Böhler
WELDING

WELDING GUIDE

Previous editions of the manual cease to be valid on publication of this edition of Böhler's manual „Information for Welders".

Particulars regarding the appearance and use of our products serve as information for the user. Details of the mechanical properties always refer to the pure weld metal in accordance with the applicable standards. The parent metal, the welding position and the welding parameters amongst other things affect the weld metal properties in the welded joint.

Express written agreement is required in each individual case as a guarantee of suitability for a specific purpose.

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Technical Handbook of BÖHLER WELDING Products

Böhler
WELDING

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WELDING GUIDE

Preface

BÖHLER WELDING – Your Partner for Welding

“Our customers' problems are our problems too”
is the basic principle at BÖHLER WELDING.

More than 80 years of experience gathered by the company in over 70 different countries has proved beyond doubt that, in practice, the quality of the welding is decisive. When extreme temperatures, maximum strength requirements, exceptional resistance to corrosion or the highest possible working speed become the critical factors, adaptable know-how is essential.

We pay close attention to all the issues relevant for successful welding - materials, application, welding additives - and cooperate with customers in developing the solution most favourable for them.

Nothing is too much trouble for us in our pursuit of optimal welding results for our customers. Even in the Antarctic or the deserts of Africa, we provide our customers with product information, training courses and welding demonstrations.

When it comes to welding, only the best can satisfy us. That is why we collaborate in product development with universities and research institutes which have the necessary equipment and personnel for performing the simulations and measurements we require (for example with scanning electron microscopes or high-speed cameras).

At BÖHLER WELDING it's results than count.

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Comparison Table EN-Classification and BÖHLER products

EN-Classification	Böhler
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E 17 B 2 2	FOX SKWA
E 18 16 5 N L B 2 2	FOX ASN 5
E 18 16 5 N L R 3 2	FOX ASN 5-A
E 18 8 Mn B 2 2	FOX A 7
E Z 18 9 MnMo R 3 2	FOX A 7-A
E 19 12 3 L R 1 2	FOX EAS 4 M-TS
E 19 12 3 L R 1 5	FOX EAS 4 M-VD
E 19 12 3 L R 3 2	FOX EAS 4 M-A
E 19 12 3 LB 2 2	FOX EAS 4 M
E 19 12 3 Nb B 2 2	FOX SAS 4
E 19 12 3 Nb R 3 2	FOX SAS 4-A
E 19 9 B 4 2 H5	FOX CN 18/11
E 19 9 H R 4 2 H5	FOX E 308 H
E 19 9 L B 2 2	FOX EAS 2
E 19 9 L R 1 5	FOX EAS 2-VD
E 19 9 L R 3 2	FOX EAS 2-A
E 19 9 Nb B 2 2	FOX SAS 2
	FOX E 347 H
E 19 9 Nb R 3 2	FOX SAS 2-A
E 20 10 3 R 3 2	FOX CN 19/9 M
E 20 25 5 Cu N L B 2 2	FOX CN 20/25 M
E 20 25 5 Cu N L R 3 2	FOX CN 20/25 M-A
E 22 12 B 2 2	FOX FF
E 22 12 R 3 2	FOX FF-A
E 22 9 3 L B 2 2	FOX CN 22/9 N-B
E 22 9 3 L R 3 2	FOX CN 22/9 N
E 24 12 B 2 2	FOX CN 24/13
E 23 12 Nb B 2 2	FOX CN 24/13 Nb
E 23 12 2 L R 3 2	FOX CN 23/12 Mo-A
E 23 12 L R 3 2	FOX CN 23/12-A
E 25 94 N L B 2 2	FOX CN 25/9 CuT
E 25 20 B 2 2	FOX FFB
E 25 20 R 3 2	FOX FFB-A
E 25 4 B 2 2	FOX FA
E 29 9 R 1 2	FOX CN 29/9
E 29 9 R 3 2	FOX CN 29/9-A
E 38 0 RC 1 1	FOX MSU, FOX OHV
	FOX KE
E 38 0 R 1 2	FOX SUM
E 38 0 RR 5 4	FOX HL 160 Ti
E 38 0 RR 7 4	FOX HL 180 Ti
E 38 2 RB 1 2	FOX SPE
	FOX SPEM
E 38 3 C 2 1	FOX CEL
E 38 2 C 2 1	FOX CEL+
E 38 4 B 4 2 H5	FOX EV 47
E 42 0 RR 1 2	FOX SUS, FOX ETI
E 42 3 B 1 2 H10	FOX EV 50-A

EN-Classification	Böhler
E 42 3 C 2 5	FOX CEL 75
E 42 3 Mo C 2 5	FOX CEL Mo
E 42 3 RB 3 2 H10	FOX EV 50-AK
E 42 4 B 1 2 H5	FOX EV 50-W
E 42 4 B 1 2 H5	FOX EV PIPE
E 42 5 B 4 2 H5	FOX EV 50
E 46 3 B 4 5 H5	FOX BVD RP
E 46 4 Z (NiCrCu) B 4 2	FOX NiCuCr
E 46 5 1Ni B 4 5 H5	FOX BVD 85
E 46 5 B 1 2 H5	FOX EV 55
E 46 6 1Ni B 4 2 H5	FOX EV 60
E 46 8 2Ni B 4 2 H5	FOX 2.5 Ni
E 50 3 1Ni C 2 5	FOX CEL 90
E 50 4 B 4 2 H5	FOX EV 63
E 50 4 1Ni B12 H5	FOX EV 60 PIPE
E 55 3 MnMo B T 4 2 H10	FOX EV 70 Mo
E 55 4 Z(Mn2NiMo) B12 H5	FOX EV 70 PIPE
E 55 5 Z2Ni B 4 5 H5	FOX BVD 90
E 55 6 1NiMo B 4 2 H5	FOX EV 65
	FOX EV 70
E 62 4 Mn1NiMo B42 H5	FOX NiMo 100
E 62 5 Z2Ni B 4 5 H5	FOX BVD 100
E 62 6 Mn2NiCrMo B42 H5	FOX EV 75
E 69 3 Mn2NiMo B 4 5 H5	FOX BVD 110
E 69 6 Mn2NiCrMo B42 H5	FOX EV 85
E CrMo1 B 4 2 H5	FOX DCMS Kb
E CrMo1 R 1 2	FOX DCMS Ti
E CrMo2 B 4 2 H5	FOX CM 2 Kb
E CrMo5 B 4 2 H5	FOX CM 5 Kb
E CrMo9 B 4 2 H5	FOX CM 9 Kb
E CrMo91 B 4 2 H5	FOX C 9 MV
E CrMoWV12 B 4 2 H5	FOX 20 MVW
E Mo B 4 2 H5	FOX DMO Kb
E Mo R 1 2	FOX DMO Ti
E MoV B 4 2 H5	FOX DMV 83 Kb
E Ni 66 20	FOX NIBAS 60/15
E Ni 40 60	FOX NIBAS 400
E Ni 66 17	FOX NIBAS 617
E Ni 60 59	FOX NIBAS C 24
E Ni 62 76	FOX NIBAS C 276
E Z 16 13 Nb B 4 2 H5	FOX CN 16/13
E Z 16 6 Mo B 6 2 H5	FOX CN 16/6 M-HD
E Z 17 4 Cu B 4 3 H5	FOX CN 17/4 PH
E Z 17 Mo B 2 2	FOX SKWAM
E Z 19 14 Si B 2 2	FOX EAS 2 Si
E Z 21 33 B 4 2	FOX CN 21/33 Mn
E Z 22 18 4 L B 2 2	FOX AM 400
E Z 25 22 2 NL B 2 2	FOX EASN 25 M
E Z 25 35 Nb B 6 2	FOX CN 25/35 Nb
E Z 35 45 Nb 6 2	FOX CN 35/45 Nb
E Z CrMoV1 B 4 2 H5	FOX DCMV

EN-Classification	Böhler
E Z CrMoWV911 B 4 2 H5	FOX C 9 MVW
E Z CrMoWVNb 9 0.5 2 B42H5	FOX P 92
E Z CrMoVNb B 21 B42 H5	FOX P 24
E Z CrWV21.5 B42 H5	FOX P 23
E Ni 61 82	FOX NIBAS 70/15
	FOX NiCr 70/15
E Ni 60 82	FOX NIBAS 70/20
	NIBAS 70/20-FD
	FOX NiCr 70 Nb
E Ni 66 25	FOX NIBAS 625
	NIBAS 625-FD
	FOX NiCr 625
G 13 4	CN 13/4-IG
G 17	KWA-IG
G 18 8 Mn	A 7-IG
G 19 12 3 L Si	EAS 4 M-IG (Si)
G 19 12 3 NbSi	SAS 4-IG (Si)
G 19 9 H	CN 18/11-IG
G 19 9 L Si	EAS 2-IG (Si)
G 19 9 NbSi	SAS 2-IG (Si)
G 20 10 3	CN 19/9 M-IG
G 22 12 H	FF-IG
G 22 9 3 NL	CN 22/9 N-IG
G 23 12 L	CN 23/12-IG
G 25 94 NL	CN 25/9 CuT-IG
G 25 20 Mn	FFB-IG
G 25 4	FA-IG
G 3 Ni 1	K Nova Ni
G 3 Si 1	EMK 6
G 3 Si 1	EMK 6
G 0	NiCu 1-IG
G 4 Si 1	EMK 7
G 42 4 M G0	NiCu 1-IG
G 4 Si 1	EMK 8
G 46 6 C G2 Ni2	2.5 Ni-IG
G 46 8 M G2 Ni2	2.5 Ni-IG
G 42 4 C G0 G 4 Si 1	SG 3-P
G 46 5 M G0 G 4 Si 1	SG 3-P
G 55 4 C Mn3Ni1Mo	NiMo 1-IG
G 55 6 M Mn3Ni1Mo	NiMo 1-IG
G 69 5 M Mn3CrNi1CrMo	X 70-IG
G 69 4 C Mn3CrNi2.5CrMo	NiCrMo 2.5-IG
G 69 6 M Mn3CrNi2.5CrMo	NiCrMo 2.5-IG
G 89 6 M Mn4Ni2CrMo	X 90-IG
G CrMo1Si	DCMS-IG
G CrMo2 Si	CM 2-IG
G CrMo5 Si	CM 5-IG
G CrMo91	C 9 MV-IG
G MoSi	DMO-IG
G MoV Si	DMV 83-IG
G Z 13	KW 10-IG
G Z 13 Nb L	KW 5 Nb-IG
G Z 17 Mo H	SKWAM-IG
G Z 17 Ti	SKWA-IG
G Z 18 Nb L	CAT 430 L Cb-IG
G Z 18 Ti L	CAT 439 L Ti-IG
G Z 18 16 5 NL	ASN 5-IG (Si)
G Z 20 25 5 Cu NL	CN 20/25 M-IG (Si)

EN-Classification	Böhler
G Z 21 33 Nb	CN 21/33 Mn-IGG Z
22 17 8 4 NL	AM 400-IG
G Z 25 35 Nb	CN 25/35 Nb-IG
G Z 35 45 Nb H	CN 35/45 Nb-IG
O I	BW VII
O III	BW XII
O IV	DMO
O V	DCMS
S 13 4 / SA FB 2	CN 13/4-UP/BB 203
S 17 / SA FB 2	SKWA-UP/BB 202
S 17 Mo H	SKWAM-UP/BB 203
S 18 16 5 NL / SA FB 2	ASN 5-UP/BB 203
S 18 8 Mn / SA FB 2	A 7CN-UP/BB 203
S 19 9 H / SA FB 2	CN 18/11-UP/BB 202
S 19 9 L / SA FB 2	EAS 2-UP/BB 202
S 19 9 Nb / SA FB 2	SAS 2-UP/BB 202
S 22 9 3NL/SA FB 2	CN 22/9 N-UP/BB 202
S 38 0 MS S2	EMS 2/BF 16
S 38 0 MS S3	EMS 3/BF 16
S 38 4 FB S2	EMS 2/BB 24
S 42 3 FB S3	EMS 3/BB 25
S 42 4 FB S2	EMS 2/BB 25
S 42 4 FB S3	EMS 3/BB 24
S 46 0 AR S2	EMS 2/BB 33 M
S 46 3 FB S2Mo	EMS 2 Mo/BB 25
S 46 4 FB S2Mo	EMS 2 Mo/BB 24
S 46 6 FB S2Ni2	Ni 2-UP/BB 24
S 50 0 AR S3	EMS 3/BB 33 M
S 50 4 FB SZ3Ni1Mo	3 NiMo 1-UP/BB24
S 69 6 FB SZ3Ni2CrMo	3 NiCrMo 2.5-UP/BB 24
S CrMo1 / SA FB 1	EMS 2 CrMo/BB 24
S CrMo1 /SA FB 1	EMS 2 CrMo/BB 25
S CrMo2 / SA FB 1	CM 2-UP/BB 24
S CrMo5 / SA FB 1	CM 5-UP/BB 24
S CrMo91 / SA FB 2	C 9 MV-UP/BB 910
S Z CrMoWVNb 9 0.5 2/SA FB 2	P 92-UP/BB 910
S Z CrWV 2	P 23-UP
	P 24-UP
S19 12 3L / SA FB 2	EAS 4 M-UP/BB 202
S19 12 3Nb/SA FB 2	SAS 4-UP/BB 202
S 23 12 L / SA FB 2	CN 23/12-UP/BB 202
SA AR 1 97 AC	BB 33 M
SA FB 1 55 AC	BB 430
SA FB 1 65 DC H5	BB 24
SA FB 1 68 AC H5	BB 25
SA FB 2	BB 444
SA FB 2 55 DC	BB 910
SA FB 2 DC	BB 202
SA FB 2 DC	BB 203
SCrMoWV12/SA FB 2	20 MVW-UP/BB 24
SF MS 1 78 AC	BF 16
S Ni 60 82	NIBAS 70/20-IG
	NiCr 70 Nb-IG
S Ni 40 60	NIBAS 400-IG
S Ni 66 17	NIBAS 617-IG
	NIBAS 617-UP
S Ni 60 59	NIBAS C24-IG
	NIBAS C24-UP

EN-Classification	Böhler
S Ni 6276	NIBAS C276-IG NIBAS C276-UP
Ni 66 25	NIBAS 625-IG NiCr 625-IG NiCr 625-UP
T 13 4 MM 2	CN 13/4 MC
T 13 4 MM 2	CN 13/4 MC (F)
T 18 8 Mn MM 1	A 7-MC
T 18 8 Mn R C 3	A 7-FD
T 18 8 Mn R M 3	A 7-FD
T 18 8 Mn P C 2	A 7 PW-FD
T 18 8 Mn P M 2	A 7 PW-FD
T 19 12 3 L MM 1	EAS 4 M-MC
T 19 12 3 L P C 1	EAS 4 PW-FD
T 19 12 3 L P M 1	EAS 4 PW-FD
T 19 12 3 L R C 3	EAS 4 M-FD
T 19 12 3 L R M 3	EAS 4 M-FD
T 19 12 3 Nb P C 1	SAS 4 PW-FD
T 19 12 3 Nb P M 1	SAS 4 PW-FD
T 19 12 3 Nb R C 3	SAS 4-FD
T 19 12 3 Nb R M 3	SAS 4-FD
TZ 19 13 4 L R M 3	E 317L-FD
TZ 19 13 4 L R C 3	E 317L-FD
TZ 19 13 4 L P M 1	E 317L PW-FD
TZ 19 13 4 L P C 1	E 317L PW-FD
T 19 9 L MM 1	EAS 2 MC
T 19 9 L P C 1	EAS 2 PW-FD
T 19 9 L P M 1	EAS 2 PW-FD
T 19 9 L R C 3	EAS 2-FD
T 19 9 L R M 3	EAS 2-FD
T 19 9 Nb P C 1	SAS 2 PW-FD
T 19 9 Nb P M 1	SAS 2 PW-FD
T 19 9 Nb R C 3	SAS 2-FD
T 19 9 Nb R M 3	SAS 2-FD
T 22 9 3 NL P C 1	CN 22/9 PW-FD
T 22 9 3 NL P M 1	CN 22/9 PW-FD
T 22 9 3 NL R C 3	CN 22/9 N-FD
T 22 9 3 NL R M 3	CN 22/9 N-FD
T 23 12 L MM 1	CN 23/12 MC
T 23 12 2 L P C 1	CN 23/12 Mo PW-FD
T 23 12 2 L P M 1	CN 23/12 Mo PW-FD
T 23 12 2 L R C 3	CN 23/12 Mo-FD
T 23 12 2 L R M 3	CN 23/12 Mo-FD
T 23 12 L P M 1	CN 23/12 PW-FD
T 23 12 L P C 1	CN 23/12 PW-FD
T 23 12 L R M 3	CN 23/12-FD
T 23 12 L R C 3	CN 23/12-FD
T CrMo 9 1	C 9 MV-MC

EN-Classification	Böhler
T 42 2 P C 1 H5	Ti 52-FD Ti 52 W-FD
T 42 5 2 MM 2 H5	HL 53-FD
T 46 2 P M 1 H10	Ti 52-FD
T 46 4 P M 1 H 10	Ti 52 W-FD
T 50 6 1 Ni P M 1 H5	Ti 60-FD
T 46 4 M M 2 H5	HL 51-FD
T Z 19 9 H P C 1	E 308 H PW-FD
T Z 19 9 H P M 1	E 308 H PW-FD
T Z 19 9 H R C 3	E 308 H-FD
T Z 19 9 H R M 3	E 308 H-FD
W 13 4	CN 13/4-IG
W 18 8 Mn	A 7CN-IG
W 19 12 3 L	EAS 4 M-IG
W 19 12 3 Nb	SAS 4-IG
W 19 9 H	CN 18/11-IG ER 308 H-IG
W 19 9 L	EAS 2-IG
W 19 9 Nb	SAS 2-IG
W 20 10 3	CN 19/9 M-IG
W 22 12 H	FF-IG
W 22 9 3 NL	CN 22/9 N-IG
W 23 12 L	CN 23/12-IG
W 25 4	FA-IG
W 25 9 4 NL	CN 25/9 CuT-IG
W 25 20 Mn	FFB-IG
W 25 2 2 2 NL	EASN 25 M-IG
W 3 Si 1	EMK 6
W 2 Mo	DMO-IG
W 2 Si	EML 5
W 2 Ni 2	2.5 Ni-IG
W 3 Ni 3	I 52 Ni
W CrMo1 Si	DCMS-IG
W CrMo2 Si	CM 2-IG
W CrMo5 Si	CM 5-IG
W CrMo9 Si	CM 9-IG
W CrMo91	C 9 MV-IG
W CrMoWV12	20 MVW-IG
W Mo Si	DMO-IG
W MoV Si	DMV 83-IG
W Z 16 13 Nb	CN 16/13-IG
W Z 18 16 5 NL	ASN 5-IG
W Z 19 13 Si NL	EASN 2 Si-IG
W Z 20 25 5 Cu NL	CN 20/25 M-IG
W Z 21 33 Nb	CN 21/33 Mn-IG
W Z 22 17 8 4 NL	AM 400-IG
W Z 25 35 Nb	CN 25/35 Nb-IG
W Z 35 45 Nb H	CN 35/45 Nb-IG
W Z CrMoVW 911	C 9 MVW-IG
W Z CrMoWVNb 9 0.5 2	P 92-IG

Comparison Table AWS-Classification and BÖHLER product

AWS-Classification	Böhler
E10018-G	FOX BVD 100 FOX EV 75
E11018-G	FOX BVD 110 FOX EV 85
E2209-15	FOX CN 22/9 N-B
E2209-17	FOX CN 22/9 N
E2553-15(mod.)	FOX CN 25/9CuT
E307-15(mod.)	FOX A 7
E307-16(mod.)	FOX A 7-A
E307T0-G	A 7-FD
E307T1-G	A7 PW-FD
E308L-15	FOX EAS 2
E308L-17	FOX EAS 2-A FOX EAS 2-VD
E308-15	FOX CN 18/11
E309Cb-15	FOX CN 24/13 Nb
E308H-16	FOX E 308 H
E309L-15	FOX CN 24/13
E309L-17	FOX CN 23/12-A
E309MoL-17(mod.)	FOX CN 23/12 Mo-A
E309-15(mod.)	FOX FF
E309-17	FOX FF-A
E310-15(mod.)	FOX FFB
E310-16	FOX FFB-A
E312-16(mod.)	FOX CN 29/9
E312-17(mod.)	FOX CN 29/9-A
E316 L-15	FOX EAS 4 M
E316 L-16 (mod.)	FOX EAS 4 M-TS
E316 L-17	FOX EAS 4 M-A FOX EAS 4 M-VD
E317L-17	FOX E 317 L
E317LN-15(mod.)	FOX ASN 5
E317LN-17(mod.)	FOX ASN 5-A
E318-15	FOX SAS 4
E318-17	FOX SAS 4-A
E347-15	FOX SAS 2 FOX E 347 H
E347-17	FOX SAS 2-A
E 385-15 (mod.)	FOX CN 20/25 M
E 385-17 (mod.)	FOX CN 20/25 M-A
E 410 NiMo-15	FOX CN 13/4 SUPRA
E 410 NiMo-25	FOX CN 13/4
E 410-15 (mod.)	FOX KW 10
E 430-15	FOX SKWA
E 6010	FOX CEL FOX CEL+
E 6013	FOX MSU FOX OHV FOX KE FOX SUM FOX SUS FOX ETI
E6013(mod.)	FOX SPE FOX SPEM
E7010-A1	FOX CEL Mo
E7010-P1	FOX CEL 75
E7016	FOX EV 50-A
E7016-1H4R	FOX EV 50-W
E7016-1H4R	FOX EV PIPE FOX EV 47
E7018(mod.)	FOX EV 50-AK
E7018-1H4R	FOX EV 50 FOX EV 55
E7018-A1	FOX DMO Kb
E7024	FOX HL 180 Ti
E7024-1	FOX HL 160 Ti
E8010-P1	FOX CEL 85
E8013-G	FOX DCMS Ti
E8016-GH4R	FOX EV 60 PIPE
E8018-B2	FOX DCMS Kb
E8018-B6H4R	FOX CM 5 Kb
E8018-B8	FOX CM 9 Kb
E8018-C1H4R	FOX 2.5 Ni
E8018-C3H4R	FOX EV 60
E8018-D1H4R(mod.)	FOX EV 65
E8018-G	FOX BVD RP FOX BVD 85
E8018-GH4R	FOX EV 63 FOX EV 65
E8018-W2H4R	FOX NiCuCr
E9015-B9	FOX C 9 MV
E9015-B9(mod.)	FOX C 9 MVW FOX P 92
E9016-GH4R	FOX EV 70 PIPE
E9018-B3	FOX CM 2 Kb
E9018-D1(mod.)	FOX EV 70 FOX EV 70 Mo
E9018-G	FOX BVD 90 FOX DCMV FOX EV 70 Mo FOX P 23 FOX P 24
E9018-GH4R	FOX EV 70
E10018-G	FOX NiMo 100
E10018-GH4R	FOX EV 75

