumable must be discarded or ask the manufacturer for advice on redrying. Precautions that apply to covered electrodes also apply in the main to granular flux, and flux-cored wires.

### Consumable recommendations

	Manufacturer	Austenitic consumables EN 1600 E 18 8 Mn AWS A/SFA 5.4-92 E 307-15 AWS A5.22 E 307 LT-2	Ferritic consumables EN 499 xxx H5 AWS: A 5.18-93 ER70S-6 E7018-1 AWS: A 5.28-79 ER80S-G
ELECTRODES	ESAB	OK 67.45 OK 67.52	OK 48.08, OK Femax 38.65 OK 55.00
	FILARC	Filarc BM 307	Filarc 35 Filarc 56 S
	OERLIKON	COMET 307 SAFDRY R 307	Special Supercord S
	THYSSEN	THERMANIT X	Phoenix 120 K SH Grün K52W
WIRES	ESAB	OK Autrod 16.95 OK Tubrod 14.36	OK Autrod 12.51 OK Tubrod 15.00
	FILARC	Filarc PZ 6070 Filarc PZ 6470	Filarc PZ 6000 Filarc PZ 6130
	OERLIKON	NERTALIC 51 SAFDUAL 651	FLUXOFIL 40 Carbofil 100
	THYSSEN	THERMANIT X	TG 50 B Union K52



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