Processos de Fabrico I

(bloco processos de ligação)

Regras gerais de seleção de materiais de adição

(soldadura de aços ao C e C-Mn e de baixa liga)

Seleção de materiais de adição :

- Composição química do metal depositado (MD) **semelhante** à do metal base (MB).

- Propriedades mecânicas do MD **maiores ou iguais** às do MB.

$\sigma_{\text{rotura do MD}}$	≥	$\sigma_{\text{rotura do MB}}$	Em qualquer situação de serviço
$\sigma_{\text{cedência do MD}}$	≥	$\sigma_{\text{cedência do MB}}$	
$\varepsilon_{\text{após rotura do MD}}$	?	$\varepsilon_{\text{após rotura do MB}}$	Depende das condições de serviço (fadiga, temperatura, corrosão, etc)
Tenacidade do MD	?	Tenacidade do MB	
Resist. Corrosão do MD	?	Resist. Corrosão do MB	
Resist. a alta temperatura do MD	?	Resist. a alta temperatura do MB	
Etc. do MD	?	Etc. do MB	

Seleção de materiais de adição :

- No Arco Submerso - o metal de adição é um binário fio/fluxo que tem que ser selecionado em conjunto.

- Diferentes combinações de fio fluxo dá origem a diferentes composições químicas e propriedades mecânicas do metal depositado.

Propriedades do metal depositado		Fluxo		
		A	B	C
Fio	A	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (A/A)	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (A/B)	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (A/C)
	B	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (B/A)	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (B/B)	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (B/C)
	C	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (C/A)	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (C/B)	$\sigma_{rot.}$, $\sigma_{ced.}$, ε, etc (C/C)

Seleção de materiais de adição :

COVERED (STICK) ELECTRODES (SMAW)
MILD STEEL ELECTRODES

ESAB

OK 43.32

Easy-to-weld rutile type electrode for welding in the flat position. The good flowing properties of the weld metal give a good finish to the weld beads on both butt and fillet welds. Good slag detachability. The stable arc, even at low welding currents, makes the electrode very suitable for sheet metal welding.

Classifications:	SFA/AWS A5.1:E6013, EN ISO 2560-A:E 42 0 RR 12
Approvals:	CE EN 13479, ABS 2, DNV 2, BV 1, GL 1, RS 2, DB 10.039.36, LR 1, VdTÜV 00621

Approvals are based on factory location. Please contact ESAB for more information.

Welding Current:	AC, DC+-
Alloy Type:	Carbon Steel
Coating Type:	Rutile

Typical Tensile Properties

Condition	Yield Strength	Tensile Strength	Elongation
ISO			
As welded	460 MPa	520 MPa	27 %

Typical Charpy V-Notch Properties

Condition	Testing Temperature	Impact Value
ISO		
As welded	0 °C	60 J
As welded	-10 °C	55 J

Typical Weld Metal Analysis %

C	Mn	Si
0.07	0.5	0.4

Deposition Data

Diameter	Current	Voltage	kg weld metal/ kg electrodes	Number of electrodes/kg weld metal	Fusion time per electrode at 90% I max	Deposition rate 90% I max
2.0 x 300 mm	50-80 A	23 V	0.54	167	36 s	0.8 kg/h
2.5 x 350 mm	50-110 A	25 V	0.54	88	46 s	0.9 kg/h
3.2 x 350 mm	80-150 A	26 V	0.57	51	57 s	1.3 kg/h
3.2 x 450 mm	80-140 A	26 V	0.54	40.5	74 s	1.3 kg/h
4.0 x 350 mm	120-210 A	25 V	0.52	35	63 s	1.6 kg/h
4.0 x 450 mm	120-210 A	27 V	0.54	27	76 s	1.9 kg/h
5.0 x 450 mm	170-290 A	26 V	0.56	17	87 s	2.5 kg/h
6.0 x 450 mm	230-370 A	30.6 V	0.52	12.4	105 s	2.8 kg/h

COVERED (STICK) ELECTRODES (SMAW)
MILD STEEL ELECTRODES

ESAB

OK 48.04

OK 48.04 is an AC/DC, general purpose, LMA electrode for welding mild and low-alloy steels. It has very good welding properties and deposits a high quality weld metal with very good mechanical properties. The electrode can be used for welding restrained structures where high welding stresses cannot be avoided.