AWS-Classification	Böhler
E10018-MH4R(mod.)	FOX EV 75
E11018-GH4R	FOX EV 85
EC90S-B9	C 9 MV-MC
EC307(mod.)	A 7-MC
EC308L	EAS 2-MC
EC309L	CN 23/12-MC
EC316L	EAS 4 M-MC
EC410NiMo(mod.)	CN 13/4-MC
EC410NiMo(mod.)	CN 13/4-MC (F)
ECuNi	FOX CuNi 30 Fe
ENiCrFe-3	FOX NIBAS 70/15
	FOX NiCr 70/15
ENiCrFe-3(mod.)	FOX NIBAS 70/20
	FOX NiCr 70 Nb
ENiCrCoMo1	FOX NIBAS 617
ENiCrMo-3	FOX NIBAS 625
	FOX NiCr 625
ENiCrMo-4	FOX NIBAS C 24
ENiCrMo-6	FOX NIBAS 60/15
ENiCrMo-13	FOX NIBAS C 24
ENiCr-3T0-4	NIBAS 70/20-FD
ENiCu-7	FOX NIBAS 400
E16-8-2-25(mod.)	FOX CN 16/6 M-HD
E2209T0-1	CN 22/9 N-FD
E2209T0-4	CN 22/9 N-FD
E2209T1-1	CN 22/9 PW-FD
E2209T1-4	CN 22/9 PW-FD
E308HT0-1	E 308 H-FD
E308HT0-4	E 308 H-FD
E308HT1-1	E 308 H PW-FD
E308HT1-4	E 308 H PW-FD
E308LT0-1	EAS 2-FD
E308LT0-4	EAS 2-FD
E308LT1-1	EAS 2 PW-FD
E308LT1-4	EAS 2 PW-FD
E308Mo-17(mod.)	FOX CN 19/9 M
E309LMoT0-1	CN 23/12 Mo-FD
E309LMoT0-4	CN 23/12 Mo-FD
E309LMoT1-1	CN 23/12 Mo PW-FD
E309LMoT1-4	CN 23/12 Mo PW-FD
E309LT0-1	CN 23/12-FD
E309LT0-4	CN 23/12-FD
E309LT1-4	CN 23/12 PW-FD
E309LT1-1	CN 23/12 PW-FD
E316LT0-1	EAS 4 M-FD
E316LT0-4	EAS 4 M-FD
E316LT1-1	EAS 4 PW-FD
E316LT1-4	EAS 4 PW-FD
E317LT0-4	E 317L-FD
E317LT1-4(1)	E 317L PW-FD
E318 T1-4	SAS 4 PW-FD
E318 T1-1	SAS 4 PW-FD
E318 T0-1	SAS 4-FD
E318 T0-4	SAS 4-FD
E347LT1-1	SAS 2 PW-FD
E347LT1-4	SAS 2 PW-FD
E347LT0-1	SAS 2-FD
E347LT0-4	SAS 2-FD
EC410NiMo(mod.)	CN 13/4 MC

AWS-Classification	Böhler
EG	P 23-UP
	P 24-UP
E630-15(mod.)	FOX CN 17/4 PH
E70CGMH4	HL 53-FD
E70C-6MH4	HL 51-FD
E71T-1H4	Ti 52-FD
E71T-1MH8	
ER80S-Ni1	Ti 52 W-FD
E81T1-Ni1MH4	Ti 60-FD
ERCuNi	CuNi 30 Fe-IG
ERNiCr-3	NIBAS 70/20-IG
	NiCr 70 Nb-IG
	NIBAS 70/20-UP
ERNiCrCoMo1	NIBAS 617-IG
	NIBAS 617-UP
ERNiCrMo-3	NIBAS 625-IG
	NIBAS 625-UP
ERNiCrMo-3	NiCr 625-IG
ERNiCrMo4	NIBAS C 276-IG
	NIBAS C 276-UP
ERTi2	ER Ti 2-IG
ERNiCrMo13	NIBAS 24-IG
	NIBAS 24-UP
ER110S-G	NiCrMo 2.5-IG
	X 70-IG
ERNiCu7	NIBAS 400-IG
ER120S-G	X 90-IG
ER19-10H	CN 18/11-IG
ER2209	CN 22/9 N-IG
	CN 22/9 N-UP/BB 202
ER307(mod.)	A 7CN-IG
	A 7-IG
	A 7CN-UP/BB 203
ER308LSi	EAS 2-IG (Si)
ER308H	ER 308 H-IG
ER308L	EAS 2-IG
	EAS 2-UP/BB 202
ER308Mo(mod.)	CN 19/9 M-IG
ER309(mod.)	FF-IG
ER309L	CN 23/12-IG
	CN 23/12-UP/BB 202
ER310(mod.)	FFB-IG
ER316LSi	EAS 4 M-IG (Si)
ER316L	EAS 4 M-IG
	EAS 4 M-UP/BB 202
ER317L	ASN 5 S4-UP/BB 202
ER317LN(mod.)	ASN 5-IG (Si)
	ASN 5-IG
	ASN 5-UP/BB 203
ER318	SAS 4-IG
	SAS 4-UP/BB 202
ER318(mod.)	SAS 4-IG (Si)
ER347Si	SAS 2-IG (Si)

AWS-Classification	Böhler
ER385(mod.)	CN 20/25 M-IG CN 20/25 M-IG (Si)
ER409Cb	KW 5 Nb-IG
ER410NiMo(mod.)	CN 13/4-IG CN 13/4-UP/BB 203
ER430(mod.)	KWA-IG SKWA-IG CAT 430 L Cb-IG CAT 439 L Ti-IG
ER70S-3	EML 5
ER70S-6	SG 3-P EMK 6 EMK 7 EMK 8
ER70S-A1	DMO-IG
ER80S-B6	CM 5-IG
ER80S-B8	CM 9-IG
ER80S-G	DMO-IG NiCu 1-IG DCMS-IG DMV 83-IG K Nova Ni I 523 Ni
ER80S-Ni2	2.5 Ni-IG
ER90S-B3(mod.)	CM 2-IG
ER90S-B9	C 9 MV-IG
ER90S-B9 (mod.)	C 9 MVW-IG P 92-IG
ER90S-G	NiMo 1-IG CM 2-IG P 23-IG P 24-IG
ER2553(mod.)	CN 25/9 CuT-IG
F43A3-EH10K	EMS 3/BF 16
F43A2-EM12K	EMS 2/BF 16
F48A0-EH10K	EMS 3/BB 33 M
F48A0-EM12K	EMS 2/BB 33 M
F48A2-EH10K	EMS 3/BB 25
F48A4-EH10K	EMS 3/BB 24
F48A4-EM12K	EMS 2/BB 24
F55A4-EA2-A2	EMS 2 Mo/BB 24 EMS 2 Mo/BB 25
F55A6-ENi2-Ni2	Ni 2-UP/BB 24
F55P4-EB2-B2	EMS 2 CrMo/BB 24 EMS 2 CrMo/BB 25
F55P3-EB3-B3	CM 2-UP/BB 24
F62A4-EF3(mod.)-F3	3 NiMo 1-UP/BB24
F62PZ-EB6-B6	CM 5-UP/BB 24
F62PZ-EB9-B9	C 9 MV-UP/BB 910
F69A4-EM4(mod.)-M4	3 NiCrMo 2.5-UP/BB 24
F6A0-EH10K	EMS 3/BF 16
F6A0-EM12K	EMS 2/BF 16
F7A3-EH10K	EMS 3/BB 25
F7A4-EH10K	EMS 3/BB 24
F7AZ-EH10K	EMS 3/BB 33 M
F7A4-EM12K	EMS 2/BB 24 EMS 2/BB 25

AWS-Classification	Böhler
F7AZ-EM12K	EMS 2/BB 33 M
F8A4-EA2-A2	EMS 2 Mo/BB 24 EMS 2 Mo/BB 25
F8A8-ENi2-Ni2	Ni 2-UP/BB 24
F8P4-EB2-B2	EMS 2 CrMo/BB 24 EMS 2 CrMo/BB 25
F9A4-EF3(mod.)-F3	3 NiMo 1-UP/BB24
F9P2-EB3-B3	CM 2-UP/BB 24
F9PZ-EB6-B6	CM 5-UP/BB 24
F9PZ-EB9-B9	C 9 MV-UP/BB 910
F10A4-EM4(mod.)-M4	3 NiCrMo 2.5-UP/BB 24
R45-G	BW VII
R60-G	DMO BW XII
R65-G	DCMS

1. General Information

Objectives

Between publication of the last updated version of this manual and the present re-organised and updated version, a whole series of standards, which were previously only applicable nationally, have been replaced by EN standards. This section provides a summary of the new standards now taken into account in the product information and refers to the national standards affected.

This section also contains information regarding the various forms of supply in which you may purchase the different filler metals and notes about storing them properly.

Contents

1.1. Standard Classification Systems

Classification System according European Standard

European Standards for Filler Metals - Overview

EN-Standard	Official Title of Filler Metal Standard	recent national standards
EN 440	Wire electrodes and deposits for gas shielded metal arc welding of non alloy and fine grain steels. Classification.	ÖNORM M 7822 DIN 8559 BS 2901-1
EN 499	Covered electrodes for manual metal arc welding of non alloy and fine grain steels. Classification.	ÖNORM M 7820 DIN 1913 DIN 8529 BS 639 NF A81-309
EN 756	Wire electrodes and wire flux combinations for submerged arc welding of non alloy and fine grain steels. Classification.	ÖNORM M 7821
EN 757	Welding consumables. Covered electrodes for manual metal arc welding of high strength steels. Classification.	ÖNORM M 7824 DIN 8529 BS 2493 NF A81-340, NF A81-347
EN 758	Tubular cored electrodes for metal arc welding with or without a gas shield of non-alloy and fine grain steels. Classification.	DIN 8559 BS 7084
EN 760	Fluxes for submerged arc welding. Classification.	DIN 32522
EN 1599	Covered electrodes for manual metal arc welding of creep resisting steels. Classification.	ÖNORM M 7832 DIN 8575 BS 2493 NF A81-345
EN 1600	Covered electrodes for manual arc welding of stainless and heat resisting steels. Classification.	ÖNORM M 7831 DIN 8556 BS 2926 NF A81-343
EN 1668	Classification of rods, wires and deposits for tungsten inert gas welding of non alloy and fine grain steels.	DIN 8559 BS 2901-1
EN 12070	Wire electrodes, wires and rods for arc welding of creep-resisting steels. Classification.	ÖNORM M 7832 DIN 8555, 8575 BS 2901-1
EN 12071	Tubular cored electrodes for gas shielded metal arc welding of creep-resisting steels. Classification.	
EN 12072	Wire electrodes, wires and rods for arc welding of stainless and heat resisting steels. Classification.	ÖNORM M 7831 DIN 8556 BS 2901-2
EN 12073	Tubular cored electrodes for metal arc welding with or without a gas shield of stainless and heat resisting steels. Classification.	DIN 8556
EN 12534	Wire electrodes, wires, rods and deposits for gas shielded metal arc welding of high strength steels. Classification.	DIN 8555 BS 2901-1
EN 12535	Tubular cored electrodes for gas shielded metal arc welding of high strength steels. Classification.	
EN 12536	Rods for gas welding of non alloy and creep resisting steels. Classification.	ÖNORM M 7823-1 DIN 8554 BS 1453

The listed European Standards became or will become transformed into national standards. From this the contents of an European Standard are equal to a national standard (e.g. DIN-EN, ÖNORM-EN, NF-EN, BS-EN etc.).

Note: „tubular cored electrodes“ are equal to the generally used term „flux cored wires“

Classification system for EN 499 and EN 757, partially for EN 1599 and EN 1600
for example FOX EV 70 Mo

short key	description	related EN-standards
	welding process, type of product	
E	designator characterising the welding process or the type of product	449, 757, 1599, 1600
	mechanical properties, alloying type	
55	key number indicating the mechanical properties of the all-weld metal	449, 757
3	key number indicating the lowest temperature with an defined average impact work	449, 757
MnMo	designator for the alloying type of the weld deposit	499, 757, 1599, 1600
	coating and heat treatment	
B	descriptor showing the type of coating	499, 757, 1599, 1600
T	designator indicating a heat treatment of the weld deposit	757
	supplemental designations	
4	designator indicating deposition rate and type of current to be used	449, 757, 1599, 1600
2	key number for the welding positions	449, 757, 1599, 1600
H10	diffusible hydrogen designator indicating the maximum diffusible hydrogen level obtained with the product	449, 757, 1599

short keys/designators used for classification in EN-standards

designator characterising the welding process or the type of product

designator	description	related EN-standards
E	manual metal arc welding	449, 757, 1599, 1600
G	gas shielded metal arc welding with solid wires	440, 12070, 12072, 12534
W	tungsten inert gas welding	1668, 12070, 12072
T	gas shielded metal arc welding with flux cored wires	758, 12071, 12073, 12535
S	submerged arc welding	756, 12070, 12072
O	gas welding	12536
P	plasma welding	12072

key number indicating the mechanical properties of the all-weld metal

short key	R_{eL} [N/mm²]	R_m [N/mm²]	A_5 [%]	related EN-standards
35	355	440-570	22	440, 449, 756, 758, 1668
38	380	470-600	20	
42	420	500-640	20	
46	460	530-680	20	
50	500	560-720	18	
55	550	610-780	18	757, 12534, 12535
62	620	690-890	18	
69	690	760-960	17	
79	790	880-1080	16	
89	890	980-1180	15	

key figures for strength properties

designator	yield strength of all-weld metal [N/mm²]	tensile strength of all-weld metal [N/mm²]	related EN-standards
2T	275	370	756
3T	355	470	756, 758
4T	420	520	
5T	500	600	

short keys for impact work classification of deposit

short key	temperature [°C] with average impact work >47 J (one specimen can have lower values, minimum >32 J)	related EN-standards
Z	no requirements	440, 449, 756, 757, 788, 1668, 12534, 12535
A	+20	
0	0	
2	-20	
3	-30	
4	-40	
5	-50	
6	-60	
7	-70	756, 757
8	-80	

short key indicating a heat treatment of the weld deposit		
short key	**description**	**related EN-standards**
T	mech. properties after annealing 560-600°C / 1h / furnace / 300°C / air	757, 12534, 12535
	mechanical properties in as-welded condition	all

short key for deposition rate and type of current			
short key	**deposition rate [%]**	**type of current**	**related EN-standards**
1	≤ 105	alternating current or direct current	449, 757, 1599, 1600
2	≤ 105	direct current	
3	> 105 ≤ 125	alternating current or direct current	
4	> 105 ≤ 125	direct current	
5	> 125 ≤ 160	alternating current or direct current	449, 757
6	> 125 ≤ 160	direct current	
7	> 160	alternating current or direct current	
8	> 160	direct current	

keys for describing possible welding positions		
short key	**description**	**related EN-standards**
1	all welding positions	449, 757, 758, 1599, 1600, 12071, 12073, 12535
2	all welding positions except vertical down	
3	butt weld in flat position, fillet weld in flat- and horizontal welding position	
4	butt weld in flat position, fillet weld in flat position	
5	vertical down position and positions described under key 3	

keys for hydrogen content of the deposited weld-metal		
short key	**maximum hydrogen content [ml/100 g deposit]***	**related EN-standards**
H5	5	449, 757, 758, 760, 1599, 12071, 12535
H10	10	
H15	15	449, 758, 760
*valid for ø 4 mm, 90% max. amperage, alternating current for recovery-keys 1,3,5,7		

keys for shielding gases		
short key	**type of shielding gas**	**related EN-standards**
M	shielding gas EN439-M2, yet without helium	440, 758, 12071, 12073, 12534, 12535
C	shielding gas EN439-C1, carbondioxide	
N	no shielding gas	12534, 12535

designator for coating types

designator	type of coating	related EN-standards
A	acid coated	449, 757, 1599, 1600
C	cellulosic coated	
R	rutile coated	
RR	thick rutile coated	
RC	rutile-cellulosic- coated	
RA	rutile-acid- coated	
RB	rutile-basic- coated	
B	basic coated	

designators for sub-arc welding flux types

designator	type of sub-arc welding flux	related EN-standards
MS	mangenese-silicate	756, 760
CS	calcium-silicate	
ZS	zirkonium-silicate	
RS	rutile-silicate	
AR	aluminium-rutile	
AB	aluminium-basic	
AS	aluminium-silicate	
AF	aluminium-fluoride-basic	
FB	fluoride-basic	
Z	other types	

keys for types of fillings in flux-cored wires

short key	type and properties	related EN-standards
R	rutile, slow freezing slag, shielding gas necessary	758, 12071, 12073, 12535
P	rutile, fast freezing slag, shielding gas necessary	758
B	basic, shielding gas necessary	758, 12071, 12073, 12535
M	metal powder, shielding gas necessary	758
V	rutile or basic/fluoride, shielding gas not necessary	
W	basic/fluoride, slow freezing slag, shielding gas not necessary	
Y	basic/fluoride, fast freezing slag, shielding gas not necessary	
S	other types	
Z	other types	12071, 12073, 12535
U	without shielding gas	12535

A description of all keys defining the chemical composition is not part of this handbook.

1.2. Forms of Supply

Forms of Supply for Stick Electrodes

Non-alloy and low-alloy stick electrodes:	4 boxes per master carton
Cellulose and basic-coated vertical-down electrodes:	In hermetically sealed TINS approx. 9.5 kg net weight.2 tins per master carton.
High-alloy stick electrodes:	With the exception of a few products, Böhler high-alloy stick electrodes are supplied in hermetically-sealed TINS with net contents of approx. 3.5 to 5 kg. 3 tins per master carton.

The advantages of this packaging, which is impermeable to water vapour, are:

- The electrode coating remains absolutely dry.
- The electrodes can always be welded with the best possible usability properties without re-drying.
- There is absolutely no starting porosity.
- The ability to store and transport the electrodes is not dependent on climate.
- The tin itself is made of tinplate and is ecologically disposable.

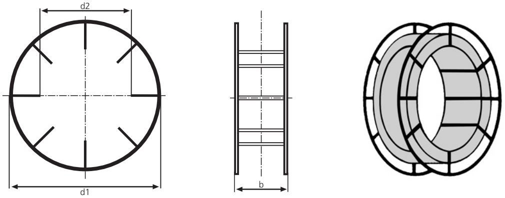
Vacuum-packed Böhler stick electrodes, which are available at additional cost in all alloy variants on request, offer similar advantages.

Forms of Supply for TIG and Gas Welding Rods

Non-alloy and low-alloy welding rods are supplied in 25 kg packs.
High-alloy welding rods in 20 kg packs (4 x 5 kg units per pack)

Forms of Supply for GMAW Wires

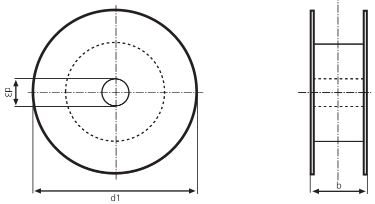
wire basket spool



ENISO 544	outside diameter d_1	Inside diameter d_2	external width b	kg wire
B 300	300	180	103	15/16/18

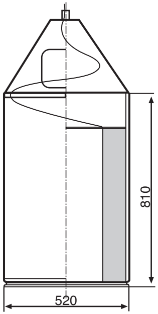
wire net weight per spool for:	non-alloy/low-alloy solid wires	18 kg
	high-alloy solid wires and flux-cored wires	15 kg
	non-alloy/low-alloy flux-cored wires	16 kg

plastic spool



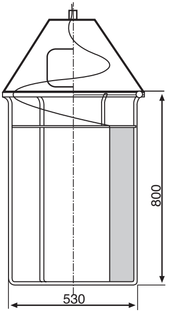
ENISO 544	outside dia-meter d_1	spindle hole d_3	external width b	tapped hole dia-meter d_4	distance from center e_1	kg wire
S 100	100	16,5	45	–	–	1,0
S 200	200	50,5	55	10	44,5	5
S 300	300	51,5	103	10	44,5	15

ECO-DRUM



ideal bulk pack for 250 kg of non-, low- and high-alloy welding wires in robotic quality; outstanding for welding robots and other mechanised stations

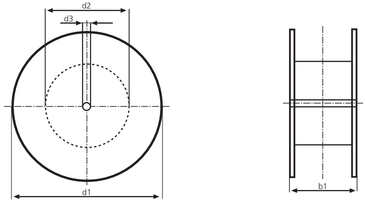
ÖKO-MULTI



for 250 kg of non-, low- and high-alloyed welding wires in robotic quality; ECO-MULTI's are reuseable and will reduce waste disposal expense and/or storage space as empty units can be packed

Drum heads in two different design can be ordered seperately

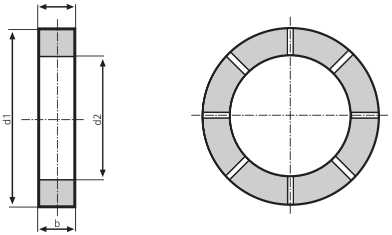
buld spool (steel)



BÖHLER	outside dia-meter d_1	inside dia-meter d_2	spindle hole dia-meter d_3	width outside b_1	inside b_2	kg wire
GS 760 Non returnable	760	430	41	310	270	300

Forms of Supply for Sub-arc Wires

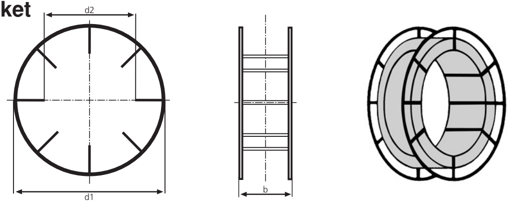
coils



BÖHLER	outside dia-meter d_1	inside dia-meter d_2	width b	kg wire
B	390	280	70	26
I	430	310	100	30
S	390	300	70	23
PRG 80*	390	310	80	21
PRG 100*	430	310	100	25

* coiled on a cardboard former

wire basket

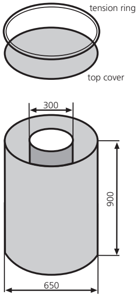


BÖHLER	outside dia-meter d_1	inside dia-meter d_2	external width b	kg wire
K 415-100	415	300	100	25
K 435-70*	435	300	70	25

* K 435 is the standard spool for stainless steel sub-arc wires

Paper Drum

Ideal bulk pack up to 400 kg for un-, low and high alloyed welding wire in robotic quality. Outstanding for welding robots and other mechanized welding stations.



Forms of Supply for Sub-arc Welding Fluxes

in bags of 25 kg (BF 16, BB 24, BB 25, BB 33 M)
in tins of 30 kg (BB 202, BB 203, BB 910)

Individual Forms of Supply

Please enquire if you have specific delivery requests for wire electrodes or other filler metals.

1.3. Storage and Re-drying

Storage of Stick Electrodes

On principle coated stick electrodes should be stored in their original packaging until used. If possible the packs of electrodes should be taken out of storage in the sequence in which they were received in the warehouse.

The stick electrodes must be stored in dry rooms to protect them against damage caused by moisture. As a result the electrode warehouse should be protected against the elements and easily ventilated. Ceiling, floor and walls must be dry and there should be no uncovered water in the room. The room must be fitted out with pallets or shelves since storage directly on the floor or against the walls is not recommended.

Opened packs of electrodes should also be stored in dry and, if necessary, heated rooms so that there is no likelihood of the temperature dropping below the dew point.

Re-drying of Stick electrodes

Where electrodes have become damp it is recommended that re-drying is carried out immediately prior to welding in accordance with the temperature details specified in the following tables. Welding straight from the dryer is recommended in all cases so as to comply with the lowest possible water contents.

stick electrodes for …	type of coating	re-drying recommended	re-drying temperature in °C	re-drying time in hours
non and low alloy steels	A, AR, C, RC, R, RR, RB	no	--	--
	B	yes	300 – 350	2 – 10
high strength fine grained steels	B	yes	300 – 350	2 – 10
creep resistant steels	R	no	--	--
	RB, B	yes	300 – 350	2 – 10
corrosion resistant and scaling resistant steels	R	yes	120 – 200	2 – 10
	RB, B	no	--	--
soft-martensitic steels	B	yes	300 – 350	2 – 10
duplex-steels	RB	yes	250 – 300	2 – 10
nickel alloys	all	if necessary	120 – 300	2 – 10

Re-drying temperature and re-drying time can be found at the labels of our products.

The following procedure is worthwhile for re-drying electrodes:

- The electrodes should be placed into a pre-heated oven (approx. 80-100°C) with no more than three layers on top of each other.
- The recommended temperature should be maintained for approx. 2 hours after the electrodes have heated up. In the case of re-drying temperatures above 250°C the temperature should be increased slowly (approx. 150°C/hour) to the recommended temperature.
- A total drying time of 10 hours (= sum total of the times for the individual re-drying processes) should not be exceeded. This maximum time must also be observed if re-drying takes place in several cycles.
- The temperature should be decreased to 70 to 90°C before removing the electrodes from the furnace.

Electrodes that have been in direct contact with water, grease or oil should not be used for welding fabrication. In this case even re-drying does not provide an adequate solution with the result that they should only be used for low-quality work.

Coated stick electrodes that are supplied in tins require no re-drying if they are placed directly into the dryer and are used straight from there.

It may still be worthwhile to re-dry in individual cases even in the case of stick electrodes for which there is no re-drying recommendation given in the table above. This may be appropriate in the case of incorrect storage or as a result of other conditions leading to high water contents. The high water content can usually be recognised from the welding behaviour which exhibits increased spattering or pore formation. In these cases the stick electrodes may be re-dried for approx. one hour at 100-120°C unless specified otherwise by the manufacturer. This recommendation does not apply to cellulose-coated stick electrodes which may not be re-dried at all.
The temperature for temporary storage in an oven following re-drying should be 120-200°C (maximum 30 days total holding time), for storage in dryers 100-200°C (10 days maximum total holding time).

Storage of Flux-cored Wires

The danger of moisture absorption is not the same for flux-cored wires as for stick electrodes. The flux core is largely shielded from the ambient atmosphere by the outer metal. Nevertheless, the „low-hydrogen" character of a flux-cored wire may be impaired by extreme contact with damp air. This may happen for example if they are stored overnight without protection in an atmosphere with high humidity.
Flux-cored wires should be stored in warehouses with controlled temperature and humidity conditions. We recommend dry, if necessary, heated rooms so that there is no likelihood of the temperature dropping below the dew point. The aim is not more than 60 % relative humidity and at least 15°C.
If stored at below 10°C there is a danger that condensation will form on the surface of the wire when the package is opened in a heated room. This can lead to pore and gas impressions on the weld at the beginning of welding.
Welding should only be performed using acclimatised wires.
The coil with the remaining wire should be removed from the unit when welding is finished and replaced in its original packaging taking care to re-seal the compound aluminium foil as effectively as possible. A tin such as those used for the delivery of BÖHLER flux powders for high-alloy steels may also be used for temporary storage.

Re-drying of Flux-cored Wires

Re-drying is usually possible in principle and should be carried out over 24 hours at approx. 150°C.

Storage and Re-drying of Sub-arc Welding Fluxes

It is recommended that flux powders are stored under the driest possible conditions and at temperatures which are as even as possible to keep water absorption to a minimum during storage. Powders stored in this manner may generally be kept for up to three years. Powder from containers damaged during transport must be used or re-packed immediately.
Fluoride-basic flux powders should be re-dried prior to use to ensure crack-free welding. It is possible to dispense with re-drying for flux powders that are taken directly from sealed, airtight, undamaged sheet metal containers (BB 202, BB 203, BB 910).

flux production	type of flux	re-drying recommended	re-drying temperature in °C	re-drying time in hours
agglomerated	FB	yes	ca. 350	2 - 10
	AR	yes	ca. 300	2 - 10
fused	MS	yes	ca. 150	2 - 500

The drying temperatures and times given in the previous table should be considered as general reference values. Re-drying may take place several times within the sum total of hours specified. After re-drying, flux powder that is not used immediately must be stored temporarily at increased temperature or in sealed airtight containers. The temporary storage temperature should be around 150°C and storage itself should not exceed 30 days.

The ovens used for re-drying should not permit localised overheating of the powder and must be adequately ventilated. In the case of stationary drying the layer of powder should not exceed 50 mm.

1.4. Cerfificates of Compliance and Test Reports

General Notes

Works certificates or acceptance test certificates to EN 10204 can be issued for every delivery on request. It is also possible to receive test reports in accordance with AWS A5.01. Basically speaking all types of certificates should be requested on placing the order.
It is imperative that the scope of testing is specified in the case of acceptance test certificates EN 10204-3.1 und test reports. Subsequent issuing of a 3.1 certificate or a test report with a scope of testing which deviates from schedules F and H always entails increased costs for administration and expenditure. It is no longer possible to issue certificates at a later date if a series has already come out of production and has been processed in its entirety.

Works Certificates acc. EN 10204-2.2

These certificates are product-related, i.e. a separate certificate is issued for each series or batch number. This certificate records all the values arising during the current in-process inspection that are relevant to the certificate. This means that for all low, medium and high-alloy stick electrodes and flux cored wires the respective actual values from the current quality test are inserted for the chemical analysis whilst for non-alloy electrodes and flux cored wires to some extent only statistical values based on non-specific testing are shown.
The heat analyses of the associated batches are specified for all solid wires and rods.
With the exception of the submerged-arc wires and flux powder, mechanical property data are shown on the works certificates for all products. The values specified are guaranteed tolerance limits (minimum and/or maximum depending on the standard requirement) and correspond to the minimum properties guaranteed for the product in this manual.

Acceptance Test Certificates acc. EN 10204-3.1 and 3.2

Acceptance test certificates 3.1 or 3.2 will also be issued on request. In order to do this tests must be performed on the delivery or on the production unit with which the delivery is associated. Since this is a certificate concerning a delivery-related test according to information supplied by the purchaser, it is imperative that the scope of testing should be made clear at the time of ordering or even at the enquiry stage. The costs arising will be charged according to expenditure.

Test Reports acc. AWS A5.01

A test report should be requested if a certificate of the product’s conformity with the AWS is required for a customer’s project. The test report includes as standard a confirmation of conformity for compliance with the applicable AWS standard or the reference to this AWS standard contained in ASME II, Part C.
The test report will correspond to "Schedule F" of AWS A5.01 if no further elements are specified by the customer. This test report is comparable with a works certificate "2.2" as regards content.
The scope of testing required must be disclosed at the point of ordering for all other schedules. In this case costs will be charged according to expenditure.

Notes

2. Product Information

◆ Contents

2.1. General remarks

The product information on the following pages has been kept standard for all filler metals produced by BÖHLER Welding. Unlike previous versions of this manual, all the data for a product is summarised on one page. The intention is to make it easier for you, the reader, to have a complete overview of a product.

Again, to make it easier to navigate, the header section of each page of data contains a reference to the sub-section, product form and/or a colour coding. Numbering in the footer section refers only to the section itself. Details of the version are intended to facilitate archiving if individual pages of the manual are to be used as reference in other documents.

Each of the following eight sections is sub-divided in the following order according to product forms where available: **stick electrodes, TIG rods, solid wires, flux cored wires, sub-arc wire/flux combinations and gas welding rods.**

Each product is identified by its trade name and a product group.
The product description contains some alterations compared with the most recent editions of the manual. Amongst other things the classification according to standard was consistently switched over to valid editions of the EN or AWS standard. To make the changeover easier, national standards such as DIN, NF and BS are still shown but are provided with a note referring to substitution by the EN.

The changeover was also carried out consistently with regard to the information about parent metals. If you encounter problems with the new material designations, Section 1 provides a brief overview of the systematic way in which materials are classified according to EN 10027 and ECISS IC10.

The section **„Description“** on each page of data briefly characterises the filler metal. It describes the type of coating or alloy, the area of application, the welding behaviour, areas of use and any information about temperature control and/or post-weld heat treatment.

The **„Typical Composition“** specifies the chemical composition of the pure weld metal for stick electrodes, flux-cored electrodes and sub-arc wire/flux combinations, and the chemical composition of the wire, rod or welding flux for the other types of filler metals.

The information provided in **„Mechanical Properties“** always refers to the pure weld metal and test conditions in accordance EN 1597-1. The information regarding minimum values or ranges for the chemical composition and mechanical property values of the weld metal were primarily specified allowing for the requirements of the standard and may be considerably higher in individual cases. By comparison the guideline values specified are based on evaluations by our permanent statistical quality control department and are of an informative nature. In both cases the data supplied was state of the art at the time of going to press.

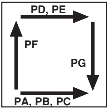
The **„Operating Data“** represent an addition compared with previous editions of the manual. The symbol code used for the welding position and current polarisation is matched to the labels of the product packaging. In addition you will also find information about stamping or embossing of products and notes about re-drying.

Details about same-alloy and similar-alloy products are also an additional feature that is designed to make it easier if you want to change the welding procedure whilst the base metal remains the same.

Symbols and Abbreviations

W.-Nr. = EN/DIN Material Number
EN = European Standard (resp. the derived national standard)
AWS = American Welding Society
DIN = German Industry Standard
BS = British Standard
NF = Normes Françaises

Welding Positions



PA	(w)	(1G, 1F)	downhand/flat position
PB	(h)	(2F)	horizontal position
PC	(q)	(2G)	horizontal vertical position
PD	(hü)	(4F)	horizontal overhead position
PE	(ü)	(4G)	overhead position
PF	(s)	(3G, 3F, 5G up)	vertical position up
PG	(f)	(3G, 3F, 5G down)	vertical position down

dotted arrow - - - - - - -► = limited weldability in this welding position

bold arrow ———► = especially designed for welding in this position

Type of Current and Polarity

=+ = direct current (positive polarity)

=− = direct current (negative polarity)

∼ = alternating current

Combinations are possible, e.g.

=± ∼ = direct current (positive or negative polarity) or alternating current

Mechanical Property Values

yield strength R_e N/mm^2 = independent from the base material the term yield strength covers the upper or lower elastic limit (R_{eH}, R_{eL}) or the proof stress in the case of non-proportional elongation ($R_{p0.2}$).

impact work ISO-V KV J = the test results shown in this handbook are measured using test specimen with ISO-V-notch.

Approvals and Certifying Organisations

ABS = American Bureau of Shipping
BN = „Baseler Norm“
BV = Bureau Veritas
CL = Vereniging voor Controlle op Lasgebied Controlas
CRS = Croatian Register of Shipping
CWB = Canadian Welding Bureau
DB = German Railways
DNV = Det Norske Veritas
FI = Force Technology (Dansk Standard)
GdF = Gaz de France
GL = German Lloyd

Approvals and Certifying Organisations

KTA 1408.1 = TSA Germany-approval – KTA-Standard 1408.1 (Germany)
LR = Lloyd's Register
LTSS = Lithuanian Technical Supervision Service
ÖBB = Austrian Railways
PRS = Polish Register of Shipping
R.I.NA = Registro Italiano Navale
RMR = Maritime Register of Shipping, Russia
SEPROZ = Approval Society, Ukraine
Statoil = Statoil, Norway
TÜV-D = Technical Supervisory Association, Germany
TÜV-A = Technical Supervisory Association, Austria
UDT = Technical Supervisory Association, Poland
Ü = Certificate of Conformity acc. Bauregelliste A, Part 1, Germany
VNIIGAZ = Scientific & Research Institute of Natural Gases & Gas Technologies
VNIIST = Engineering Research Company – Russia
VUZ = Vyskumny Ústav Zváracsky
WIWEB = Federal Office of Defence, Technology and Procurement

Remark:
details for approvals regarding base materials, classifications, welding positions, etc. can be found in the approval certificates – please contact the service departments for detailed information.

Shielding Gases acc. EN 439 and DIN 32526

components in Vol.-%						**DIN 32526**	**EN 439**	components in Vol.-%					
CO_2	O_2	H_2	N_2	He	Ar	group	group	CO_2	O_2	H_2	N_2	He	Ar
		100				**R1**	**--**						
		1-5			bal.	**R2**	**R1**			0-15			bal.
						--	**R2**			15-35			bal.
					100	**I1**	**I1**						100
				100		**I2**	**I2**					100	
				25-75	bal.	**I3**	**I3**					0-95	bal.
						--	**M11**	0-5		0-5			bal.
2-5					bal.	**M12**	**M12**	0-5					bal.
	1-3				bal.	**M11**	**M13**		0-3				bal.
						--	**M14**	0-5	0-3				bal.
6-14					bal.	**M13**	**M21**	5-25					bal.
15-25					bal.	**M21**	**M21**	5-25					bal.
	4-8				bal.	**M23**	**M22**		3-10				bal.
						--	**M23**	0-5	3-10				bal.
5-15	1-3				bal.	**M22**	**M24**	5-25	0-8				bal.
5-20	4-6				bal.	**M32**	**M24**	5-25	0-8				bal.
26-40					bal.	**M31**	**M31**	25-50					bal.
	9-12				bal.	**M33**	**M32**		10-15				bal.
							M22		3-10				bal.
						--	**M33**	5-50	8-15				bal.
100						**C1**	**C1**	100					
						--	**C2**	bal.	0-30				
		1-30			bal.	**F1**	**--**						
						--	**F1**				100		
		1-30	bal.			**F2**	**F2**			0-50	bal.		

Remark: This handbook references standardised shielding gases just in these cases where best welding result can be expected. If the shielding gas class shows too wide ranges the handbook recommends the optimum gas composition. The standardised shielding gas can be applicable but will produce different welding behaviour and/or other mechanical property values.

2.2. Filler Metals for Mild steels

Objectives

This section provides detailed product information for filler metals that may be used to weld mild steels.

Due to their tensile strength and yield strength mild steels (particularly general-purpose constructional steels) are used primarily in the as-delivered condition (rolled, forged or normalised) for welded, riveted and screwed structures in structural engineering, civil and underground engineering, bridge building, hydro power engineering, tank construction and mechanical engineering.

In each case the choice of filler metal must be appropriate for the material involved and must allow for welding engineering aspects where the rule applicable is that the minimum mechanical and technological values of the parent metal must also be achieved in the weld metal. In addition to choosing according to welding engineering conditions such as the weld position, edge preparation, work in the workshop or on site, it is also necessary to allow for the metallurgical features of the material, material thickness, shrinkage conditions and susceptibility to cracks.

Contents

Overview – Standard Classifications

Böhler	EN		AWS	
SMAW stick electrodes				
FOX MSU	EN 499:	E 38 0 RC 1 1	AWS A5.1-04:	E6013
FOX OHV	EN 499:	E 38 0 RC 1 1	AWS A5.1-04:	E6013
FOX KE	EN 499:	E 38 0 RC 1 1	AWS A5.1-04:	E6013
FOX SUM	EN 499:	E 38 0 RR 1 2	AWS A5.1-04:	E6013
FOX SUS	EN 499:	E 42 0 RR 1 2	AWS A5.1-04:	E6013
FOX ETI	EN 499:	E 42 0 RR 1 2	AWS A5.1-04:	E6013
FOX SPE	EN 499:	E 38 2 RB 1 2	AWS A5.1-04:	E6013(mod.)
FOX SPEM	EN 499:	E 38 2 RB 1 2	AWS A5.1-04:	E6013(mod.)
FOX HL 160 Ti	EN 499:	E 38 0 RR 5 4	AWS A5.1-04:	E7024-1
FOX HL 180 Ti	EN 499:	E 38 0 RR 7 4	AWS A5.1-04:	E7024
FOX EV 47	EN 499:	E 38 4 B 4 2 H5	AWS A5.1-04:	E7016-1H4R
FOX EV 50	EN 499:	E 42 5 B 4 2 H5	AWS A5.1-04:	E7018-1H4R
FOX EV 50-A	EN 499:	E 42 3 B 1 2 H10	AWS A5.1-04:	E7016
FOX EV 50-AK	EN 499:	E 42 3 RB 3 2 H10	AWS A5.1-04:	E7018(mod.)
FOX EV 50-W	EN 499:	E 42 5 B 1 2 H5	AWS A5.1-04:	E7016-1H4R
FOX EV 55	EN 499:	E 46 5 B 1 2 H5	AWS A5.1-04:	E7018-1H4R
FOX NUT	–		–	
GTAW rods				
EMK 6	EN 1668:	W 42 5 W3Si1	AWS A5.18-01:	ER70S-6
EML 5	EN 1668:	W 46 5 W2Si	AWS A5.18-01:	ER70S-3
ER 70S-2	–		AWS A5.18-01:	ER70S-2
GMAW solid wires				
EMK 6	EN 440:	G 42 4 M G3Si1	AWS A5.18-01:	ER70S-6
		G 42 4 C G3Si1		
EMK 7	EN 440:	G 46 4 M G4Si1	AWS A5.18-01:	ER70S-6
		G 46 4 C G4Si1		
EMK 8	EN 440:	G 46 4 M G4Si1	AWS A5.18-01:	ER70S-6
		G 46 4 C G4Si1		
GMAW flux cored wires				
Ti 52-FD	EN 758:	T 46 2 P M 1 H10	AWS A5.20-95:	E71T-1MH8
		T 42 2 P C 1 H5		E71T-1H4
Ti 52 W-FD	EN 758:	T 46 4 P M 1 H10	AWS A5.20-95:	E71T-1JH8
		T 42 2 P C 1 H5		E71T-1MJH8
HL 51-FD	EN 758:	T 46 4 M M 2 H5	AWS A5.18-01:	E70C-6MH4
HL 53-FD	EN 758:	T 42 5 Z M M 2 H5	AWS A5.18-01:	E70C-GMH4
			AWS A5.18M-01:	E48C-GMH4

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Ti	
SMAW stick electrodes					
FOX MSU	0.05	0.3	0.4		
FOX OHV	0.06	0.4	0.6		
FOX KE	0.06	0.3	0.5		
FOX SUM	0.07	0.3	0.5		
FOX SUS	0.07	0.5	0.6		
FOX ETI	0.07	0.4	0.5		
FOX SPE	0.08	0.2	0.5		
FOX SPEM	0.08	0.2	0.6		
FOX HL 160 Ti	0.08	0.3	0.6		
FOX HL 180 Ti	0.07	0.5	0.8		
FOX EV 47	0.06	0.5	0.7		
FOX EV 50	0.07	0.5	1.1		
FOX EV 50-A	0.05	0.6	1.0		
FOX EV 50-AK	0.04	0.6	1.0		
FOX EV 50-W	0.07	0.5	1.1		
FOX EV 55	0.08	0.35	1.4		
FOX NUT	–	–	–		
GTAW rods					
EMK 6	0.1	0.9	1.4		
EML 5	0.1	0.6	1.2		
ER 70S-2	0.05	0.5	1.2	+	Al, Zr
GMAW solid wires					
EMK 6	0.1	0.9	1.4		
EMK 7	0.08	0.9	1.7		
EMK 8	0.07	1.0	1.7		
GMAW flux cored wires					
Ti 52-FD	0.06	0.5	1.2	+	
Ti 52 W-FD	0.05	0.5	1.3	+	
HL 51-FD	0.07	0.7	1.5		
HL 53-FD	0.06	0.5	1.2		Ni 0.9

Overview – Standard Classifications (continued)

Böhler	EN	AWS	
SAW wire/flux-combinations			
EMS 2	EN 756: S2	AWS A5.17-97:	EM12K
EMS 2/BB 24	EN 756: S 38 6 FB S2	AWS A5.17-97:	F7A8-EM12K F48A6-EM12K
EMS 2/BB 25	EN 756: S 42 4 FB S2	AWS A5.17-97:	F7A4-EM12K F48A4-EM12K
EMS 2/BB 33 M	EN 756: S 46 0 AR S2	AWS A5.17-97:	F7AZ-EM12K F48A0-EM12K
EMS 2/BF 16	EN 756: S 38 0 MS S2	AWS A5.17-97:	F6A0-EM12K F43A2-EM12K
EMS 3	EN 756: S3	AWS A5.17-97:	EH10K
EMS 3/BB 24	EN 756: S 42 4 FB S3	AWS A5.17-97:	F7A4-EH10K F48A4-EH10K
EMS 3/BB 25	EN 756: S 42 3 FB S3	AWS A5.17-97:	F7A3-EH10K F48A2-EH10K
EMS 3/BB 33 M	EN 756: S 50 0 AR S3	AWS A5.17-97:	F7AZ-EH10K F48A0-EH10K
EMS 3/BF 16	EN 756: S 38 0 MS S3	AWS A5.17-97:	F6A0-EH10K F43A 3-EH10K
Gas welding rods			
BW VII	EN 12536: O I	AWS A5.2-92:	R45-G
BW XII	EN 12536: O III	AWS A5.2-92:	R60-G

Overview – Standard Classifications (continued)

Böhler	C	Si	Mn	Ti	Ni
SAW wire/flux-combinations					
EMS 2	0.12	0.12	1.0		
EMS 2/BB 24	0.07	0.25	1.05		
EMS 2/BB 25	0.07	0.4	1.45		
EMS 2/BB 33 M	0.08	0.7	1.3		
EMS 2/BF 16	0.04	0.5	1.3		
EMS 3	0.12	0.15	1.5		
EMS 3/BB 24	0.08	0.3	1.5		
EMS 3/BB 25	0.06	0.4	1.9		
EMS 3/BB 33 M	0.08	0.8	1.7		
EMS 3/BF 16	0.04	0.5	1.7		
Gas welding rods					
BW VII	0.08	0.1	0.5		
BW XII	0.08	0.1	1.1		0.4

EN 499:1994:	E 38 0 RC 1 1
AWS A5.1-04:	E6013
AWS A5.1M-04:	E4313

BÖHLER FOX MSU

SMAW stick electrode, mild steel, rutile-cellulosic-coated

Description

Rutile-cellulosic coated electrode with good weldability in all positions including vertical-down.
Viscous puddle, good gap bridging ability, easy handling.
For industry and trade, assembly and shop welding.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.05**	**0.3**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**430**	(≥ 380)
Tensile strenght R_m N/mm²:		**490**	(470 - 600)
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 55)
	± 0 °C:	**60**	(≥ 47)
	- 10 °C:	**58**	

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary: not necessary

Electrode identification:
FOX MSU 6013 E 38 0 RC

ø mm	L mm	amps A
2.5	250	70 - 100
3.2	350	90 - 130
4.0	350	140 - 180

Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S275JR, S235J0G3 - S355J0G3, P235GH, P265GH, P255NH, P235T1, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2
ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C A 135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr.45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

TÜV-D (1104.), DB (10.014.01), ÜZ (10.014/1), ÖBB, ABS (2,2Y), BV (2Y), CL (0849), DNV (2), GL (2Y), LR (2m, 2Ym), RMR (2Y), SEPROZ

EN 499:1994:	E 38 0 RC 1 1
AWS A5.1-04:	E6013
AWS A5.1M-04:	E4313

BÖHLER FOX OHV

SMAW stick electrode, mild steel, rutile-cellulosic-coated

Description

Rutile-cellulosic coated electrode with good weldability in all positions including vertical-down. Most popular E6013 type.
For small transformators, very good operating characteristics, flexible coating, good for tack welding. Versatile applications in structural welding, vehicle construction, boiler and tank welding, and in shipbuilding, also suitable for galvanised components.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.06**	**0.4**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm^2:		**460**	(≥ 380)
Tensile strenght R_m N/mm^2:		**520**	(470 - 600)
Elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 55)
	± 0 °C:	**60**	(≥ 47)
	- 10 °C:	**47**	

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX OHV 6013 E 38 0 RC

ø mm	**L mm**	**amps A**
2.0	250	45 - 80
2.5	250/350	60 - 100
3.2	350	90 - 130
4.0	350/450	110 - 170
5.0	450	170 - 240

Base Materials

steels up to a yield strength of 380 N/mm^2 (52 ksi)

S275JR, S235J0G3 - S355J0G3, P235GH, P265GH, P255NH, P235T1, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2
ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C A 135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr.45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

TÜV-D (5687.), DB (10.014.12), ÜZ (10014), ÖBB, TÜV-A (22), ABS (2), DNV (2), FI (E 38 0 RC 11), LR (2), UDT, LTSS, SEPROZ

EN 499:1994: E 38 0 RC 1 1
AWS A5.1-04: E6013
AWS A5.1M-04: E4313

BÖHLER FOX KE

SMAW stick electrode, mild steel, rutile-cellulosic-coated

Description

Rutile-cellulosic coated electrode engineered for easy operating in all positions including vertical-down.
Excellent welding properties an A.C., good striking and restriking characteristics, sound penetration, flat beads; popular for general steel construction.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.06**	**0.3**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**430**	(≥ 380)
Tensile strenght R_m N/mm²:		**490**	(470 - 600)
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 60)
	± 0 °C:	**65**	(≥ 47)
	- 10 °C:	**50**	

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX KE 6013 E 38 0 RC

ø mm	**L mm**	**amps A**
2.0	250	45 - 80
2.5	250/350	60 - 100
3.2	350	90 - 130
4.0	350/450	110 - 170

Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S275JR, S235J0G3 - S355J0G3, P235GH, P265GH, P255NH, P235T1, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2

ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C A 135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr.45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

UDT, LR (2m), SEPROZ

EN 499:1994:	E 38 0 RR 1 2
AWS A5.1-04:	E6013
AWS A5.1M-04:	E4313

BÖHLER FOX SUM

SMAW stick electrode, mild steel, rutile-coated

Description

Rutile coated electrode with extraordinarily good weldability in all positions except vertical-down. Excellent welding properties on A.C., good striking and restriking characteristics.
Soft arc, minimum spattering, very easy slag removal, famous for fine rippled and smooth weld surfaces.