Classifications:	EN ISO 2560-A:E 42 4 B 32 H5, SFA/AWS A5.1:E7018
Approvals:	CE EN 13479, ABS 3Y H5, PRS 3Y H5, BV 3Y H5, GL 3Y H5, DNV 3Y H5, Seproz UNA 272580, RS 3Y H5, NAKS/HAKC 2.5-5.0 mm, ABS AWS A5.1 - E7018, LR 3Ym H15

Approvals are based on factory location. Please contact ESAB for more information.

Welding Current:	AC, DC+(-)
Diffusible Hydrogen:	<5.0 ml/100g
Alloy Type:	Carbon Manganese
Coating Type:	Lime Basic

Typical Tensile Properties

Condition	Yield Strength	Tensile Strength	Elongation
ISO			
As welded	480 MPa	560 MPa	28 %

Typical Charpy V-Notch Properties

Condition	Testing Temperature	Impact Value
ISO		
As welded	-30 °C	110 J
As welded	-40 °C	100 J

Typical Weld Metal Analysis %

C	Mn	Si
0.06	1.2	0.6

Deposition Data

Diameter	Current	Voltage	kg weld metal/ kg electrodes	Number of electrodes/kg weld metal	Fusion time per electrode at 90% I max	Deposition rate 90% I max
2.5 x 350 mm	75-110 A	23 V	0.64	67.0	59 s	1.00 kg/h
3.2 x 350 mm	90-155 A	22 V	0.63	42.3	62.4 s	1.37 kg/h
3.2 x 450 mm	90-155 A	25 V	0.67	30.0	92 s	1.50 kg/h
4.0 x 450 mm	125-200 A	26 V	0.68	20.0	101 s	2.00 kg/h
5.0 x 450 mm	190-260 A	26 V	0.72	13.0	106 s	2.90 kg/h

Seleção de materiais de adição :

TIG RODS (GTAW)
MILD STEEL RODS

ESAB

OK Tigrod 12.60

OK Tigrod 12.60 is a copper-coated Mn-Si-alloyed W2Si/ER70S-3 solid rod for the GTAW of non-alloyed steels, as used in general construction, pressure vessel fabrication and shipbuilding.

Classifications Weld Metal:	EN ISO 636-A:W 38 3 W2Si
Classifications Wire Electrode:	SFA/AWS A5.18:ER70S-3, EN ISO 636-A:W2Si
Approvals:	CE EN 13479, BV 3YM, ABS ER70S-s, DNV III YM (I1)*, NAKS/HAKC 2.0MM, VdTÜV 11141, ABS 3YSA

Approvals are based on factory location. Please contact ESAB for more information.

Alloy Type:	Carbon-manganese steel

Typical Tensile Properties

Condition	Yield Strength	Tensile Strength	Elongation
Ar (I1) EN			
As welded	420 MPa	515 MPa	26 %

Typical Charpy V-Notch Properties

Condition	Testing Temperature	Impact Value
Ar (I1) EN		
As welded	-30 °C	90 J

Typical Wire Composition %

C	Mn	Si
0.10	1.11	0.72

MIG/MAG WIRES (GMAW)
MILD STEEL WIRES

ESAB

OK Autrod 12.51

OK Autrod 12.51 is a copper-coated solid wire with higher levels of deoxidizers (manganese and silicon). The high content of deoxidizers allow welding over heavier amounts of dirt, rust, and mill scale while providing a more fluid puddle and smoother bead profile.

Classifications Weld Metal:	EN ISO 14341-A:G 38 3 C1 3Si1, EN ISO 14341-A:G 42 4 M21 3Si1
Classifications Wire Electrode:	EN ISO 14341-A:G 3Si1, SFA/AWS A5.18:ER70S-6, CAN/CSA-ISO 14341:B-G 49A 3 C1 S6, JIS Z 3312:YGW 12(C1)
Approvals:	CE EN 13479, DNV III YMS (M21), VdTÜV 00899, BV SA3YM (M21), JIS YGW12, CWB B-G 49A 3 C1 S6 (B-G 49A 3 C G6), DNV II YMS (C1), GL 3YS (C1), BV SA3YM (C1), DB 42.039.06, RINA 3YS (C1), RINA 3YS (M21), NAKS/HAKC 1.0MM-2.0MM, NAKS/HAKC 1.2MM-1.6MM, ABS 3YSA (C1 & M21), LR 3YS H15 (C1 & M21), PRS 3YS (C1 & M21), RS 3YMS (C1 & M21)

Approvals are based on factory location. Please contact ESAB for more information.

Alloy Type:	Carbon-manganese steel (Mn/Si-alloyed)

Typical Tensile Properties

Condition	Yield Strength	Tensile Strength	Elongation
EN 80Ar 20CO2			
As welded	460 MPa	560 MPa	25 %
Stress relieved 15 hr 620 °C	380 MPa	495 MPa	28 %

Typical Charpy V-Notch Properties

Condition	Testing Temperature	Impact Value
EN 80Ar 20CO2		
As welded	20 °C	130 J
As welded	-20 °C	130 J
As welded	-30 °C	90 J
As welded	-40 °C	90 J
Stress relieved 15 hr 620 °C	20 °C	120 J
Stress relieved 15 hr 620 °C	-20 °C	90 J

Typical Wire Composition %

C	Mn	Si
0.078	1.46	0.85

Deposition Data

Diameter	Current	Voltage	Wire Feed Speed	Deposition Rate
0.6 mm	30-100 A	15-20 V	5,5-13 m/min	0,7-1,7 kg/h
0.8 mm	60-200 A	18-24 V	3,2-13 m/min	0,8-3,0 kg/h
0.9 mm	70-250 A	18-26 V	3,0-12 m/min	0,9-3,6 kg/h
1.0 mm	80-300 A	18-32 V	2,7-15 m/min	1,0-5,6 kg/h
1.2 mm	120-380 A	18-34 V	2,5-15 m/min	1,3-8,0 kg/h
1.4 mm	150-420 A	22-36 V	2,3-12 m/min	1,6-8,7 kg/h
1.6 mm	225-550 A	28-38 V	2,3-12 m/min	2,1-11,4 kg/h
2.0 mm	300-650 A	32-44 V	4-15 m/min	3,2-12,5 kg/h

Seleção de materiais de adição :

SUBMERGED ARC WIRES & FLUXES (SAW)
MILD STEEL/LOW ALLOY FLUXES

OK Flux 10.70

OK Flux 10.70 is an agglomerated, basic flux for submerged arc welding. It is designed for welding joints with high dilution such as I-joints with one run from each side and fillet welds. Due to its high alloying of mainly Mn, it creates a weld metal with good toughness values in these joints. It can be used for single and multi-wire procedures and works equally well on DC and AC. On multi-pass welding the number of passes is limited and the plate thickness should not exceed approx. 25 mm. Non-alloyed wires such as OK Autrod 12.10 and OK Autrod 12.20 are the preferred ones to be matched with OK Flux 10.70. The main application area for OK Flux 10.70 is in shipbuilding. Here it is used preferably in the two run, double-sided technique. However, it is also used in other market segments where joints with high dilution or a number of passes are welded. This is in the construction of pressure vessels, in the transport industries and general construction.

Classifications:	EN ISO 14174:S A AB 1 79 AC
Approvals:	CE EN 13479, DB 51.039.06

Approvals are based on factory location. Please contact ESAB for more information.

Slag Type:	Aluminate-basic
Alloy Transfer:	Moderately Silicon and very high Manganese alloying
Density:	nom: 1.2 kg/dm3
Basicity Index:	nom: 1.4
Grain Size (met):	0.2-1.6 mm (10x65 mesh)

Flux Consumption

Volts	kg Flux / kg Wire DC+	kg Flux / kg Wire AC
26 V	0.7 kg	0.6 kg
30 V	1.0 kg	0.9 kg
34 V	1.3 kg	1.2 kg
38 V	1.6 kg	1.4 kg