Typical Composition of All-weld Metal

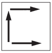
	C	Si	Mn
wt-%	**0.07**	**0.3**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**430**	(≥ 380)
Tensile strenght R_m N/mm²:		**500**	(470 - 600)
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 60)
	± 0 °C:	**60**	(≥ 47)
	- 10 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data



re-drying: not necessary

Electrode identification:
FOX SUM 6013 E 38 0 RR

ø mm	**L mm**	**amps A**
2.5	350	60 - 100
3.2	350	90 - 130
4.0	350	110 - 170

Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S275JR, S235J0G3 - S355J0G3, P235GH, P265GH, P255NH, P235T1, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2

ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C A 135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr.45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

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EN 499:1994:	E 42 0 RR 1 2
AWS A5.1-04:	E6013
AWS A5.1M-04:	E4313

BÖHLER FOX SUS

SMAW stick electrode, mild steel, rutile-coated

Description

Rutile coated electrode with excellent weldability in all positions except vertical-down, even under the most unfavourable conditions.
Distinguished by excellent restriking characteristics, minimum spattering and excellent welding properties on A.C. The weld seam is characterised by fine rippled and smooth beads, the slag is self-detaching.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.07**	**0.5**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm^2:		**430**	(≥ 420)
Tensile strenght R_m N/mm^2:		**510**	(500 - 640)
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 60)
	± 0 °C:	**55**	(≥ 47)
	- 10 °C:	**45**	

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX SUS 6013 E 42 0 RR

ø mm	**L mm**	**amps A**
2.0	300	60 - 80
2.5	350	80 - 100
3.2	350/450	120 - 150
4.0	450	160 - 200
5.0	450	220 - 250

Base Materials

steels up to a yield strength of 420 N/mm^2 (60 ksi)

S275JR, S235J0G3 - S355J0G3, P235GH, P265GH, P255NH, P295GH, P235T1, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2

ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C A 135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr.45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

TÜV-D (1657.), DB (80.014.01), ÜZ (10.014/1), ÖBB, ABS (2), BV (2Y), CL (1002), DNV (2), GL (2), LR (X), SEPROZ

EN 499:1994:	E 42 0 RR 1 2
AWS A5.1-04:	E6013
AWS A5.1M-04:	E4313

BÖHLER FOX ETI

SMAW stick electrode, mild steel, rutile-coated

Description

Rutile coated electrode offering top weldability in all positions except vertical-down. Extremely smooth beads, self-detaching slag, minimum spattering and excellent welding properties on A.C. Excellent restriking characteristics and easy handling. Good deposition lengths attainable. Versatile applications in trade and industry.

Typical Composition of All-weld Metals

	C	Si	Mn
wt-%	**0.07**	**0.4**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm^2:		**460**	(≥ 420)
Tensile strenght R_m N/mm^2:		**520**	(500 - 640)
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**65**	(≥ 50)
	± 0 °C:	**50**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX ETI 6013 E 42 0 RR

ø mm	**L mm**	**amps A**
1.5	250	40 - 60
2.0	250	45 - 80
2.5	250/350	60 - 110
3.2	350/450	90 - 140
4.0	450	110 - 190
5.0	450	170 - 240

Base Materials

steels up to a yield strength of 420 N/mm^2 (60 ksi)

S275JR, S235J0G3 - S355J0G3, P235GH, P265GH, P255NH, P295GH, P235T1, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2

ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C; A 135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

TÜV-D (1097.), TÜV-A (450), ABS (2), BV (2), DNV (2), FI (E 42 0 RR 12), GL (2), LR (2m), UDT, LTSS, SEPROZ

EN 499:1994:	E 38 2 RB 1 2
AWS A5.1-04:	E6013(mod.)
AWS A5.1M-04:	E4313(mod.)

BÖHLER FOX SPE

SMAW stick electrode, mild steel, rutile-basic-coated

Description

Rutile-basic coated electrode especially recommended for out-of-position work except vertical-down. Excellently suited for welding root passes. Produces first class X-ray quality welds. Excellent welding properties on A.C.

Preferably used in structural and tank welding as well as in tube&pipe construction. High mechanical properties, thus suitable for many different base metals.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.08**	**0.2**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**420**	(≥ 380)
Tensile strenght R_m N/mm²:		**500**	(470 - 600)
Elongation A (L_0 = $5d_0$) %:		**28**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**90**	(≥ 70)
	± 0 °C:	**75**	(≥ 60)
	- 10 °C:	**70**	(≥ 50)
	- 20 °C:	**60**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX SPE E 38 2 RB

ø mm	**L mm**	**amps A**
2.0	250	45 - 75
2.5	250/350	60 - 100
3.2	350	90 - 140
4.0	450	110 - 190
5.0	450	170 - 250

Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S275JR, S235J2G3 - S355J2G3, P235GH, P265GH, P255NH, P235T1-P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L290MB - L360MB, S235JRS1 - S235J2S1, S235JRS2 - S235J2S2

ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C; A135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

TÜV-D (0731.), DB (10.014.03), ÜZ (10.014/1), ÖBB, TÜV-A (74), DNV (2), LR (X), GL (3Y), ABS (2), CL (0727), BV (3Y), UDT, LTSS, SEPROZ

EN 499:1994:	E 38 2 RB 1 2
AWS A5.1-04:	E6013(mod.)
AWS A5.1M-04:	E4313(mod.)

BÖHLER FOX SPEM

SMAW stick electrode, mild steel, rutile-basic-coated

Description

Rutile-basic coated electrode especially suited for out-of-position welding except vertical-down. Preferably used for pipeline, boiler and tank welding. Especially suited for X-ray quality root pass and out-of-position welds. Exceeds the FOX SPE electrode in mechanical strength thanks to the elevated Mn-content of the weld deposit.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.08**	**0.2**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm^2:		**450**	(≥ 380)
Tensile strenght R_m N/mm^2:		**540**	(470 - 600)
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 55)
	- 20 °C:		(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX SPEM E 38 2 RB

ø mm	**L mm**	**amps A**
2.5	250/350	70 - 90
3.2	350	110 - 140
4.0	350	140 - 190
5.0	450	200 - 250

Base Materials

steels up to a yield strength of 380 N/mm^2 (52 ksi)

S275JR, S235J2G3 - S355J2G3, P235GH, P265GH, P255NH, P295GH, P355T1, P235T2-P355T2, P235G1TH, P255G1TH, L210 - L360NB, L210MB - L360MB, L385M, S235JRS1 - S235J2S1, S235JRS2 - S235J2S2, S255N - S355N

ASTM A36 a. A53 Gr. all; A106 Gr. A, B, C; A135 Gr. A, B; A283 Gr. A, B, C, D; A366; A285 Gr. A, B, C; A500 Gr. A, B, C; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

TÜV-D (0732.), DB (10.014.06), ÜZ (10.014/1), ÖBB, TÜV-A (528), ABS (2), CL (0720), DNV (2), GL (2Y), LR (X), BV (3Y), SEPROZ

EN 499:1994:	E 38 0 RR 5 4
AWS A5.1-04:	E7024-1
AWS A5.1M-04:	E4924-1

BÖHLER FOX HL 160 Ti

SMAW stick electrode, mild steel, high efficiency

Description

Rutile coated electrode, high efficiency with 160 % metal recovery. Fast flowing puddle. Easy slag removal in fillet welds in acute angles. Useable for rusty and coated steels and plates. Preferred for fillet and butt welds in horizontal position.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.08**	**0.3**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**420**	(≥ 400)
Tensile strenght R_m N/mm²:		**520**	(490 - 600)
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 70)
	± 0 °C:		(≥ 47)
	- 20 °C:	**30**	(≥ 27)

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX HL 160 Ti 7024-1 E 38 0 RR

ø mm	**L mm**	**amps A**
3.2	450	140 - 180
4.0	450	190 - 230
5.0	450	240 - 280

Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S235JR, S275JR, S235J0G3, S275J0G3, S355J0G3, P235GH, P265GH, S255N, P295GH, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2

ASTM A36 Gr. all; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A366; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr. 45; A936 Gr. 50

Approvals and Certificates

ABS (2,2Y*), GL (2Y), LR (X), UDT, SEPROZ

EN 499:1994:	E 38 0 RR 7 4
AWS A5.1-04:	E7024
AWS A5.1M-04:	E4924

BÖHLER FOX HL 180 Ti

SMAW stick electrode, mild steel, high efficiency

Description

Rutile coated iron powder electrode yielding approx. 180 % metal recovery. Self-detaching slag, smooth welds free of undercuts.
Excellent striking characteristics. Highly economical for multi-layer welding of heavy cross sections.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.07**	**0.5**	**0.8**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**440**	(≥ 400)
Tensile strenght R_m N/mm²:		**510**	(490 - 600)
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**85**	(≥ 60)
	± 0 °C:	**65**	(≥ 47)
	- 10 °C:	**50**	

(*) *u untreated, as-welded*

Operating Data

re-drying: not necessary

Electrode identification:
FOX HL 180 Ti 7024 E 38 0 RR

ø mm	**L mm**	**amps A**
3.2	450	120 - 180
4.0	450	160 - 230
5.0	450	200 - 330

Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S235JR, S275JR, S235J0G3, S275J0G3, S355J0G3, P235GH, P265GH, S255N, P295GH, S235JRS1 - S235J0S1, S235JRS2 - S235J0S2

ASTM A36 Gr. all; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A366; A570 Gr. 30, 33, 36, 40, 45; A607 Gr. 45; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A935 Gr. 45; A936 Gr. 50

Approvals and Certificates

TÜV-A (17), ABS (2), DNV (2), FI (E 38 0 RR 74), GL (2), LR (2m), RINA (2), UDT, SEPROZ

EN 499:1994:	E 38 4 B 4 2 H5
AWS A5.1-04:	E7016-1H4R
AWS A5.1M-04:	E4916-1H4R

BÖHLER FOX EV 47

SMAW stick electrode, mild steel, basic-coated

Description

Basic coated electrode for high-quality welds. Good weldability in all positions except vertical-down. Metal recovery about 110 %. Very low hydrogen content (according AWS condition HD < 4 ml/100 g weld metal).
Weld metal extremely ductile, crack resistant and ageing resistant thus especially suited for rigid weldments with heavy seam cross sections.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.06**	**0.5**	**0.7**

Mechanical Properties of All-weld Metal

(*)		u		s	
Yield strength R_e N/mm²:		**460**	(≥ 400)	**400**	(≥ 360)
Tensile strenght R_m N/mm²:		**530**	(490 - 600)	**500**	(450 - 580)
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 22)	**29**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**190**	(≥ 110)	**200**	(≥ 110)
	- 20 °C:	**110**		**150**	
	- 40 °C:	**90**	(≥ 47)	**100**	

(*) *u untreated, as-welded*
s stress relieved 600 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
Electrode identification:
FOX EV 47 7016-1 E 38 4 B

ø mm	L mm	amps A
2.5	250/350	80 - 110
3.2	350/450	100 - 140
4.0	450	130 - 180
5.0	450	180 - 230

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Base Materials

steels up to a yield strength of 380 N/mm² (52 ksi)

S235JR-E295, S235J2G3 - S355J2G3, C22, P235T1-P275T1, P235T2, P275T2, L210 - L320, L290MB - L320MB, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S355N, P255NH-P355NH, S255NL - S355NL, GE200-GE240

ASTM A 27 a. A36 Gr. all; A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X52

Approvals and Certificates

TÜV-D (1098.), DB (10.014.09), ÜZ (10.014/1), ÖBB, TÜV-A (72), ABS (3H5), BV (3HHH), DNV (3H10), GL (3H5), ISPESL (X), LR (3m H5), RMR (2), RINA (3YH5, 3H5), UDT, LTSS, VUZ, SEPROZ

EN 499:1994:	E 42 5 B 4 2 H5
AWS A5.1-04:	E7018-1H4R
AWS A5.1M-04:	E4918-1H4R

BÖHLER FOX EV 50

SMAW stick electrode, mild steel, basic-coated

Description

Basic coated electrode engineered for high-quality welds. Excellent strength and toughness properties down to -50 °C. Metal recovery approx. 110 %. Good weldability in all position except for vertical-down. Very low hydrogen content (according AWS condition HD < 4 ml/100 g weld metal). Suitable for welding steels with low purity and high carbon content. Welding in steel construction, boiler and tank manufacture, vehicle construction, shipbuilding, and machine construction as well as for buffer layers on build ups on high carbon steels. Especially suitable for off-shore construction, CODT tested at -10 °C. It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.07**	**0.5**	**1.1**

Mechanical Properties of All-weld Metal

(*)		u		s
Yield strength R_e N/mm²:		**490**	(≥ 420)	**430**
Tensile strenght R_m N/mm²:		**560**	(500 - 640)	**520**
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 22)	**29**
Impact work ISO-V KV J	+ 20 °C:	**190**	(≥ 120)	**220**
	- 20 °C:	**160**		**190**
	- 50 °C:	**100**	(≥ 47)	**140**

(*) *u untreated, as-welded*
s stress relieved 600 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
Electrode identification:
FOX EV 50 7018-1 E 42 5 B

ø mm	L mm	amps A
2.0	250	50 - 70
2.5	250/350	80 - 110
3.2	350/450	100 - 140
4.0	450	130 - 180
5.0	450	180 - 230
6.0	450	240 - 290

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Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235JR-E335, S235J2G3 - S355J2G3, C22, P235T1-P355T1, P235T2, P355T2, L210 - L360NB L290MB - L320MB, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S355N, P255NH-P355NH, S255NL - S355NL, GE200-GE260, GE300

ASTM A 27 a. A36 Gr. all; A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

TÜV-D (0426.), DB (10.014.02), ÜZ (10.014/1), ÖBB, TÜV-A (32), ABS (3H5, 4Y), BV (3YHHH), CL (0210), DNV (3YH10), FI (E 42 5 B 42 H5), GL (4Y40H15), ISPESL (X), LR (3, 3YH5), RMR (3YHH), RINA (4YDH5/4DH5), UDT, LTSS, VUZ, SEPROZ, PDO, CRS (3YH5)

EN 499:1994:	E 42 3 B 1 2 H10
AWS A5.1-04:	E7016
AWS A5.1M-04:	E4916

BÖHLER FOX EV 50-A

SMAW stick electrode, mild steel, basic-coated

Description

Basic double coated electrode with excellent weldability in all positions except vertical-down. Especially suited for out-of-position welding thanks to the well controlled arc.
Excellent root penetration. Good suitability for welding on AC Minimum spatter loss. Very easy slag removal with uniform beads. Well suited for small transformers. Low hydrogen content in the weld deposit (HD < 10 ml/100 g deposit).

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.05**	**0.6**	**1.0**

Mechanical Properties of All-weld Metal

(*)		u		s
Yield strength R_e N/mm^2:		**440**	(≥ 420)	**400**
Tensile strenght R_m N/mm^2:		**550**	(500 - 640)	**520**
Elongation A ($L_0 = 5d_0$) %:		**28**	(≥ 20)	**28**
Impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 100)	**180**
	- 30 °C:		(≥ 47)	

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
Electrode identification:
FOX EV 50-A 7016 E 42 3 B

ø mm	**L mm**	**amps A**
2.5	350	60 - 90
3.2	350/450	100 - 150
4.0	450	140 - 190
5.0	450	190 - 250

Base Materials

steels up to a yield strength of 420 N/mm^2 (60 ksi)

S235J2G3 - S355J2G3, S235JR-E295, C22, P235T1-P355T1, P235T2-P355T2, L210 - L360NB, L290MB - L360MB, P235G1TH, P255G1TH, P235GH, P265GH, S255N, P295GH, S235JRS1 - S235J3S, S355G1S - S355G3S, S255N - S355N, P255NH-P355NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A214; A242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

TÜV-D (7105.), DB (10.014.17), ÖBB

EN 499:1994:	E 42 3 RB 3 2 H10
AWS A5.1-04:	E7018(mod.)
AWS A5.1M-04:	E4918(mod.)

BÖHLER FOX EV 50-AK

SMAW stick electrode, mild steel, rutile-basic-coated

Description

Rutile basic coated electrode for high quality weld joints. Specially suited for welding on AC-polarity. Good weldability in all position except vertical down.
Increased weld metal recovery of app. 125 %.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.04**	**0.6**	**1.0**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**480**	(≥ 420)
Tensile strenght R_m N/mm²:		**560**	(500 - 640)
Elongation A ($L_0 = 5d_0$) %:		**30**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 120)
	- 20 °C:	**140**	
	- 30 °C:		(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
Electrode identification:
FOX EV 50-AK E 42 3 RB

ø mm	**L mm**	**amps A**
2.5	250	70 - 90
3.2	350	100 - 140
4.0	450	150 - 210

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Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235JR-E335, S235J2G3 - S355J2G3, C22, P235T1-P355T1, P235T2, P355T2, L210 - L360NB, L290MB, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, S235JRS1 - S235J3S, S355G1S - S355G3S, S255N - S355N, P255NH-P355NH, S255NL - S355NL, GE200-GE260, GE300

ASTM A27 a. A36 Gr. all; A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

UDT, LTSS

EN 499:1994:	E 42 5 B 1 2 H5
AWS A5.1-04:	E7016-1H4R
AWS A5.1M-04:	E4916-1H4R

BÖHLER FOX EV 50-W

SMAW stick electrode, mild steel, basic-coated

Description

Basic coated electrode for high-quality joint welds. Especially suited for root pass welding. Excellent weldability in all positions except vertical-down. Smooth and slag-free welds. Crack resistant deposits of high toughness at ambient and subzero temperatures. Very low hydrogen contents in the weld deposit (according AWS condition HD < 4 ml/100 g weld metal). Especially suited for welding on AC. For root pass welding, DC negative polarity is recommended.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.07**	**0.5**	**1.1**

Mechanical Properties of All-weld Metal

(*)		u		s
Yield strength R_e N/mm^2:		**460**	(≥ 420)	**400**
Tensile strenght R_m N/mm^2:		**560**	(510 - 640)	**520**
Elongation A ($L_0 = 5d_0$) %:		**28**	(≥ 25)	**28**
Impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 110)	**200**
	- 20 °C:	**150**		**160**
	- 40 °C:	**120**		**130**
	- 50 °C:		(≥ 47)	

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
Electrode identification:
FOX EV 50-W 7016-1 E 42 5 B

ø mm	L mm	amps A
2.0	300	40 - 60
2.5	350	55 - 85
3.2	350	80 - 140
4.0	350	110 - 180
5.0	450	180 - 230

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Polarity negative for root pass

Base Materials

steels up to a yield strength of 420 N/mm^2 (60 ksi)

S235JR-E335, S235J2G3 - S355J2G3, C22, P235T1-P355T1, P235T2, P355T2, L210 - L360NB, L290MB, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S355N, P255NH-P355NH, S255NL - S355NL, GE200-GE260, GE300

ASTM A27 a. A36 Gr. all; A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

TÜV-D (4180.), CL (0498), FI (E 42 2 B 12 H5), GL (3YH5), UDT, LTSS, PDO, SEPROZ

EN 499:1994:	E 46 5 B 1 2 H5
AWS A5.1-04:	E7018-1H4R
AWS A5.1M-04:	E4918-1H4R

BÖHLER FOX EV 55

SMAW stick electrode, mild steel, basic-coated

Description

Basic coated electrode for high-quality joint welds with high strength and toughness properties. Low-temperature ductility down to -50 °C. Very low hydrogen content in the weld deposit (according AWS condition HD < 4 ml/100 g weld metal). Excellent weldability in all positions except vertical-down. Suitable for welding in steel construction, boiler, tank, container and vehicle construction, shipbuilding and mechanical engineering. Also suited for buffer layers on build ups on high-carbon steels. It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.08**	**0.35**	**1.4**

Mechanical Properties of All-weld Metal

(*)		u		s
Yield strength R_e N/mm²:		**500**	(≥ 460)	**470**
tensile strenght R_m N/mm²:		**550**	(530 - 680)	**530**
Elongation A (L_0 = 5d_0) %:		**30**	(≥ 22)	**30**
Impact work ISO-V KV J	+ 20 °C:	**220**	(≥ 130)	**200**
	- 20 °C:	**170**		
	- 50 °C:	**90**	(≥ 47)	

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
Electrode identification:
FOX EV 55 7018-1 E 46 5 B

ø mm	L mm	amps A
2.5	250	80 - 110
3.2	350	100 - 140
4.0	450	130 - 180

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Base Materials

steels up to a yield strength of 460 N/mm² (78 ksi)

S235J2G3 - S355J2G3, S235JR - S355J0, P235T1-P355T1, P235T2 -P355T2, L210 - L415NB, L290MB, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S460N, P255NH-P355NH, S255NL - S460NL, S255NL1, GE200-GE300

ASTM A27 a. A36 Gr. all; A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X60

Approvals and Certificates

TÜV-D (3654.), TÜV-A (232), RMR (3 YHH), UDT, LTSS, SEPROZ

BÖHLER FOX NUT

SMAW stick electrode, mild steel, gouging electrode

Description

Special electrode for gouging of various base Materials without oxygen. High gouging speed in all positions useable.
Suitable for edge bevelling, cutting grooves, removal of unsound material and cracks prior to repair welding.