Dimensions	Amps	Travel Speed
Ø 4.0 mm	580 A	55 cm/min

Classifications	Wire	Weld Metal		
Wire	**AWS/EN**	**EN - As Welded**	**AWS - As Welded**	**AWS - PWHT**
OK Autrod 12.10	A5.17:EL12/ 14171-A:S1	S 42 3 AB S1	A5.17: F7A4-EL12	A5.17: F7P4-EL12
OK Autrod 12.20	A5.17:EM12/ 14171-A:S2	S 46 3 AB S2	A5.17: F7A2-EM12	A5.17: F7P2-EM12
OK Autrod 12.24	A5.23:EA2/ 14171-A:S2Mo; 24598-A:S S Mo	S 50 0 AB S2Mo	A5.23: F9A0-EA2-A3	A5.23: F9PZ-EA2-A3

SUBMERGED ARC WIRES & FLUXES (SAW)
MILD STEEL/LOW ALLOY FLUXES

OK Flux 10.70

Approvals

Wire	ABS	BV	DNV	GL	LR	DB	CE	PRS	RS	VdTÜV
OK Autrod 12.10	•	•	•	•	•	•	•	•	•	•
OK Autrod 12.20	-	-	-	-	-	•	•	-	-	•

**Selected production units only. Please contact ESAB for more information.*
Visit esab.com to download specific flux/wire combination fact sheets for more details.

Typical Mechanical Properties

Wire	Condition	Yield Strength	Tensile Strength	Elongation	Charpy V-Notch
OK Autrod 12.10	As Welded AWS DC+	430 MPa	520 MPa	30 %	125 J @ 20°C 100 J @ 0°C 70 J @ -20°C 55 J @ -30°C 40 J @ -40°C
OK Autrod 12.20	As Welded AWS DC+	470 MPa	580 MPa	29 %	100 J @ 20°C 90 J @ 0°C 75 J @ -20°C 50 J @ -29°C
OK Autrod 12.24	As Welded AWS DC+	580 MPa	670 MPa	23 %	60 J @ 20°C 50 J @ 0°C 40 J @ -18°C

Typical Weld Metal Analysis %

C	Mn	Si	Mo
OK Autrod 12.10 DC+ , 580A, 29V			
0.05	1.7	0.5	-
OK Autrod 12.20 DC+, 580A, 29V			
0.06	1.9	0.6	-
OK Autrod 12.24 DC+, 580A, 29V			
0.06	2.0	0.6	0.5

Seleção de materiais de adição :

SUBMERGED ARC WIRES & FLUXES (SAW)
MILD STEEL WIRES

ESAB

OK Autrod 12.10

Copper-coated, unalloyed wire for Submerged Arc Welding. For low requirements or in combination with high Si and Mn alloying fluxes. Suitable for non- and low alloyed steels.

Classifications Wire Electrode:	SFA/AWS A5.17:EL12, EN ISO 14171-A:S1
Approvals:	CE EN 13479, DB 52.039.01, VdTÜV 12103

Approvals are based on factory location. Please contact ESAB for more information.

Typical Wire Composition %		
C	**Mn**	**Si**
0.07	0.52	0.08

OK Autrod 12.20

Copper-coated, unalloyed wire for Submerged Arc and Electroslag Welding. Suitable in combination with most fluxes. For structural steels, ship building steels, pressure vessel steels, fine grained steels, etc.

Classifications Wire Electrode:	SFA/AWS A5.17:EM12, EN ISO 14171-A:S2
Approvals:	CE EN 13479, VdTÜV 12103, DB 52.039.02, NAKS/HAKC 3.0 mm, 4.0 mm

Approvals are based on factory location. Please contact ESAB for more information.

Typical Wire Composition %		
C	**Mn**	**Si**
0.10	1.06	0.07

OK Autrod 12.22

Copper-coated, unalloyed wire for Submerged Arc Welding. Suitable in combination with most fluxes. Increased Si content and thus especially for neutral fluxes (e.g. OK Flux 10.62) or in order to increase the fluidity of the molten pool. For structural steels, ship buildings steels, pressure vessel steels, fine grained steels, etc.

Classifications Wire Electrode:	SFA/AWS A5.17:EM12K, EN ISO 14171-A:S2Si
Approvals:	CE EN 13479, VdTÜV 12103, DB 52.039.05, NAKS/HAKC 2.0 mm-5.0 mm

Approvals are based on factory location. Please contact ESAB for more information.

Typical Wire Composition %		
C	**Mn**	**Si**
0.09	1.01	0.19