Operating Data

re-drying: not necessary
Electrode identification:
FOX NUT

ø mm	L mm	amps A
3.2	350	180 - 240
4.0	350	250 - 320

Approvals and Certificates

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EN 1668:1997:	W 42 5 W3Si1
AWS A5.18-01:	ER70S-6
AWS A5.18M-04:	ER48S-6
W.Nr:	1.5125

BÖHLER EMK 6

GTAW rod, mild steel

Description

TIG-welding rod with high silicon content. The welding rod is suited for joints in boiler and vessel fabrication as well as in structural steel engineering.
It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of Welding Rod

	C	Si	Mn
wt-%	**0.1**	**0.9**	**1.4**

Mechanical Properties of All-weld Metal

(*)		u		s
Yield strength R_e N/mm²:		**430**	(≥ 420)	**400**
Tensile strenght R_m N/mm²:		**540**	(500 - 640)	**510**
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 20)	**28**
Impact work ISO-V KV J	+ 20 °C:	**160**	(≥ 100)	**180**
	- 40 °C:	**70**		**110**
	- 50 °C:		(≥ 47)	

(*) *u untreated, as-welded – shielding gas Argon*
s stress relieved, 620 °C/2 h – shielding gas 100 % Argon

Operating Data

shielding gases: **Argon**
rod marking:
front: **W3Si1**
back: **ER70S-6**

ø mm
1.6
2.0
2.4

Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235J2G3-S355J2G3, E360, P235T1-P355T1, P235G1TH, L210, L290MB, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, S235JRS1-S235J4S, S355G1S-S355G3S, S255N-S385N, P255NH-P385NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X56

Approvals and Certificates

TÜV-D (09717.), TÜV-A (521), UDT, LTSS, SEPROZ

EN 1668:1997:	W 46 5 W2Si
AWS A5.18-01:	ER70S-3
AWS A5.18M-04:	ER48S-3

BÖHLER EML 5

GTAW rod, mild steel

Description

Very popular TIG rod for high integrity welds. The low Si-content renders this filler metal particularly also for joint welds that are subjected to enamelling or galvanising.
Especially suited for root pass welding (approved at - 50 °C)

BÖHLER EML 5 can be used in sour gas applications (HIC-Test acc. NACE TM-02-84) as well.

Typical Composition of Welding Rod

	C	Si	Mn
wt-%	**0.1**	**0.6**	**1.2**

Mechanical Properties of All-weld Metal

(*)		u		s
Yield strength R_e N/mm²:		**500**	(≥ 460)	**490**
Tensile strenght R_m N/mm²:		**600**	(530 - 680)	**570**
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 23)	**30**
Impact work ISO-V KV J	+ 20 °C:	**220**	(≥ 130)	**200**
	- 20 °C:	**200**		**210**
	- 50 °C:		(≥ 47)	

(*) *u untreated, as-welded – shielding gas 100 % Argon*
s stress relieved, 620 °C/5 h – shielding gas 100 % Argon

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W2Si**
back: **ER70S-3**

ø mm
1.6
2.0
2.4
3.0

=–

Base Materials

steels up to a yield strength of 460 N/mm² (67 ksi)

S235J2G3 - S355J2G3, E360, P235T1-P355T1, P235G1TH, L210, L290MB, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S385N, P255NH-P385NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A214; A242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A570 Gr. 30, 33, 36, 40, 45; A 572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5 L Gr. B, X42 - X60

Approvals and Certificates

TÜV-D (1096.), DB (42.014.02), ÜZ (42.014/2), ÖBB, TÜV-A (373), CL (1010), Statoil, UDT

AWS A5.18-01: ER70S-2
AWS A5.18M-04: ER48S-2

BÖHLER ER 70 S-2

GTAW-rod, mild steel

Description

Böhler ER 70S-2 is a copper coated GTAW rod containing Al, Ti and Zr as strong deoxidents in addition to Mn and Si and is often referred to as triple deoxidised.
This has advantages when rimming or semi-killed mild steels are welded or where joint preparations are rusty or contaminated.
Böhler ER 70S-2 is primarily used for single pass welding. For applications involving single and multipass GTAW and/or low temperature toughness requirements down to -50 °C we recommend our GTAW rod Böhler EML 5 (AWS ER 70S-3).

Typical Composition of Welding Rod

	C	Si	Mn	Ti	Zr	Al
wt-%	**0.05**	**0.5**	**1.2**	**+**	**+**	**+**

Mechanical Properties of All-weld Metal

(*)		u
Yield strength R_e N/mm^2:		≥ **420**
Tensile strenght R_m N/mm^2:		≥ **520**
Elongation A ($L_0 = 5d_0$) %:		≥ **23**
Impact work ISO-V KV J	+ 20 °C:	≥ **80**
	- 29 °C:	≥ **27**

(*) *u untreated, as-welded – shielding gas 100 % Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front:
back: **ER70S-2**

ø mm
1.6
2.0
2.4
3.0

=–

Base Materials

especially for rod pass welding of steels up to a yield strength of 420 N/mm^2 (60 ksi)

S235J2G3, E360, P235T1, P235G1TH, L210, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, S235JRS1 - S235J4S, S255N, P255NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A 210 Gr. 1; A214; A34 Gr.1; A 36, A 113; A 139

Approvals and Certificates

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EN 440:1995:	G3Si1 (for wire)
EN 440:1995:	G 42 4 M G3Si1
	G 42 4 C G3Si1
AWS A5.18-01:	ER70S-6
AWS A5.18M-04:	ER48S-6
W.Nr:	1.5125

BÖHLER EMK 6

GMAW solid wire, mild steel

Description

Copper-coated solid wire suited for universal GMAW application in structural steel engineering, and provides excellent feeding characteristics.
Thanks to the good mechanical properties this filler wire is optimally suited for welding thick-walled components.
The non copper coated version of the solid wire BÖHLER EMK 6 TOP is designed for low spatter formation and excellent feeding properties for extremely high wire feed rates. These types are especially suited for robotic welding.

Typical Composition of Solid Wire

	C	Si	Mn
wt-%	**0.1**	**0.9**	**1.4**

Mechanical Properties of All-weld Metal

(*)		u		u2		s	
Yield strength R_e N/mm²:		**440**	(≥ 420)	**440**	(≥ 420)	**380**	(≥ 360)
Tensile strenght R_m N/mm²:		**530**	(500 - 640)	**540**	(500 - 640)	**490**	(470 - 590)
Elongation A (L_0 = 5d_0) %:		**30**	(≥ 24)	**29**	(≥ 22)	**30**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**160**	(≥ 90)	**120**	(≥ 70)	**160**	(≥ 90)
	- 40 °C:	**80**	(≥ 47)	**50**	(≥ 47)		(≥ 47)

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2
s stress relieved, 620 °C/2 h – shielding gas Ar + 15 - 25 % CO_2

Operating Data

shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm
0.8
1.0
1.2
1.6

=+

Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235J2G3 - S355J2G3, E360, P235T1-P355T1, P235G1TH, L210, L290MB, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S385N, P255NH-P385NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A106 Gr. A, B A214; A242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50

Approvals and Certificates

TÜV-D (3036.), DB (42.014.11), ÜZ (42.014/2), ÖBB, TÜV-A (83), ABS (3SA, 3YSA), CWB (X), DNV (III YMS), FI (G 38 4 C G3Si1), GL (3YS), LR (3S, 3YS H15), UDT, LTSS, SEPROZ

EN 440:1995:	G4Si1 (for wire)
EN 440:1995:	G 46 4 M G4Si1
	G 46 4 C G4Si1
AWS A5.18-01:	ER70S-6
AWS A5.18M-04:	ER48S-6
W.Nr:	1.5130

BÖHLER EMK 7

GMAW solid wire, mild steel

Description

Copper-coated solid wire used for GMAW of structural components with increased strength requirements.

BÖHLER EMK 7 is designed for semi-automatic and robotic welding and provides excellent feeding characteristics.

Typical Composition of Solid Wire

	C	Si	Mn
wt-%	**0.08**	**0.9**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u		u2		s
Yield strength R_e N/mm²:		**480**	(≥ 460)	**470**	(≥ 460)	**420**
Tensile strenght R_m N/mm²:		**590**	(530 - 680)	**580**	(530 - 680)	**540**
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)	**29**	(≥ 22)	**28**
Impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 80)	**110**	(≥ 70)	**130**
	- 40 °C:		(≥ 47)			**65**

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2
s stress relieved, 600 °C/2 h – shielding gas Ar + 15 - 25 % CO_2

Operating Data

shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm
1.0
1.2

=+

Base Materials

steels up to a yield strength of 460 N/mm² (67 ksi)

S235J2G3 - S355J2G3, E360, P235T1-P355T1, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S460N, P255NH-P460NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A106 Gr. A, B A214; A242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50

Approvals and Certificates

TÜV-D (3037.), DB (42.014.12 - 20.014.13), ÜZ (42.014/2), ÖBB

BÖHLER EMK 8

GMAW solid wire, mild steel

EN 440:1995:	G4Si1 (for wire)
EN 440:1995:	G 46 4 M G4Si1
	G 46 4 C G4Si1
AWS A5.18-01:	ER70S-6
AWS A5.18M-04:	ER48S-6
W.Nr:	1.5130

Description

Copper-coated solid wire used for GMAW of structural components with increased strength requirements and is optimally suited for welding thick-walled components.
BÖHLER EMK 8 is designed for semi-automatic and robotic welding and provides excellent feeding characteristics.
For the T.I.M.E.-process the type BÖHLER EMK 8-T is recommended (ø1.2 mm), and is especially suited for robotic welding.

Typical Composition of Solid Wire

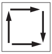
	C	Si	Mn
wt-%	**0.07**	**1.0**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u		u2		s
Yield strength R_e N/mm²:		**470**	(≥ 460)	**470**	(≥ 460)	**410**
Tensile strenght R_m N/mm²:		**600**	(530 - 680)	**580**	(530 - 680)	**540**
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)	**29**	(≥ 22)	**28**
Impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 80)	**110**	(≥ 70)	**130**
	- 40 °C:	**50**	(≥ 47)	**50**	(≥ 47)	**70**

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2
s stress relieved, 600 °C/2 h – shielding gas Ar + 15 - 25 % CO_2

Operating Data



shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm
0.8
1.0
1.2

=+

Base Materials

steels up to a yield strength of 460 N/mm² (67 ksi)

S235J2G3 - S355J2G3, E360, P235T1-P355T1, P235G1TH, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, S235JRS1 - S235J4S, S355G1S - S355G3S, S255N - S460N, P255NH-P460NH, GE200-GE260

ASTM A27 a. A36 Gr. all; A106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50

Approvals and Certificates

TÜV-D (3038.), DB (42.014.05), ÜZ (42.014/2), ÖBB, ABS (3SA, 3YSA), DNV (III YMS), GL (3YS), LR (3S, 3YS H15), UDT, SEPROZ

EN 758:1997:	T 46 2 P M 1 H10 T 42 2 P C 1 H5
AWS A5.20-95:	E71T-1H4 E71T-1MH8

BÖHLER Ti 52-FD

GMAW flux-cored wire, mild steel, rutile type

Description

All–position rutile flux-cored wire with fast freezing slag system. User friendly welding characteristics in all positions with one wire dia. 1.2 mm and same parameter setting. Excellent mechanical properties, easy slag removal, low spatter loss, smooth, finely rippled bead surface, high X-ray safety.
The product performs to the highest productivity with significant savings in time and economical aspects when used for positional welding.

Typical Composition of All-weld Metal

	C	Si	Mn	Ti
wt-%	**0.06**	**0.5**	**1.2**	**+**

Mechanical Properties of All-weld Metal

(*)		u		u2	
Yield strength R_e N/mm²:		**490**	(≥ 460)	**470**	(≥ 420)
Tensile strenght R_m N/mm²:		**580**	(550 - 640)	**540**	(510 - 640)
Elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)	**27**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 130)	**170**	(≥ 120)
	- 20 °C:	**130**	(≥ 54)	**120**	(≥ 54)
	-40 °C:	**90**		**80**	

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2

Operating Data

re-drying: not necessary
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2
Welding with standard GMAW-facilities possible.

ø mm
1.2
1.6

=+

Base Materials

steels up to a yield strength of 460 N/mm² (67 ksi)

S235J2G3 - S355J2G3, GE200, GE240, GE260, S235JRS1 - S235J2S, AH, DH, EH, S255N - S355N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210 - L360NB, P235G1TH, P255G1TH

ASTM A27 a. A36 Gr. all; A106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 G907 Gr. 30, 33, 36, 40; Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; AA841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X56

Approvals and Certificates

TÜV-D (09929.), TÜV-A (709), ABS (3SA, 3YSA (CO_2,M21)), BV (X), DNV (III YMS(H10) [CO_2, M21]), GL (3YHHS (C1, M21)), LR (DXVudO; BF; 3S; 3YS; H15; NA), UDT, CRS (3YH10S)

EN 758: T 46 4 P M 1 H10
T 42 2 P C 1 H5
AWS A5.20-95: E71T-1J H8
E71T-1MJ H8

BÖHLER Ti 52 W-FD

flux cored wire, unalloyed, rutile type

Description

Rutile based flux-cored wire with fast freezing slag. Excellent welding characteristics in all positions. Very good mechanical properties, easy slag removability, low spatter level, smooth and well shaped beads with x-ray-quality. Higher welding current (230 A) is applicable in out-of-position welding, which results in cost reduction due to higher productivity and less time for post-weld cleaning.

Particularly suited for welding prime coated plates in shipbuilding, steel- and bridge constructions.

Typical Composition of All-weld Metal

	C	Si	Mn	Ti
Gew-%	**0.05**	**0.5**	**1.3**	**+**

Mechanical Properties of All-weld Metal

(*)		u		u2	
yield strength R_e N/mm²:		**520**	(≥ 460)	**480**	(≥ 420)
tensile strength R_m N/mm²:		**580**	(550-640)	**540**	(530-630)
elongation A ($L_0=5d_0$) %:		**24**	(≥ 22)	**25**	(≥ 24)
impact work ISO-V KV J	+20 °C:	**140**	(≥ 130)	**130**	(≥ 100)
	-20 °C:	**110**	(≥ 54)	**100**	(≥ 54)
	-40 °C:	**95**	(≥ 54)		

(*) *u* *untreated, as-welded – shielding gas Ar + 15-25 % CO_2*
u2 *untreated, as-welded – shielding gas 100 % CO_2*

Operating Data

re-drying: if necessary
shielding gases:
Argon +15-25 % CO_2
100 % CO_2
welding with standard GMAW-facilities possible.

ø mm
1.0
1.2
1.4
1.6

=+

Base Materials

Steels up to a yield strength of 460 N/mm² (67 ksi)

S235 - S355J4G3, GE200, GE240, GE260, S235JRS1 - S235J4S, AH, DH, EH, S255N - S355N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210 - L360NB, X 42-X 60, P235G1TH, P255G1TH
ASTM A27 u. A36 Gr. all; A106 Gr. A, B A214; A 242 Gr.1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 G907 Gr. 30, 33, 36, 40; Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; AA841; A851 Gr. 1, 2; A935 Gr.45; A936 Gr. 50; API 5L X42-X60

Approvals and Certificates

TÜV-D (600.001.487), DB (42.014.03), ÜZ (42.014/1), ÖBB, GL (3YH10S)

EN 758:1997:	T 46 4 M M 2 H5
AWS A5.18-01:	E70C-6MH4
AWS A5.18M-04:	E48C-6MH4

BÖHLER HL 51-FD

GMAW flux cored wire, mild steel, metal-cored

Description

Metal-cored high-efficiency wire for semi-automatic and fully automatic joint welding of unalloyed and fine-grained constructional steels and service temperatures from -40 °C to +450 °C. Very high metal recovery between 93 and 97 % and deposition rate up to 9 kg/hr. Steady spray arc-like droplet transfer with minimal spatter formation. Good penetration, high resistance to porosity, good wetting behaviour as well as low hydrogen contents (< 5 ml/100 g deposit) are further quality features of this flux cored wire.
Minimum oxide residues permit the welding of multi passes without the need for inter-run cleaning. Ideal for horizontal and flat fillet welds. Compared to solid wires 20 % higher productivity can be achieved.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.07**	**0.7**	**1.5**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**490**	(≥ 460)
Tensile strenght R_m N/mm²:		**610**	(550 - 650)
Elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 24)
Impact work ISO-V KV J	+ 20 °C:	**130**	(≥ 100)
	- 40 °C:	**90**	(≥ 47)

(*) *u untreated, as-welded - shielding gas Ar + 15 - 25 % CO_2*

Operating Data

re-drying: not necessary
shielding gases:
Argon + 15 - 25 % CO_2
Welding with standard GMAW-facilities possible.

ø mm
1.2
1.6

=+

Base Materials

steels up to a yield strength of 460 N/mm² (67 ksi)

S235J2G3 - S355J2G3, GE200, GE240, GE260, S235JRS1 - S235J4S, AH, DH, EH, S255N - S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210 - L360NB, P235G1TH, P255G1TH

ASTM A27 a. A36 Gr. all; A106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X60

Approvals and Certificates

TÜV-D (09928.), DB (42.014.29), ÜZ (42.014/1), ÖBB, ABS (4Sa-4YSAH5), DNV (requested), GL (4YH5S), LR (DXVudO; BF, 3S; 4YS; H5)

EN 758:	T 42 5 Z M M 2 H5
AWS A5.18-01:	E 70 C-GM H4
AWS A5.18M-01:	E 48 C-GM H4

BÖHLER HL 53-FD

Flux cored wire, unalloyed, high efficiency

Description

Metal-cored high-efficiency wire for fully automatic and semi-automatic joint welding of unalloyed and fine-grained constructional steels. The special filling composition permits very high metal recovery between 93 and 97 % and deposition rates of up to 8 kg/hr. Smooth spray transfer, minimum spattering, a very good bead profile and excellent wetting behaviour are the characteristics of HL 53-FD. Another advantage is minimum oxide formation, which allows multi-pass welding without deslagging. The hydrogen content of the weld deposit is ≤ 5 ml/100 g deposit. HL 53-FD is suitable for fillet welds and butt welds of standard constructional steels as well as for fine-grained steels in structural steel engineering. The service temperature range is -50 / +450 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.06**	**0.5**	**1.2**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u	s
yield strength R_e N/mm²:		≥ 420	**470**
tensile strength R_m N/mm²:		520-620	**530**
elongation A ($L_0 = 5d_0$) %:		≥ 22	**27**
impact work ISO-V A_V J	+20 °C:	≥ 100	**190**
	-50 °C:	(≥ 47)	

(*) *u untreated, as welded – shielding gas Ar +15-20 % CO_2*
s stress relieved, 600°C/2 h – shielding gas Ar +15-20 % CO_2

Operating Data

Rebaking: not necessary	**ø mm**
shielding gas:	1.2
Argon +15-25 % CO_2	1.6

Welding with standard welding facilities.

=+

Base Materials

Steels with yield strength ≤ 420 N/mm² (60 ksi)
S235 - S355J2G3, GE200, GE240, GE260, S235JRS1 - S235J4S, AH, DH, EH, S255N - S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210 - L360NB, X 42-X 60, P235G1TH, P255G1TH

ASTM A27 u. A36 Gr. all; A106 Gr. A, B A214; A242 Gr.1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45 572 Gr. 42, 50; A606 Gr. all A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr.45; A936 Gr. 50; API 5L X42-X60

Approvals and Certificates

TÜV-D (09968.)

BÖHLER EMS 2 // BB 24

SAW wire/flux-combination, mild steel

SAW solid wire:	
EN 756:2004:	S2
AWS A5.17-97:	EM12K
sub-arc flux:	
EN 760:1996:	SA FB 1 65 DC H5
wire/flux-combination:	
EN 756:2004:	S 38 6 FB S2
AWS A5.17-97:	F7A8-EM12K (F6P8-EM12K)
AWS A5.17M-97:	F48A6-EM12K (F43P6-EM12K)

Description

Universally applicable for constructional steels and fine grained steels, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication. The flux reacts metallurgically Mn-neutral.
The sub-arc wire/flux combination produces very good low temperature impact properties down to - 60 °C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (HD ≤ 5 ml/100 g) are further important features. The combination is ideally suited for multi-pass welding of thick plates.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.12**	**1.00**
all-weld metal %	**0.07**	**0.25**	**1.05**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**440**	(≥ 400)
Tensile strenght R_m N/mm²:		**520**	(≥ 500)
Elongation A ($L_0 = 5d_0$) %:		**33**	(≥ 26)
Impact work ISO-V KV J	+ 20 °C:	**185**	(≥ 160)
	± 0 °C:	**180**	(≥ 140)
	- 20 °C:	**170**	(≥ 100)
	- 60 °C:	**140**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm	
2.0	3.2
2.5	4.0
3.0	

=±

Base Materials

steels up to a yield strength of 400 N/mm² (56 ksi)

S235JR - S335JR, S235J2G3 - S335J2G3, P235T1 - P335T1, P235T2 - P355T2, P235GH, P265GH, S255N, P295GH, P310GH, S235JRS1 - S235J4S, S255N - S380N

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X52

Approvals and Certificates

TÜV-D (7808.), UDT. Wire: TÜV-D (02603.), KTA 1408 1 (8058.00),
DB (52.014.03), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

SAW solid wire:
EN 756:2004: S2
AWS A5.17-97: EM12K
sub-arc flux:
EN 760:1996: SA FB 1 68 AC H5
wire/flux-combination:
EN 756:2004: S 42 4 FB S2
AWS A5.17-97: F7A4-EM12K
AWS A5.17M-97: F48A4-EM12K

BÖHLER EMS 2 // BB 25

SAW wire/flux-combination, mild steel

Description

Universally applicable for constructional steels and fine grained steels, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication. The flux is active and shows some pick-up of silicon and manganese.
The sub-arc wire/flux combination produces higher strength values with very good low temperature impact properties down to -40 °C.
For information regarding the sub-arc welding flux BÖHLER BB 25 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.12**	**1.00**
all-weld metal %	**0.07**	**0.40**	**1.45**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**450**	(≥ 420)
Tensile strenght R_m N/mm²:		**530**	(≥ 500)
Elongation A ($L_0 = 5d_0$) %:		**28**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**180**	
	± 0 °C:	**130**	
	- 20 °C:	**100**	
	- 40 °C:	**90**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm	
2.0	3.2
2.5	4.0
3.0	

=±

Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235J2G3-S355J2G3, GE200, GE240, GE260, S235JRS1-S235J4S, AH, DH, EH, S255N-S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210-L360NB, P235G1TH, P255G1TH

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X56

Approvals and Certificates

TÜV-A (621), UDT. Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.03), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

BÖHLER EMS 2 // BB 33 M

SAW wire/flux-combination, mild steel

SAW solid wire:	
EN 756:2004:	S2
AWS A5.17-97:	EM12K
sub-arc flux:	
EN 760:1996:	SA AR 1 97 AC SKM
wire/flux-combination:	
EN 756:2004:	S 46 0 AR S2
AWS A5.17-97:	F7AZ-EM12K
AWS A5.17M-97:	F48A0-EM12K

Description

Universally applicable for high-speed welding of constructional steels and fine grained steels, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication.
The sub-arc wire/flux combination produces good impact properties at 0 °C and higher strength properties. Good wetting characteristics with fine rippled bead appearance at high travel speed. For information regarding the sub-arc welding flux BÖHLER BB 33 M see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.12**	**1.0**
all-weld metal %	**0.08**	**0.70**	**1.3**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**540**	(≥ 460)
Tensile strenght R_m N/mm²:		**620**	(≥ 520)
Elongation A ($L_0 = 5d_0$) %:		**29**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 60)
	± 0 °C:	**50**	(≥ 47)
	- 20 °C:	**40**	

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
275 - 325 °C, 2 h - 4 h
max. amperage of sub-arc flux: **800 A**

ø mm	
2.0	3.2
2.5	4.0
3.0	

=±

Base Materials

steels up to a yield strength of 460 N/mm² (67 ksi)

S235J0G3-S355J0G3, GE200, GE240, GE260, S235JRS1-S235J0S, AH, DH, EH, S255N-S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210-L360NB, P235G0TH, P255G0TH

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42-X60

Approvals and Certificates

TÜV-D (5685.), TÜV-A (617), UDT
Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.03), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

BÖHLER EMS 2 // BF 16

SAW wire/flux-combination, mild steel

SAW solid wire:
- EN 756:2004: S2
- AWS A5.17-97: EM12K

sub-arc flux:
- EN 760:1996: SF MS 1 78 AC M

wire/flux-combination:
- EN 756:2004: S 38 0 MS S2
- AWS A5.17-97: F6A0-EM12K
- AWS A5.17M-97: F43A2-EM12K

Description

BÖHLER BF 16 is a fused acid Si and Mn alloying flux with high current carrying capacity on both AC and DC. In combination with the wire BÖHLER EMS 2 it gives fine performance in universal applications for mild steel constructural work of thinner walled components.
For information regarding the sub-arc welding flux BÖHLER BF 16 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.12**	**1.0**
all-weld metal %	**0.04**	**0.50**	**1.3**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**400**	(≥ 380)
Tensile strenght R_m N/mm²:		**500**	(≥ 470)
Elongation A ($L_0 = 5d_0$) %:		**29**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**90**	(≥ 70)
	± 0 °C:	**60**	(≥ 47)
	- 20 °C:	**40**	(≥ 27)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
250 - 350 °C, 1 h - 10 h
max. amperage: **1300 A**

ø mm	
2.0	3.2
2.5	4.0
3.0	

=±

Base Materials

steels up to a yield strength of 380 N/mm² (50 ksi)

S235JR-S335JR, S235J0G3-S335J0G3, P235T1-P335T1, P235T2- P355T2, P235GH, P265GH, S255N, P295GH, P310GH, S235JRS1-S235J0S, S255N-S380N

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X52

Approvals and Certificates

TÜV-A (6), UDT
Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.03), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

BÖHLER EMS 3 // BB 24

SAW wire/flux-combination, mild steel

SAW solid wire:	
EN 756:2004:	S3
AWS A5.17-97:	EH10K
sub-arc flux:	
EN 760:1996:	SA FB 1 65 DC H5
wire/flux-combination:	
EN 756:2004:	S 42 4 FB S3
AWS A5.17-97:	F7A4-EH10K (F7P8-EH10K)
AWS A5.17M-97:	F48A4-EH10K (F48P6-EH10K)

Description

Universally applicable, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication. The flux reacts metallurgically Mn-neutral.
The sub-arc wire/flux combination produces higher strength values with very good low temperature impact properties. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (≤ 5 ml/100 g) are further important features. The combination is ideally suited for multi-pass welding of thick plates.
The deposit produces very good low temperature impact properties down to -40 °C.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.15**	**1.5**
all-weld metal %	**0.08**	**0.30**	**1.5**

Mechanical Properties of All-weld Metal

(*)		u
Yield strength R_e N/mm²:		(≥ 420)
Tensile strenght Rm N/mm²:		(≥ 480)
Elongation A ($L_0 = 5d_0$) %:		(≥ 24)
Impact work ISO-V KV J	+ 20 °C:	(≥ 130)
	± 0 °C:	(≥ 100)
	- 20 °C:	(≥ 70)
	- 40 °C:	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage: **800 A**

ø mm
4.0

=±

Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235J2G3 - S355J2G3, GE200, GE240, GE260, S235JRS1 - S235J4S, AH, DH, EH, S255N - S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210 - L360NB, P235G1TH, P255G1TH

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45; A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X56

Approvals and Certificates

TÜV-D (7811.). Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.04), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

SAW solid wire:
EN 756:2004: S3
AWS A5.17-97: EH10K
sub-arc flux:
EN 760:1996: SA FB 1 68 AC H5
wire/flux-combination:
EN 756:2004: S 42 3 FB S 3
AWS A5.17-97: F7A3-EH10K
AWS A5.17M-97: F48A2-EH10K

BÖHLER EMS 3 // BB 25

SAW wire/flux-combination, mild steel

Description

Universally applicable, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication. The flux reacts metallurgically active and shows some pick-up of silicon and manganese. The sub-arc wire/flux combination produces higher strength values with very good low temperature impact properties down to -30 °C.
For information regarding the sub-arc welding flux BÖHLER BB 25 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.15**	**1.5**
all-weld metal %	**0.06**	**0.40**	**1.9**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**520**	(≥ 420)
Tensile strenght R_m N/mm²:		**600**	(≥ 530)
Elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 20)
Impact work ISO-V KV J	+ 20 °C:	**140**	
	- 20 °C:	**70**	
	- 30 °C:	**50**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage: **800 A**

ø mm
4.0

=±

Base Materials

steels up to a yield strength of 420 N/mm² (60 ksi)

S235J2G3-S355J2G3, GE200, GE240, GE260, S235JRS1-S235J3S, AH, DH, EH, S255N-S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210-L360NB, P235G1TH, P255G1TH

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45, A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X56

Approvals and Certificates

Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.04), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

BÖHLER EMS 3 // BB 33 M

SAW wire/flux-combination, mild steel

SAW solid wire:
EN 756:2004: S3
AWS A5.17-97: EH10K
sub-arc flux:
EN 760:1996: SA AR 1 97 AC SKM
wire/flux-combination:
EN 756:2004: S 50 0 AR S3
AWS A5.17-97: F7AZ-EH10K
AWS A5.17M-97: F48A0-EH10K

Description

Universally applicable for high-speed welding of constructional steels and fine grained steels, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication.
The sub-arc wire/flux combination produces good impact properties at 0 °C and higher strength properties. Good wetting characteristics with fine rippled bead appearance at high travel speed. For information regarding the sub-arc welding flux BÖHLER BB 33 M see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.15**	**1.5**
all-weld metal %	**0.08**	**0.80**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm²:		**550**	(≥ 500)
Tensile strenght R_m N/mm²:		**650**	(≥ 560)
Elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 18)
Impact work ISO-V KV J	+ 20 °C:	**60**	
	± 0 °C:		(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
275 - 325 °C, 2 h - 4 h
max. amperage: **800 A**

ø mm
4.0

=±

Base Materials

steels up to a yield strength of 500 N/mm² (72 ksi)

S235J0G3 - S355J0G3, GE200, GE240, GE260, S235JRS1 - S235J0S, AH, DH, EH, S255N - S380N, P235GH, P265GH, S255N, P295GH, S235G2T, S255GT, S355GT, L210 - L360NB, P235G0TH, P255G0TH

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45, A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42-X60

Approvals

Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.04), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

BÖHLER EMS 3 // BF 16

SAW wire/flux-combination, mild steel

SAW solid wire:	
EN 756:2004:	S3
AWS A5.17-97:	EH10K
sub-arc flux:	
EN 760:1996:	SF MS 1 78 AC M
wire/flux-combination:	
EN 756:2004:	S 38 0 MS S3
AWS A5.17-97:	F6A0-EH10K
AWS A5.17M-97:	F43A3-EH10K

Description

Universally applicable, e.g. in shipbuilding, structural steel work, and pressure vessel fabrication. The wire/flux combination produces higher strength properties. BÖHLER BF 16 is a fused acid Si and Mn alloying flux with high current carrying capacity on both AC and DC. In combination with the wire BÖHLER EMS 3 it gives fine performance in universal applications for mild steel constructural work of thinner walled components.
The sub-arc wire/flux combination produces good impact properties at 0 °C.
For information regarding the sub-arc welding flux BÖHLER BF 16 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn
SAW wire wt-%	**0.12**	**0.15**	**1.5**
all-weld metal %	**0.04**	**0.50**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u	
Yield strength R_e N/mm^2:		**410**	(≥ 380)
Tensile strenght R_m N/mm^2:		**520**	(≥ 470)
Elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 22)
Impact work ISO-V KV J	+ 20 °C:	**70**	
	± 0 °C:	**55**	(≥ 47)
	- 20 °C:	**45**	
	- 30 °C:	**40**	

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
250 - 350 °C, 1 h - 10 h:
max. amperage: **1300 A**

ø mm
4.0

=±

Base Materials

steels up to a yield strength of 380 N/mm^2 (52 ksi)

S235JR - S355JR, S235J0G3 - S355J0G3, P235T1-P355T1, P235T2- P355T2, P235GH, P265GH, S255N, P295GH, P310GH, S235JRS1 - S235J0S, S355N - S420N

ASTM A36 Gr. all; A 106 Gr. A, B A214; A 242 Gr. 1-5; A266 Gr. 1, 2, 4; A283 Gr. A, B, C, D; A285 Gr. A, B, C; A299 Gr. A, B; A328; A366; A515 Gr. 60, 65, 70; A516 Gr. 55; A556 Gr. B2A; A570 Gr. 30, 33, 36, 40, 45, A572 Gr. 42, 50; A606 Gr. all; A607 Gr. 45; A656 Gr. 50, 60; A668 Gr. A, B; A907 Gr. 30, 33, 36, 40; A841; A851 Gr. 1, 2; A935 Gr. 45; A936 Gr. 50; API 5L X42 - X52

Approvals and Certificates

Wire: TÜV-D (02603.), KTA 1408 1 (8058.00), DB (52.014.04), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

EN 12536:2000:	O I
AWS A5.2-92:	R 45-G
W.Nr.:	1.0324

BÖHLER BW VII

rod for gas welding, mild steel

Description

Copper coated, unalloyed rod for gas welding for joints subject to normal stresses, up to base metal grade S275JR.
Fluid weld puddle.

Typical Composition of Welding Rod

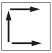
	C	Si	Mn
wt-%	**0.08**	**0.1**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u
Yield strength R_e N/mm^2:		≥ 235
Tensile strenght R_m N/mm^2:		≥ 340
Elongation A ($L_0 = 5d_0$) %:		≥ 14
Impact work ISO-V KV J	+ 20 °C:	≥ 35

(*) *u untreated, as-welded*

Operating Data



rod marking:
front: **O I**
back: **1.0324**

ø mm
2.0
2.5
3.2
4.0

Base Materials

steels up to a yield strength of 235 N/mm^2 (34 ksi)

S235JR, L195

ASTM A36 Gr. all; A283 Gr. B, C, D; A570 Gr. 33, 36, 40

Approvals and Certificates

TÜV-D (06315.), UDT, LTSS

EN 12536:2000:	O III
AWS A5.2-92:	R 60-G
W.Nr.:	1.6215

BÖHLER BW XII

rod for gas welding, mild steel

Description

Gas welding rod, nickel alloyed. Easy to operate due to very easy weld pool and slag control and good gap bridging ability.
Weld pools are not susceptible to overheating when welded with a too hot flame.

Typical Composition of Welding Rod

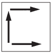
	C	Si	Mn	Ni
wt-%	**0.08**	**0.1**	**1.1**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u
Yield strength R_e N/mm²:		≥ 275
Tensile strenght R_m N/mm²:		≥ 410
Elongation A ($L_0 = 5d_0$) %:		≥ 14
Impact work ISO-V KV J	+ 20 °C:	≥ 47

(*) *u untreated, as-welded*

Operating Data



rod marking:
front: **O III**
back: **1.6215**

ø mm
2.0
2.5
3.0

Base Materials

steels up to a yield strength of 275 N/mm² (40 ksi)

S235JR - S275JR, P275GH, L235 - L290NB

ASTM A36 Gr. all; A283 Gr. B, C, D; A285 Gr. B; A414 Gr.C; A442 Gr.60; A515 Gr. 60; A516 Gr. 55, 60; A570 Gr. 33, 36, 40

Approvals and Certificates

TÜV-D (02323.), DB (70.014.01), ÜZ (./.), ÖBB, UDT

Notes

Notes

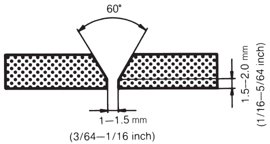
2.3. Filler Metals for Pipeline Welding

Objectives

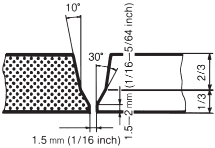
This section provides detailed product information for filler metals that may be used to weld pipelines.
The significance of oil and gas as a source of energy leads to the construction and planning of cross-country pipelines throughout the world. In this case new high-strength pipe steels place the highest possible demands on welding technology. As a result various filler metals have been developed that can cover all the requirements of individual steel qualities.

Welding procedure when using cellulosic electrodes

Recommended joint preparation

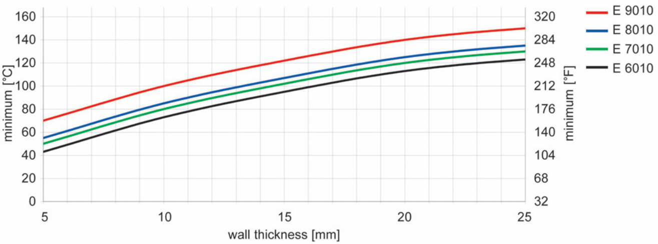


Wall thicknesses ≤ 20 mm (≤ 3/4 inch)



Wall thicknesses > 20 mm (> 3/4 inch)

Preheating and interpass temperatures in relation to wall thicknesses



Cellulose electrodes
Generally speaking the welds are performed in the vertical-down position using cellulose electrodes. The use of vertical-down electrodes makes it possible to use larger electrode diameters, higher welding currents and higher travel speeds. As a result it is possible to achieve a much higher degree of economic efficiency than with vertical-up welding.

Basic vertical-down electrodes
Basic vertical-down electrodes excel due to their outstanding mechanical and technological properties and their low hydrogen content (HD < 5 ml/100 g). They are thus suitable for welding thick-walled pipes, high-strength pipe steels or where there are high requirements for toughness. They allow the same travel speeds for filler and cover passes as cellulose electrodes.

Basic vertical up electrodes
Especially designed for welding of circumferential beads in the vertical up position. The electrodes are preferably used in cases where the imprecise joint preparation do not allow the use of the vertical down process, or vertical down skilled welders are not available. Root runs are basically welded on the minus polarity, where as for filler and cap layers the plus polarity should be applied.

Solid wires
For the sake of higher productivity and in order to reduce production costs semi/fully automated welding processes are introduced. For these applications the wire types SG3-P and NiMo 1-IG have been developed. Both wires fullfil the high quality demands applied in pipeline constructions.

Contents

Overview – Standard Classifications

Böhler	EN		AWS	
SMAW stick electrodes				
FOX CEL	EN 499:	E 38 3 C 2 1	AWS A5.1-04:	E6010
FOX CEL+	EN 499:	E 38 2 C 2 1	AWS A5.1-04:	E6010
FOX CEL 75	EN 499:	E 42 3 C 2 5	AWS A5.5-96:	E7010-P1
FOX CEL Mo	EN 499:	E 42 3 Mo C 2 5	AWS A5.5-96:	E7010-A1
FOX CEL 85	EN 499:	E 46 4 1Ni C 2 5	AWS A5.5-96:	E8010-P1
FOX CEL 90	EN 499:	E 50 3 1Ni C 2 5	AWS A5.5-96:	E9010-G
FOX BVD RP	EN 499:	E 46 3 B 4 5 H5	AWS A5.5-96:	E8018-G
FOX BVD 85	EN 499:	E 46 5 1Ni B 4 5 H5	AWS A5.5-96:	E8018-G
FOX BVD 90	EN 757:	E 55 5 Z2Ni B 4 5 H5	AWS A5.5-96:	E9018-G
FOX BVD 100	EN 757:	E 62 5 Z2Ni B 4 5 H5	AWS A5.5-96:	E10018-G
FOX BVD 110	EN 757:	E 69 3 Mn2NiMo B 4 5 H5	AWS A5.5-96:	E11018-G
FOX BVD 120	EN 757:	E 69 3 Mn2NiMo B 4 5 H5	AWS A5.5-96:	E12018-G
FOX EV PIPE	EN 499:	E 42 4 B 1 2 H5	AWS A5.1-04:	E7016-1H4R
FOX EV 60 PIPE	EN 499:	E 50 41 Ni B 1 2 H5	AWS A5.5-96:	E8016-GH4R
FOX EV 70 PIPE	EN 757:	E 55 4 Z(Mn2NiMo) B 12 H5	AWS A5.5-96:	E9016-GH4R
GTAW rod				
I 52 Ni	EN 1668:	W 3 Ni 1	AWS A5.18:	ER80S-Ni1
GMAW solid wires				
SG 3-P	EN 440:	G 46 5 M G0 G4 SI1 G 42 4 C G0 G4 SI1	AWS A5.18-01:	ER70S-G
K-Nova Ni	EN 440:	G 3 Ni 1	AWS A5.28-96:	ER80S-G
NiMo 1-IG	EN 12534:	G 55 6 M Mn3Ni1Mo G 55 4 C Mn3Ni1Mo	AWS A5.28-96:	ER90S-G

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	Ti
SMAW stick electrodes							
FOX CEL	0.12	0.14	0.5				
FOX CEL+	0.17	0.15	0.6				
FOX CEL 75	0.14	0.14	0.7				
FOX CEL Mo	0.1	0.14	0.4			0.5	
FOX CEL 85	0.14	0.1	0.7		0.6		
FOX CEL 90	0.17	0.15	0.9		0.8		
FOX BVD RP	0.05	0.3	1.0				
FOX BVD 85	0.04	0.4	0.9		0.9		
FOX BVD 90	0.04	0.3	1.2		2.2		
FOX BVD 100	0.07	0.4	1.2		2.3		
FOX BVD 110	0.07	0.4	1.5		2.0	0.3	
FOX BVD 120	0.07	0.4	1.85		2.25	0.35	
FOX EV PIPE	0.06	0.6	0.9		0.17		
FOX EV 60 PIPE	0.07	0.6	1.2		0.9		
FOX EV 70 PIPE	0.06	0.5	1.7		2.2	0.3	
GTAW rod							
I 52 Ni	0.07	0.7	1.6		0.9		
GMAW solid wires							
SG 3-P	0.05	0.75	1.5				+
K Nova Ni	0.06	0.7	1.5		0.9		+
NiMo 1-IG	0.08	0.6	1.8		0.9	0.3	

EN 499:1994:	E 38 3 C 2 1
AWS A5.1-04:	E6010
AWS A5.1M-04:	E4310

BÖHLER FOX CEL

SMAW stick electrode for vertical-down welding, cellulosic coated, pipe welding

Description

Cellulose-coated electrode for vertical-down welding of large diameter pipelines; suitable for root runs, hot passes, filler and cover layers. Especially recommended for root run welding. Highly economical compared with vertical-up welding. Apart from its excellent welding and gap bridging characteristics FOX CEL offers a weld deposit with outstanding impact strength values and thus offers the benefit of still more safety in field welding of pipelines. It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.12**	**0.14**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**450**	(≥ 390)
tensile strength R_m N/mm²:		**520**	(470 - 540)
elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 70)
	± 0 °C:	**105**	
	- 20 °C:	**95**	
	- 30 °C:	**65**	(≥ 47)
	- 40 °C:	**45**	

(*) *u untreated, as-welded*

Operating Data

re-drying: **not allowed**
electrode identification:
FOX CEL 6010 E 38 3 C
preheating and interpass temperature
see Page 2-49

ø mm	L mm	amps A
2.5	250/300	50 - 90
3.2	350	80 - 130
4.0	350	120 - 180
5.0	350	160 - 210

=±
polarity negative for root pass

Base Materials

S235JR, S275JR, S235J2G3, S275J2G3, S355J2G3, P235GH, P265GH,
P355T1, P235T2 - P355T2, L210NB - L415NB, L290MB - L415MB,
P235G1TH, P255G1TH
Root pass up to L555NB, L555MB
API Spec. 5 L: A, B, X 42, X 46, X 52, X 56, Root pass up to X 80

Approvals and Certificates

TÜV-D (1281.), TÜV-A (1), CL (0366), DNV (3), FI (E 38 3 C 21), ISPESL (X), Statoil, UDT, SEPROZ, PDO; VNIIST(ø3.2-4.0 mm)

EN 499:1994:	E 38 2 C 2 1
AWS A5.1-04:	E6010
AWS A5.1M-04:	E4310

BÖHLER FOX CEL+

SMAW stick electrode, un-alloyed, pipe welding

Description

Cellulose-coated electrode for vertical-down welding of large diameter pipelines.
Especially recommended for root pass welding on D.C. positive polarity in the vertical down and vertical up welding positions.
Apart from its good welding and gap bridging characteristics Böhler FOX CEL+ provides a powerful arc that deposites well penetrated, smooth root passes with high travel speeds as well as high safety against the formation of piping or hollow bead and undercut.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.17**	**0.15**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**450**	(≥ 390)
tensile strength R_m N/mm^2:		**520**	(470 - 540)
elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**105**	(≥ 70)
	± 0 °C:	**95**	
	- 20 °C:	**65**	(≥ 47)
	- 30 °C:		(≥ 27)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying: **not allowed**	**ø mm**	**L mm**	**amps A**
electrode identification:	2.5	300	50 - 90
FOX CEL+ 6010 E 38 2 C	3.2	350	80 - 130
preheating and interpass temperature	4.0	350	120 - 180
see Page 2-49			

=+

Base Materials

S235JR, S275JR, S235J2G3, S275J2G3, S355J2G3, P235GH, P265GH, P355T1, P235T2 - P355T2, L210NB - L415NB, L290MB - L415MB, P235G1TH, P255G1TH
Root pass up to L555NB, L555MB
API Spec. 5 L: A, B, X 42, X 46, X 52, X 56, Root pass up to X 80

Approvals and Certificates

–

EN 499:1994: E 42 3 C 2 5
AWS A5.5-96: E7010-P1

BÖHLER FOX CEL 75

SMAW stick electrode for vertical-down welding, un-alloyed, pipe welding

Description

Cellulose-coated electrode for vertical-down welding of high strength large diameter pipelines. Especially recommended for hot passes, filler and cover layers. Highly economical compared with conventional vertical-up welding. The penetrating arc characteristics and the low slag formation allow good bead control and ensure best performance in all positions even with the larger diameter electrodes and high amperages
It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.14**	**0.14**	**0.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**480**	(≥ 420)
tensile strength R_m N/mm²:		**550**	(510 - 610)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 85)
	± 0 °C:	**95**	
	- 20 °C:	**85**	
	- 30 °C:	**55**	(≥ 47)
	- 40 °C:	**45**	(≥ 27)

(*) *u untreated, as-welded*

Operating Data

re-drying: **not allowed**
electrode identification:
FOX CEL 75 7010-P1 E 42 3 C
preheating and interpass temperature
see Page 2-49

ø mm	L mm	amps A
3.2	350	80 - 130
4.0	350	120 - 180
5.0	350	160 - 210

=±
polarity negative for root pass

Base Materials

S235JR, S275JR, S235J2G3, S275J2G3, S355J2G3, P235GH, P265GH,
L210 - L415NB, L290MB - L415MB, P355T1, P235T2 - P355T2,
P235G1TH, P255G1TH
Root pass up to L480MB
API Spec. 5 L: Grade A, B, X 42, X 46, X 52, **X 56, X 60,** Root pass up to X 70

Approvals and Certificates

TÜV-A (533), CL (0553), FI (E 42 3 C 25), UDT

EN 499:1994:	E 42 3 Mo C 2 5
AWS A5.5-96:	E7010-A1

BÖHLER FOX CEL Mo

SMAW stick electrode for vertical-down welding cellulosic coating, pipe welding

Description

Cellulose-coated electrode for vertical-down welding of high strength large diameter pipelines. Highly economical compared with conventional vertical-up welding.
Especially recommended for hot passes, filler and cover layers. Besides the excellent weld metal toughness properties it offers easy operation, and a concentrated intensive arc with deep penetration characteristics in order to ensure sound joint welds with good X-ray quality.
It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn	Mo
wt-%	**0.1**	**0.14**	**0.4**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**480**	(≥ 420)
tensile strength R_m N/mm^2:		**550**	(510 - 590)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 70)
	± 0 °C:	**95**	
	- 20 °C:	**85**	
	- 30 °C:	**50**	(≥ 47)
	- 40 °C:	**42**	

(*) *u untreated, as-welded*

Operating Data

re-drying: **not allowed**
electrode identification:
FOX CEL Mo 7010-A1 E 42 3 Mo C
preheating and interpass temperature
see Page 2-49

ø mm	L mm	amps A
3.2	350	80 - 130
4.0	350	120 - 180
5.0	350	160 - 210

=±

polarity negative for root pass

Base Materials

S235JR, S275JR, S235J2G3, S275J2G3, S355J2G3, P235GH, P265GH,
L210 - L415NB, L290MB - L415MB, P355T1, P235T2 - P355T2,
P235G1TH, P255G1TH
Root pass up to L555MB
API Spec. 5 L: Grade A, B, X 42, X 46, X 52, **X 56, X 60,** Root pass up to X 80

Approvals and Certificates

TÜV-D (1325.), TÜV-A (2), ABS (E 7010-A1), CL (0960), ISPESL (X), UDT, SEPROZ, VNIST(ø4.0 mm)

EN 499:1994: E 46 4 1Ni C 2 5
AWS A5.5-96: E8010-P1

BÖHLER FOX CEL 85

SMAW stick electrode for vertical-down welding, cellulosic coating, pipe welding

Description

Cellulose-coated electrode for vertical-down welding of high strength large diameter pipelines. Highly economical compared with conventional vertical-up welding.
Especially recommended for hot passes, filler and cover layers. Without doubt BÖHLER FOX CEL 85 is the most popular cellulosic electrode which meets all the exacting demands of the field welding of cross country pipelines extremely well. It ensures highest joint weld quality down to temperatures of -40 °C
It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.14**	**0.1**	**0.7**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**490**	(≥ 460)
tensile strength R_m N/mm²:		**570**	(550 - 650)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 80)
	± 0 °C:	**105**	
	- 20 °C:	**100**	
	- 40 °C:	**70**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying: **not allowed**
electrode identification:
FOX CEL 85 8010-P1 E 46 4 1Ni C
preheating and interpass temperature
see Page 2-49

ø mm	L mm	amps A
3.2	350	80 - 130
4.0	350	120 - 180
5.0	350	160 - 210

=+

Base Materials

L415NB - L485NB, L415MB - L485MB
API Spec. 5 L: X 56, **X 60, X 65, X 70**

Approvals and Certificates

TÜV-D (1361.), TÜV-A (3), ABS (E 8010-P1), CL (0809), FI (E 46 4 1Ni C 25), GdF (X), ISPESL (X), UDT, SEPROZ, GdFø3.2;4.0;5.0 mm, PDO

EN 499:1994: E 50 3 1Ni C 2 5
AWS A5.5-96: E9010-G

BÖHLER FOX CEL 90

SMAW stick electrode for vertical-down welding
cellulosic coating, pipe welding

Description

Cellulose-coated electrode for vertical-down welding of high strength large diameter pipelines.
Highly economical compared with conventional vertical-up welding.
Especially recommended for hot passes, filler and cover layers.
The special design of the coating and the core wire guarantees the highest metallurgical quality & soundness of the weld metal deposit with excellent mechanical properties. The electrode allows good weld pool visability, and easy manipulation in all positions, as well as high safety margins against porosity and slag inclusions.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.17**	**0.15**	**0.9**	**0.8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**610**	(≥ 530)
tensile strength R_m N/mm²:		**650**	(620 - 720)
elongation A ($L_0 = 5d_0$) %:		**21**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 80)
	± 0 °C:	**90**	
	- 20 °C:	**75**	
	- 30 °C:	**65**	(≥ 47)
	- 40 °C:	**40**	(≥ 27)

(*) *u untreated, as-welded*

Operating Data

re-drying: **not allowed**
electrode identification:
FOX CEL 90 9010-G E 50 3 1Ni C
preheating and interpass temperature
see Page 2-49

ø mm	L mm	amps A
4.0	350	120 - 180
5.0	350	160 - 210

=+

Base Materials

L450MB, L485MB, L555MB
API Spec. 5 L: X 65, **X 70,** X 80

Approvals and Certificates

TÜV-D (1324.), TÜV-A (4), CL (0564), GdF (X), ISPESL (X), Statoil, UDT, SEPROZ,
GdF ø3.2; 4.0; 5.0 mm; VNIIST

EN 499:1994:	E 46 3 B 4 1 H5
AWS A5.5-96:	E8018-G

BÖHLER FOX BVD RP

SMAW stick electrode for vertical-down welding, basic coating, pipe welding

Description

Basic coated electrode for vertical-down welding of root passes in pipeline construction and structural work. Also suitable for vertical- up welding of root passes. The deposit is extremely crack resistant and features high toughness and a very low hydrogen content (HD < 5 ml/100 g). Highly economical compared with conventional vertical-up welding.
It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.05**	**0.3**	**1.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**510**	(≥ 460)
tensile strength R_m N/mm^2:		**560**	(550 - 650)
elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 130)
	± 0 °C:	**150**	
	- 20 °C:	**120**	
	- 30 °C:	**60**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX BVD RP 8018-G E 46 3 B

ø mm	**L mm**	**amps A**
2.5	350	80 - 110
3.2	350	100 - 160

=+

Base Materials

root passes for following steels:
S235J2G3 - S355J2G3, L290NB - L415NB, L290MB - L555MB,
P235GH - P310GH
API Spec. 5 L: X 42, X 46, X 52, X 56, X 60, X 70, X 80

Approvals and Certificates

TÜV-D (03532.), UDT, SEPROZ

EN 499:1994:	E 46 5 1Ni B 4 5 H5
AWS A5.5-96:	E8018-G

BÖHLER FOX BVD 85

SMAW stick electrode for vertical-down welding, basic coating, pipe welding

Description

Basic coated electrodes for vertical-down welds of large diameter pipelines and for structural work. Suitable for filler and cover pass welding in pipeline construction. Deposit is extremely crack resistant, and features high toughness and a very low hydrogen content (HD < 5 ml/100 g). Deposition rate is 80-100 % higher than for vertical up welding. The weld deposit of BÖHLER FOX BVD 85 shows an ideal combination between high strength and cryogenic toughness down to - 50 °C (- 58 °F). Special design and development work has enabled this electrode to provide exceptional striking characteristics and the avoidance of start porosity on cover (cap) passes. Due to this and the good welding characteristics this special basic electrode offers easy handling even under field conditions.
It can be used in sour gas applications (HIC-Test acc. NACE TM-02-84). Test values for SSC-test are available too.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.04**	**0.4**	**0.9**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**510**	(≥ 460)
tensile strength R_m N/mm^2:		**560**	(550 - 650)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 130)
	± 0 °C:	**150**	
	- 20 °C:	**120**	
	- 40 °C:	**85**	(≥ 60)
	- 50 °C:	**65**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX BVD 85 8018-G E 46 5 1Ni B

ø mm	L mm	amps A
3.2	350	110 - 160
4.0	350	180 - 210
4.5	350	200 - 240

=+

Base Materials

S235J2G3 - S355J2G3, L290NB - L450NB, L290MB - L450MB,
P235GH - P295GH
API Spec. 5 L: A, B, X 42, X46, **X 52, X 56, X 60, X 65**

Approvals and Certificates

TÜV-D (03531.), CL (1404), GdF, UDT, SEPROZ

EN 757:1997: E 55 5 Z2Ni B 4 5 H5
AWS A5.5-96: E9018-G

BÖHLER FOX BVD 90

SMAW stick electrode for vertical-down welding, basic coating, pipe welding

Description

Basic coated electrodes for vertical-down welds of large diameter pipelines and for structural work. Suitable for filler and cover pass welding in pipeline construction. Deposit is extremely crack resistant, and features high toughness and a very low hydrogen content (HD < 5 ml/100 g). Special design and development work has enabled this electrode to provide exceptional striking characteristics and the avoidance of start porosity on cover (cap) passes. Due to this and the good welding characteristics this special basic electrode offers easy handling even under field conditions. Deposition rate is 80-100 % higher than for vertical up welding.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.04**	**0.3**	**1.2**	**2.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**600**	(≥ 550)
tensile strength R_m N/mm^2:		**650**	(620 - 720)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 120)
	± 0 °C:	**145**	
	- 20 °C:	**130**	
	- 40 °C:	**110**	
	- 50 °C:	**80**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
300 - 350 °C, min. 2 h	3.2	350	110 - 160
electrode identification:	4.0	350	180 - 210
FOX BVD 90 9018-G E 55 5 Z 2Ni B	4.5	350	200 - 240

=+

Base Materials

L485MB, L555MB
API Spec. 5 L: X 70, X 80

Approvals and Certificates

TÜV-D (03402.), CL (1178), GdF (X), Statoil, UDT, GdF ø3.2; 4.0; 5.0 mm, SEPROZ

EN 757:1997: E 62 5 Z2Ni B 4 5 H5
AWS A5.5-96: E10018-G

BÖHLER FOX BVD 100

SMAW stick electrode for vertical-down welding, basic coating, pipe welding

Description

Basic coated electrodes for vertical-down welds of large diameter pipelines and for structural work. Suitable for filler and cover pass welding in pipeline construction. Deposit is extremely crack resistant, and features high toughness and a very low hydrogen content (HD < 5 ml/100 g). Special design and development work has enabled this electrode to provide exceptional striking characteristics and the avoidance of start porosity on cover (cap) passes. Due to this and the good welding characteristics this special basic electrode offers easy handling even under field conditions. Deposition rate is 80-100 % higher than for vertical up welding.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.07**	**0.4**	**1.2**	**2.3**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**670**	(≥ 620)
tensile strength R_m N/mm²:		**730**	(690 - 810)
elongation A ($L_0 = 5d_0$) %:		**24**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 110)
	± 0 °C:	**125**	
	- 20 °C:	**120**	
	- 50 °C:	**70**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX BVD 100 10018-G E 62 5 Z2Ni B
Recommended interpass temperature > 100 °C

ø mm	**L mm**	**amps A**
4.0	350	180 - 210
4.5	350	200 - 240

=+

Base Materials

L555MB
API Spec. 5 L: X 80

Approvals and Certificates

TÜV-D (06333.), UDT, SEPROZ

EN 757:1997: E 69 3 Mn2NiMo B 4 5 H5
AWS A5.5-96: E11018-G

BÖHLER FOX BVD 110

SMAW stick electrode for vertical-down welding, basic coating, pipe welding

Description

Basic coated electrodes for vertical-down welds of large diameter pipelines and for structural work. Suitable for filler and cover pass welding in pipeline construction. Deposit is extremely crack resistant, and features high toughness and a very low hydrogen content (HD < 5 ml/100 g). Deposition rate is 80-100 % higher than for vertical up welding.
This stick electrode has become optimised for best striking properties and for avoiding start porosity in the cap layer. With its excellent welding properties the electrode offers easy handling also under difficult conditions.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni	Mo
wt-%	**0.07**	**0.4**	**1.5**	**2.0**	**0.3**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**720**	(≥ 690)
tensile strength R_m N/mm^2:		**810**	(≥ 760)
elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 17)
impact work ISO-V KV J	+ 20 °C:	**90**	(≥ 80)
	- 20 °C:	**70**	(≥ 50)
	- 40 °C:	**50**	(≥ 40)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:	**ø mm**	**L mm**	**amps A**
300 - 350 °C, min. 2 h	4.0	350	180-210
electrode identification:	4.5	350	200-240

FOX BVD 110 11018-G E 69 3 Mn2NiMo B
Recommended interpass temperature > 110 °C

=+

Base Materials

L690*
API Spec. 5 L: X100*
* not standardised yet

Approvals and Certificates

SEPROZ

EN 757: 1997: E 69 3 Mn2NiMo B 4 5 H5
AWS A5.5-96: E12018-G

BÖHLER FOX BVD 120

SMAW stick electrode for vertical-down welding basic coating, pipe welding

Description

Basic coated electrodes for vertical-down welds of large diameter pipelines and for structural work. Suitable for filler and cover pass welding in pipeline construction. Deposit is extremely crack resistant, and features high toughness and a very low hydrogen content (according AWS condition HD <4ml/100 g). Deposition rate is 80-100 % higher than for vertical up welding. This stick electrode is optimised for best striking properties and for avoiding start porosity in the cap layer. With its excellent welding properties the electrode offers easy handling also under difficult conditions.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni	Mo
wt-%	**0.07**	**0.4**	**1.85**	**2.25**	**0.35**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**815**	(≥ 740)
tensile strength Rm N/mm^2:		**870**	(≥ 830)
elongation A (L0=5d0) %:		**18**	(≥ 17)
impact work ISO-V KV J	+20 °C:	**80**	(≥ 80)
	-20 °C:	**60**	(≥ 50)
	-40 °C:	**50**	(≥ 40)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary
300-350 °C, min. 2 h
electrode identification:
FOX BVD 120 12018-G E 69 3 Mn2NiMo B
Recommended interpass temperature >120 °C

ø mm	L mm	amps A
3.2	350	110-160
4.0	350	180-220

=+

Base Materials

EN: L690[1)]
API Spec. 5 L: X100[1)], X110[1)]

[1)] not standardised yet

EN 499:1994: E 42 4 B 1 2 H5
AWS A5.1-04: E7016-1H4 R
AWS A5.1M-04: E4916-1H4 R

BÖHLER FOX EV PIPE

SMAW stick electrode for vertical-up welding, basic coating, pipe welding

Description

BÖHLER FOX EV PIPE is a basic coated electrode with some additions of rutile and silicates. It is excellent suited for positional welding of root passes using D.C. negative polarity as well as for filler and cover passes of pipes, tubes and plates on D.C. positive polarity, or even AC. It is user friendly and provides a good gap bridging ability together with easy slag removal to ensure minimum grinding. Weld metal toughness is available down to -46 °C; very low hydrogen content (HD < 5 ml/100 g). BÖHLER FOX EV PIPE offers considerable time savings against AWS E 7018 type electrodes when welding root passes due to increased travel speeds. Also the use of dia. 3.2 mm is possible for root passes in case of wall thicknesses of 8 mm and more.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.06**	**0.6**	**0.9**	**0.17**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**470**	(≥ 420)
tensile strength R_m N/mm^2:		**560**	(520 - 640)
elongation A ($L_0 = 5d_0$) %:		**29**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 120)
	- 20 °C:	**100**	
	- 40 °C:	**60**	(≥ 47)
	- 46 °C:	**55**	(≥ 27)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX EV PIPE 7016-1 E 42 4 B

ø mm	**L mm**	**amps A**
2.0	300	30 - 60
2.5	300	40 - 90
3.2	350	60 - 130
4.0	350	110 - 180

polarity negative for root pass

Preheated and interpass temperatures as required by the base material. The optimum gap width for root passes is 2 - 3 mm, the root face should be in the range 2 - 2.5 mm. The electrodes are ready for use straight from the hermetically sealed tins.

Base Materials

EN	P235GH, P265GH, P295GH, P235T1, P275T1, P235G2TH, P255G1TH, S255N - S420N[1], S255NL1 up to S420NL1, L290NB up to L360NB, L290MB up to L415MB, L450MB[2] up to L555MB[2]
API Spec. 5L:	X 42, X46, X52, X56, X60, X65-X80[2]
ASTM	A53 Gr. A-B, A106 Gr. A-C, A179, A192, A210 Gr. A-1

[1] stress relieved up to S380N / S380NL1
[2] only for root pass

Approvals and Certificates

TÜV-D (7620.), CL (1469), UDT, LTSS, SEPROZ, VNIIST, VNIIGAZ

EN 499:1994: E 50 4 1 Ni B 1 2 H5
AWS A5.5-96: E8016-GH4 R

BÖHLER FOX EV 60 PIPE

SMAW stick electrode for vertical up welding, basic coating, pipe welding

Description

Basic coated electrode excellent suited for positional welding of root passes using D.C. negative polarity as well as for filler and cover passes for pipes, tubes and plates on D.C. positive polarity, or even A.C. The electrode offers considerable time savings against AWS E 8018 type electrodes when welding root passes due to increased travel speeds.
Good impact properties down to - 40 °C, low hydrogen content (HD < 5 ml/100 g), as well as packaging in hermetically sealed tins are further features for the user. BÖHLER FOX EV 60 PIPE offers considerable time savings against AWS E 8018 type electrodes when welding root passes due to increased travel speeds. Also the use of dia. 3.2 mm is possible for root passes in case of wall thicknesses of 8 mm and more.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.07**	**0.6**	**1.2**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**550**	(≥ 500)
tensile strength R_m N/mm^2:		**590**	(560 - 720)
elongation A ($L_0 = 5d_0$) %:		**29**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 130)
	0 °C:	**150**	
	-20 °C:	**140**	
	- 40 °C:	**110**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
300 - 350 °C, min. 2 h	2.5	300	40 - 90
electrode identification:	3.2	350	60 - 130
FOX EV 60 PIPE 8016-G E 50 4 1 Ni B	4.0	350	110 - 180
	5.0	450	180 - 230

polarity negative for root pass

Preheated and interpass temperatures as required by the base material.
The optimum gap width for root passes is 2-3 mm, the root face should be in the range 2-2.5 mm. The electrodes are ready for use straight from the hermetically sealed tins.

Base Materials

EN: S235J2G3 - S355J2G3, L210NB - L450NB, L210MB - L450MB, P235GH - P295GH, E295, E335, S355J2G3, C35-C45, P310GH, S380N - S460N, P380NH-P460NH, S380NL - S460NL, S380NL1 - S460NL2, GE260-GE300

API Spec. 5 L: A, B, X 42, X46, **X 52, X 56, X 60, X 65**
ASTM A516 Gr. 65, A572 Gr. 55, 60, 65, A633 Gr. E, A612, A618 Gr. I, A537 Gr. 1-3

Approvals and Certificates

VNIIGAZ

EN 757:1997: E 55 4 Z (Mn 2Ni Mo) B 1 2 H5
AWS A5.5-96: E9016-GH4 R

BÖHLER EV 70 PIPE

SMAW stick electrode for vertical-up welding
basic coating, pipe welding

Description

BÖHLER FOX EV 70 PIPE is a high strength basic coated electrode. It is excellent suited for positional welding of root passes using D.C. negative polarity as well as for filler and cover passes of pipes, tubes and plates on D.C. positive polarity, or even A.C.
BÖHLER FOX EV 70 PIPE offers considerable time savings against AWS E 9018 type electrodes when welding root passes due to increased travel speeds. Also the use of dia. 3.2 mm is possible for root passes in case of wall thicknesses of 8 mm and more.
It is user friendly and provides a good gap bridging ability together with easy slag removal to ensure minimum grinding. Good impact properties down to -40 °C, low hydrogen content (HD < 5 ml/100 g), as well as packaging in hermetically sealed tins are further features for the user.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni	Mo
wt-%	**0.06**	**0.50**	**1.7**	**2.2**	**0.3**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**620**	(≥ 550)
tensile strength R_m N/mm²:		**680**	(630 - 780)
elongation A (L_0 = 5d0) %:		**20**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 90)
	- 20 °C:	**80**	
	- 40 °C:	**70**	(≥ 47)

u untreated, as-welded

Operating Data

re-drying: **300-350 °C, min. 2 h**
electrode identification:
FOX EV 70 PIPE 9016-G

ø mm	**L mm**	**amps A**
2.5	300	40 - 90
3.2	350	60 - 130
4.0	350	110 - 180

polarity negative for root pass

Preheat and interpass temperature as required by the base material. The optimum gap width for root passes is 2-3 mm, the root face should be in the range 2-2.5 mm. The electrodes are ready for use straight from the hermetically sealed tins.

Base Materials

EN: L450MB, L485MB, L555MB
API Spec. 5 L: X 65, X 70, X 80

Approvals and Certificates

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EN 440:1995:	G4Si1 (for wire)
EN 440:1995:	G 46 5 M G0 G4 Si1
	G 42 4 C G0 G4 Si1
AWS A5.18-01:	ER70S-G
AWS A5.18M-01:	ER485S-G

BÖHLER SG 3-P

GMAW solid wire for automatic welding, pipe welding

Description

BÖHLER SG 3-P is a micro alloyed GMAW solid wire designed for high quality automatic welding of pipelines. An optimum balanced alloying concept ensures good weld metal properties to fulfil the high requirements in the On-Offshore-Pipeline Industry. Deposit is extremely crack resistant and the weld metal toughness is available down to -50 °C.
The very important quality aspects, prerequisite for uninterrupted feedability of the solid wire e.g. helix of the wire, copper coating, close wire diameter tolerance and precision layer wound spooling are taken into account during the production.

Typical Composition of Solid Wire

	C	Si	Mn	Ti
wt-%	**0.05**	**0.75**	**1.5**	**+**

Mechanical Properties of All-weld Metal

(*)		u1		u2	
yield strength R_e N/mm²:		**510**	(≥ 470)	**470**	(≥ 440)
tensile strength R_m N/mm²:		**640**	(600 - 680)	**610**	(570 - 640)
elongation A (L_0 = 5d0) %:		**25**	(≥ 24)	**26**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 100)	**100**	(≥ 95)
	- 40 °C:	**75**	(≥ 65)	**60**	(≥ 47)
	- 50 °C:	**55**	(≥ 47)		

(*) *u1 untreated, as-welded - shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded - shielding gas 100 % CO_2

Operating Data

shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm
0.9

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

EN:	L290MB - L485MB
API Spez. 5L:	X42, X46, X52, X56, X60, X65

Approvals and Certificates

TÜV-D (07682.), UDT

EN 440:1995:	G3Ni1
EN 440:1995:	G 42 5 M G3Ni1
AWS A5.28-96:	ER80S-G

BÖHLER K NOVA Ni

GMAW solid wire
for automatic welding

Description

GMAW wire micro alloyed, designed for high quality automatic welding of pipelines. An optimum balanced alloying concept ensures good weld metal properties to fulfil the high requirements in the on-offshore pipeline industry. The deposit is extremely crack resistant and the weld metal offers high impact values down to -50 °C.

Typical Composition of Solid Wire

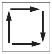
	C	Si	Mn	Ni	Ti
wt-%	**0.06**	**0.70**	**1.50**	**0.90**	**+**

Mechanical Properties of All-weld Metal

(*)		u		u1	
yield strength R_e N/mm²:		**500**	(> 420)	**470**	(> 420)
tensile strength R_m N/mm²:		**590**	(> 550)	**560**	(> 500)
elongation A ($L_0 = 5d_0$) %:		**24**	(> 20)	**25**	(> 20)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 47)	**110**	
	- 50 °C:	**80**		**45**	

(*) *u untreated, as-welded shielding gas: Ar +15-25 % CO_2*
u1 untreated, as-welded shielding gas: 100 % CO_2

Operating Data



Shielding gases	**ø mm wire**
Argon +15-25 % CO_2	0.9
Argon +0-5 % CO_2 +3-10 % O_2	1.0
100 % CO_2	1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

API5L:	X 42 – X 70 (X 80)
EN 10208-2:	L290MB – L485MB
DIN 17172:	StE290TM up to StE480.7TM

Approvals and Certificates

DNV

EN 12534:1999:	Mn3Ni1Mo (for wire)
EN 12534:1999:	G 55 6 M Mn3Ni1Mo
	G 55 4 C Mn3Ni1Mo
AWS A5.28-96:	ER90S-G

BÖHLER NiMo 1-IG

GMAW solid wire for automatic welding, pipe welding

Description

Copper coated GMAW wire for high strength, quenched and tempered fine-grained constructional steels. The wire is suited for joint welding in boiler, pressure vessel, pipeline, and crane construction as well as in structural steel engineering. The typical composition of the wire fulfils the requirements of the NORSOK-regulation for „water injection systems".
Due to the precise addition of micro alloying elements NiMo1-IG wire features excellent ductility and crack resistance in spite of its high strength. Good cryogenic impact energy down to -60 °C, low hydrogen contents in the deposit, best feedability and low copper contents are other advantages of this wire.

Typical Composition of Solid Wire

	C	Si	Mn	Mo	Ni
wt-%	**0.08**	**0.6**	**1.8**	**0.3**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u		u2	
yield strength R_e N/mm²:		**620**	(≥ 550)	**590**	(≥ 550)
tensile strength R_m N/mm²:		**700**	(650 - 800)	**680**	(620 - 770)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 20)	**22**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 120)	**120**	(≥ 100)
	- 40 °C:	**110**	(≥ 90)		(≥ 47)
	- 60 °C:		(≥ 47)		

(*) *u untreated, as-welded - shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded - shielding gas 100 % CO_2

Operating Data

shielding gases:	**ø mm**
Argon + 15 - 25 % CO_2	0.9
Argon + 0.5 % CO_2 + 3–10 % O_2	1.0
100 % CO_2	

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

pipe steels and fine-grained steels
S460N - S500N, S460NL - S500NL, S500NC - S550NC, L480MB, L555MB
quenched and tempered fine-grained steels
e. g. N-A-XTRA 56-70, BHV 70, PAS 700, HSM 700, 20MnMoNi5-5
API Spec. 5L: X 70, X 80

Approvals and Certificates

DB (42.014.06), ÜZ (42.014/4), ÖBB, GL (4Y56S), UDT, SEPROZ

Notes

2.4. Filler Metals for Weather-resistant, High-strength and Cryogenic Steels

Objectives

This section provides detailed product information for filler metals that may be used to weld weather-resistant, high-tensile and cryogenic steels.

Weather-resistant steels are used in all areas of structural steel engineering and light-gauge steel construction, amongst other things for overhead wire and overhead trolley wire masts, in the form of rod and sectional steel, light-gauge sheets and heavy plates. Due to their excellent strength properties they may also be used for higher operating temperatures (over 400 °C) although in this case the proof stress decreases considerably.

High-tensile steels may be used down to very low temperatures in structural steel engineering and plant construction, the construction of vehicles, wagons and agricultural machinery for welded structures subject to high static and dynamic loads. The cryogenic qualities and special qualities of steel may be used down to -60 °C without fear of brittle fracture. Generally speaking it should be noted that increased care must be taken during fabrication and a structural design suitable for welding and withstanding stress is an essential prerequisite since the minimum values of the yield stress rise as the wall thickness increases.

Cryogenic steels are intended for components subject to static and dynamic loads at operating temperatures below -40 °C in gas liquefaction plants in the processing of mineral oil, for fractionated distillation of hydrocarbons, for the transport of liquefied natural gas and in air liquefaction plants. Consult the building regulations for pressurised vessels with regard to special applications.

Contents

Overview – Classifications

Böhler	EN	AWS	
SMAW stick electrodes			
FOX NiCuCr	EN 499: E 46 4 Z (NiCrCu) B 4 2 H5	AWS A5.5-96:	E8018-W2H4R
FOX EV 60	EN 499: E 46 6 1Ni B 4 2 H5	AWS A5.5-96:	E8018-C3H4R
FOX EV 63	EN 499: E 50 4 B 4 2 H5	AWS A5.5-96:	E8018-GH4R
FOX EV 65	EN 757: E 55 6 1NiMo B 4 2 H5	AWS A5.5-96:	E8018-GH4R E8018-D1H4R (mod.)
FOX EV 70	EN 757: E 55 6 1NiMo B 4 2 H5	AWS A5.5-96:	E9018-GH4R E9018-D1H4R (mod.)
FOX EV 70 Mo	EN 757: E 55 3 MnMo B T 4 2 H10	AWS A5.5-96:	E9018-G E9018-D1(mod.)
FOX NiMo 100	EN 757: E 62 4 Mn1NiMoB 42 H5	AWS A5.5-96:	E10018-G (E10018-D2mod.)
FOX EV 75	EN 757: E 62 6 Mn2NiCrMo B42 H5	AWS A5.5-96:	E10018-GH4R E10018-MH4R(mod.)
FOX EV 85	EN 757: E 69 6 Mn2NiCrMo B42 H5	AWS A5.5-96:	E11018-GH4R E11018-MH4R(mod.)
FOX EV 85 M	–	AWS A5.5-96:	E11018-MH4R
FOX EV 100	EN 757: E 89 4 Mn2Ni1CrMoB42 H5	AWS A5.5-96:	E12018G
FOX 2.5 Ni	EN 499: E 46 8 2Ni B 4 2 H5	AWS A5.5-96:	E8018-C1H4R
GTAW rods			
DMO-IG	EN 1668: W 46 3 W2Mo	AWS A5.28-96:	ER80S-G ER70S-A1
I 52 Ni	EN 1668: W 3 Ni 1	AWS A5.18:	ER80S-Ni1
2.5 Ni-IG	EN 1668: W 50 8 W2Ni2	AWS A5.28-96:	ER80S-Ni2
GMAW solid wires			
NiCu 1-IG	EN 440: G 42 4 M G0 G 42 4 C G0	AWS A5.28-96:	ER80S-G
K Nova Ni	EN 440: G 3 Ni 1	AWS A5.28-96:	ER80S-G
NiMo 1-IG	EN 12534: G 55 6 M Mn3Ni1Mo G 55 4 C Mn3Ni1Mo	AWS A5.28-96:	ER90S-G
NiCrMo 2.5-IG	EN 12534: G 69 6 M Mn3Ni2.5CrMo G 69 4 C Mn3Ni2.5CrMo	AWS A5.28-96:	ER110S-G
X 70-IG	EN 12534: G 69 5 M Mn3Ni1CrMo	AWS A5.28-96:	ER110S-G
X 90-IG	EN 12534: G 89 6 M Mn4Ni2CrMo	AWS A5.28-96:	ER120S-G
2.5 Ni-IG	EN 440: G 46 8 M G2 Ni2 G 46 6 C G2 Ni2	AWS A5.28-96:	ER80S-Ni2
Flux cored wire			
Ti 60-FD	EN 758: T 50 6 1 Ni P M 1 H5	AWS A5.20-95:	E81T1-Ni1MH8
SAW wire/flux-combinations			
3 NiMo 1-UP	EN 756: S Z3Ni1Mo	AWS A5.23-97:	EF3(mod.)
3 NiMo 1-UP/BB24	EN 756: S 50 4 FB SZ3Ni1Mo	AWS A5.23-97:	F9A4-EF3(mod.)-F3 F62A4-EF3(mod.)-F3
3 NiCrMo 2.5-UP	EN 756: S Z 3Ni2CrMo	AWS A5.23-97:	EM4(mod.)
3 NiCrMo 2.5-UP/BB 24	S 69 6 FB S Z 3Ni2CrMo	AWS A5.23-97:	F11A8-EM4(mod.)-M4 F76A6-EM4(mod.)-M4
Ni 2-UP	EN 756: S 2Ni2	AWS A5.23-97:	ENi2
Ni 2-UP/BB 24	EN 756: S 46 6 FB S2Ni2	AWS A5.23-97:	F8A8-ENi2-Ni2 F55A6-ENi2-Ni2

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	V	Cu
SMAW stick electrodes								
FOX NiCuCr	0.05	0.4	0.7	0.6	0.6			0.45
FOX EV 60	0.07	0.4	1.15		0.9			
FOX EV 63	0.06	0.7	1.7					
FOX EV 65	0.06	0.3	1.2		0.8	0.35		
FOX EV 70	0.035	0.3	1.1		0.9	0.4		
FOX EV 70 Mo	0.06	0.4	1.6			0.5		
FOX NiMo 100	0.11	0.25	1.85		0.95	0.4		
FOX EV 75	0.05	0.4	1.6	0.4	2.0	0.4		
FOX EV 85	0.05	0.4	1.7	0.4	2.0	0.5		
FOX EV 85 M	0.05	0.2	1.5	0.35	2.2	0.35		
FOX EV 100	0.06	0.35	1.8	0.7	2.5	0.5	0.07	
FOX 2.5 Ni	0.04	0.3	0.8		2.4			
GTAW rods								
DMO-IG	0.1	0.6	1.2			0.5		
2.5 Ni-IG	0.1	0.6	1.1		2.5			
GMAW solid wires								
NiCu 1-IG	0.1	0.5	1.1		0.9			0.4
K Nova Ni	0.06	0.7	1.5		0.9			Ti +
NiMo 1-IG	0.08	0.6	1.8		0.9	0.3		
NiCrMo 2.5-IG	0.08	0.6	1.4	0.30	2.5	0.4		
X 70-IG	0.1	0.6	1.6	0.25	1.3	0.25	0.1	
X 90-IG	0.1	0.8	1.8	0.35	2.25	0.6		
2.5 Ni-IG	0.1	0.6	1.1		2.5			
Flux cored wire								
Ti 60-FD	0.06	0.45	1.2		0.85			
SAW wire/flux-combinations								
3 NiMo 1-UP	0.12	0.3	1.6		1.0	0.6		
3 NiMo 1-UP/BB24	0.08	0.45	1.55		0.95	0.55		
3 NiCrMo 2.5-UP	0.12	0.15	1.5	0.6	2.3	0.55		
3 NiCrMo 2.5-UP/BB 24	0.06	0.3	1.5	0.50	2.2	0.50		
Ni 2-UP	0.11	0.1	1.0		2.25			
Ni 2-UP/BB 24	0.07	0.25	1.05		2.2			

EN 499:1994: E 46 4 Z(NiCrCu) B 4 2 H5
AWS A5.5-96: E8018-W2H4R

BÖHLER FOX NiCuCr

SMAW stick electrode, low-alloyed, weather resistant

Description

NiCuCr alloyed basic coated electrode for welding weathering resistant constructional steels such as CORTEN, PANTINAX, CORALDUR and KORRALPIN. Excellent mechanical properties, and high crack resistance even when subjected to restraint.
Metal recovery approx. 115 %. Easily weldable in all positions except vertical-down. Very low hydrogen contents (according AWS condition HD ≤ 4 ml/100 g weld metal).

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Cu
wt-%	**0.05**	**0.4**	**0.7**	**0.6**	**0.6**	**0.45**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**520**	(≥ 460)	**500**	(≥ 410)
tensile strength R_m N/mm²:		**570**	(530 - 680)	**550**	(490 - 610)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 25)	**27**	(≥ 26)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 140)	**190**	(≥ 118)
	- 30 °C:	**150**	(≥ 110)		
	- 40 °C:	**130**	(≥ 90)		

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
300 - 350 °C, min. 2 h	2.5	350	80 - 110
electrode identifikation:	3.2	350	130 - 150
FOX NiCuCr 8018-W2 E 46 4 Z B	4.0	450	150 - 190

=+

Base Materials

weather-resistant constructional steels

S235JR, S235JRW, S355JRW, S355J2G3 Cu

ASTM A36, A283 Gr. B, C

Approvals and Certificates

RMR (3 YHH), UDT

Similar-alloy Filler Metals

GMAW solid wire: NiCu 1-IG

EN 499:1994: E 46 6 1Ni B 4 2 H5
AWS A5.5-96: E8018-C3H4R

BÖHLER FOX EV 60

SMAW stick electrode, low-alloyed, high strength

Description

Basic coated MnNi alloyed electrode with excellent mechanical properties, particularly high toughness and crack resistance. For higher strength fine-grained constructional steels.
Suitable for service temperatures at – 60 °C to + 350 °C. Very good impact strength in aged condition. Metal recovery about 115 %. Easily weldable in all positions except vertical-down.
Very low hydrogen content (according AWS condition HD ≤ 4 ml/100 g weld metal).

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.07**	**0.4**	**1.15**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**510**	(≥ 460)	**480**	(≥ 460)
tensile strength R_m N/mm²:		**610**	(580 - 680)	**580**	(560 - 680)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 23)	**27**	(≥ 23)
impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 130)	**160**	(≥ 120)
	- 60 °C:	**110**	(≥ 65)		

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX EV 60 8018-C3 E 46 6 1Ni B

ø mm	L mm	amps A
2.5	350	80 - 100
3.2	350	110 - 140
4.0	450	140 - 180
5.0	450	190 - 230

=+

Base Materials

constructional steels, pipe- and vessel steels, cryogenic fine-grained steels and special grades

E295, E335, S355J2G3, C35-C45, L210 - L450NB, L245MB - L450MB, P310GH, P355 NL1 - P460NL1, P355NL2 - P460NL2, S380N - S460N, P355NH-P460NH, S380NL - S460NL, S380NL1, GE260-GE300

ASTM A516 Gr. 65, A572 Gr. 55, 60, 65, A633 Gr. E, A612, A618 Gr. I, A537 Gr. 1-3.

Approvals and Certificates

TÜV-D (1524.), TÜV-A (275), DNV (3 YHH), ISPESL (X), RMR (3 YHH), Statoil, UDT, LTSS, SEPROZ, CRS (3YH5)

EN 499:1994: E 50 4 B 4 2 H5
AWS A5.5-96: E8018-GH4R

BÖHLER FOX EV 63

SMAW stick electrode, low-alloyed, high strength

Description

Basic coated electrode for carbon and low-alloy steels of higher strength with carbon contents up to 0.6 %. Also suitable for rail joint welding.
Ductile and crack resistant weld metal. Metal recovery approx. 115 %. Weldable in all positions except vertical-down.
Very low hydrogen content (according AWS condition HD ≤ 4 ml/100 g weld metal).

Typical Composition of All-weld Metal

	C	Si	Mn
wt-%	**0.06**	**0.7**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**580**	(≥ 500)	**560**	(≥ 500)
tensile strength R_m N/mm²:		**630**	(610 - 720)	**610**	(590 - 710)
elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 22)	**26**	(≥ 24)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 140)	**130**	(≥ 100)
	- 40 °C:	**90**	(≥ 47)		

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX EV 63 8018-G E 50 4 B

ø mm	**L mm**	**amps A**
2.5	350	80 - 110
3.2	350	100 - 140
4.0	450	140 - 180
5.0	450	190 - 230

=+

Base Materials

constructional steels, pipe steels, rail steels

S355J2G3, E295 - E360, C35 - C60, S355N - S500N, P315NH - P500NH, GE200 - GE300, R0800

ASTM A225 Gr. C; A517 Gr. A, B, C, E, F, H, J, K, M, P

Approvals and Certificates

TÜV-D (0730.), DB (10.014.07), ÜZ (10.014/1), ÖBB, TÜV-A (X), RMR (3 YHH), UDT, SEPROZ

EN 757:1997:	E 55 6 1NiMo B 4 2 H5
AWS A5.5-96:	E8018-GH4R
	E8018-D1H4R(mod.)

BÖHLER FOX EV 65

SMAW stick electrode, low-alloyed, high strength

Description

Basic coated electrode with high ductility and crack resistance, for high-strength fine-grained steels. Ductile down to -60 °C. Resistant to ageing.
Easy to handle in all positions except vertical-down.
Very low hydrogen content (according AWS condition HD ≤ 4 ml/100 g weld metal).

Typical Composition of All-weld Metal

	C	Si	Mn	Ni	Mo
wt-%	**0.06**	**0.3**	**1.2**	**0.8**	**0.35**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**600**	(≥ 550)	**580**	(≥ 530)
tensile strength R_m N/mm²:		**650**	(630 - 750)	**630**	(620 - 730)
elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 20)	**25**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 130)	**160**	(≥ 120)
	- 60 °C:	**80**	(≥ 47)		

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
300 - 350 °C, min. 2 h	2.5	350	80 - 100
electrode identifikation:	3.2	350	100 - 140
FOX EV 65 8018-G E 55 6 1NiMo B	4.0	450	140 - 180

=+

Preheating and interpass temperature, as well as post weld heat treatment as required by the base metal.

Base Materials

constructional steels, pipe- and vessel steels, cryogenic fine-grained steels and special grades

E295 - E360, 20MnMoNi5-5, 22NiMoCr4-7, P355NL1 - P460NL1, P355NL2 - P460NL2, S380N - S500N, S355NH - S460NH, S380NL - S500NL, S380NL1 - S500NL1, 15NiCuMoNb5S (WB 36), 20MnMoNi5-5, 17MnMoV6-4 (WB 35), 22NiMoCr4-7

ASTM A302 Gr. A-D; A517 Gr. A, B, C, E, F, H, J, K, M, P; A225 Gr. C; A572 Gr. 65

Approvals and Certificates

TÜV-D (1802.), UDT, SEPROZ

EN 757:1997: E 55 6 1NiMo B 4 2 H5
AWS A5.5-96: E9018-GH4R
E9018-D1H4R(mod.)

BÖHLER FOX EV 70

SMAW stick electrode, low-alloyed, high strength

Description

Basic coated Mo-Ni alloyed electrode exhibiting high ductility and crack resistant for applications on high-strength fine-grained steels. Suitable for service temperatures between -60 °C and +350 °C. Metal recovery approx. 115 %. Easy to handle in all positions except vertical-down. Very low hydrogen content (according AWS condition HD ≤ 4 ml/100 g weld metal).
Preheat and interpass temperatures, as well as post weld heat treatment as required by the base metal.

Typical Composition of All-weld Metal

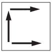
	C	Si	Mn	Ni	Mo
wt-%	**0.035**	**0.3**	**1.1**	**0.9**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**650**	(≥ 600)	**650**	(≥ 580)
tensile strength R_m N/mm²:		**700**	(680 - 780)	**700**	(660 - 780)
elongation A ($L_0 = 5d_0$) %:		**24**	(≥ 22)	**24**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**160**	(≥ 130)	**130**	(≥ 120)
	- 60 °C:	**70**	(≥ 47)		

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data



re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX EV 70 9018-G E 55 6 1NiMo B

ø mm	**L mm**	**amps A**
3.2	350	100 - 140
4.0	450	140 - 180

=+

Preheating and interpass temperature, as well as post weld heat treatment as required by the base metal.

Base Materials

high-strength fine-grained steels

S380N - S500N, P380NL - S500NL

ASTM A517 Gr. A, B, C, E, F, H, J, K, M, P; A225 Gr. C; A633 Gr. E; A572 Gr. 65

Approvals and Certificates

TÜV-D (0112.), UDT, SEPROZ

EN 757:1997: E 55 3 MnMo B T 4 2 H10
AWS A5.5-96: E9018-G
E9018-D1(mod.)

BÖHLER FOX EV 70 Mo

SMAW stick electrode, low-alloyed, high strength

Description

Basic coated Mn-Mo alloyed electrode especially suited for high-strength fine-grained constructional steels and high-temperature steels, e.g. 15NiCuMoNb5S. Crack resistant, tough and ageing resistant. Excellent weldability in all positions except vertical-down.

Typical Composition of All-weld Metal

	C	Si	Mn	Mo
wt-%	**0.06**	**0.4**	**1.6**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**580**	(≥ 550)	**580**	(≥ 550)
tensile strength R_m N/mm²:		**680**	(620 - 780)	**650**	(620 - 760)
elongation A ($L_0 = 5d_0$) %:		**22**	(≥ 20)	**23**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 120)	**160**	(≥ 120)
	- 30 °C:	**85**	(≥ 47)	**90**	(≥ 47)

(*) *u untreated, as-welded*
s stress relieved 650 °C/15 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX EV 70 Mo 9018-G E 55 3 MnMo B T

ø mm	L mm	amps A
2.5	250	70 - 100
3.2	350	110 - 140
4.0	450	140 - 180
5.0	450	180 - 240

=+

Preheating and interpass temperature, as well as post weld heat treatment as required by the base metal.

Base Materials

high-strength, fine-grained steels, rail steels up to R0800 (for joint welding)

E295 - E360, C35 - C60, P310GH, 17MnMoV6-4, 15NiCuMoNb5S, S380N - S500N, P380NH - S460NH, GE300, 22Mo4

ASTM A225 Gr. C; A302 Gr. A-D; A514 und A517 Gr. A, B, C, E, F, H, J, K, M, P

Approvals and Certificates

TÜV-D (1178.), DB (10.014.11-20.014.12), ÜZ (10.014/2), ÖBB, TÜV-A (122), CL (0754)

EN 757:1997:	E 62 4 Mn 1 Ni Mo B 42 H5
AWS A5.5-96:	E 10018-G (E 10018-D2 mod.)

BÖHLER FOX NiMo 100

Basic covered electrode

Description

Basic covered MnNiMo alloyed electrode. Extremely high resistance to cracking and cold toughness at temperatures as low as -40 °C. Very low H_2-content ≤ 5 ml/100 g. For creep resistant steels and cast steel grades, valves and oil tools according to sour gas specification; post-weld heat treatment: stress relieving according to parent metal.

Typical Composition of All-weld Metal

	C	Si	Mn	Mo	Ni
wt-%	**0.11**	**0.25**	**1.85**	**0.40**	**0.95**

Mechanical Properties of All-weld Metal

(*)		s
yield strength R_e N/mm²:		**≥ 620**
tensile strength R_m N/mm²:		**≥ 690**
elongation A (L_0=5d_0) %:		**≥ 18**
impact work ISO-V KV J		
	+20 °C:	**≥ 47**
	-40 °C:	**≥ 47**

(*) s Stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300-350 °C, min. 2 h
electrode identification:
FOX NiMo 100

ø mm	L mm	amps A
3.2	350	100-150
4.0	350	140-200
5.0	450	180-250

=+

Base Materials

GS-30CrMoV64, steels acc. ASTM A 487-4Q; AISI 4130

Approvals and Certificates

–

EN 757:1997: E 62 6 Mn2NiCrMo B 4 2 H5
AWS A5.5-96: E10018-GH4R
E10018-MH4R(mod.)

BÖHLER FOX EV 75

SMAW stick electrode, low-alloyed, high strength

Description

Mn-Mo-Ni-alloyed basic coated electrode with high ductility and crack resistance for high-strength, quenched and tempered fine-grained constructional steels. Suitable for service temperatures at – 60 °C to + 400 °C.
Weld metal recovery approx. 120 %. Easily weldable in all positions except vertical-down. Preheat, interpass temperature and post weld heat treatment as required by the base metal.
Very low hydrogen content (according AWS condition HD ≤ 4 ml/100 g weld metal).

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.05**	**0.4**	**1.6**	**0.4**	**2.0**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u		s		v	
yield strength R_e N/mm²:		**700**	(≥ 650)	**700**	(≥ 630)	**500**	(≥ 430)
tensile strength R_m N/mm²:		**750**	(730 - 850)	**750**	(710 - 830)	**615**	(550 - 670)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 20)	**23**	(≥ 20)	**24**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 120)	**120**	(≥ 70)	**120**	(≥ 70)
	- 60 °C:		(≥ 47)				

(*) *u untreated, as-welded*
s stress relieved 580 °C/2h/furnace down to 300 °C/air
v quenched/tempered 910 °C/1h/air and 600 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX EV 75 10018-G E 62 6 Mn2NiCrMo B

ø mm	**L mm**	**amps A**
3.2	350	100 - 140
4.0	450	140 - 180

=+

Preheating and interpass temperature, as well as post weld heat treatment as required by the base metal.

Base Materials

quenched and tempered fine-grained steels up to 650 N/mm² yield strength, QT-steels up to 730 N/mm² tensile strength

S500N, S500NH, S460NL

ASTM A225 Gr. C; A 514 and A517 Gr. A, B, C, E, F, H, J, K, M, P; A656; A678 Gr. C

Approvals and Certificates

UDT, SEPROZ

EN 757:1997: E 69 6 Mn2NiCrMo B 4 2 H5
AWS A5.5-96: E11018-GH4R
E11018-MH4R(mod.)

BÖHLER FOX EV 85

SMAW stick electrode, low-alloyed, high strength

Description

Basic coated Mn-Ni-Mo-alloyed electrode with high ductility and crack resistant for high-strength fine-grained constructional steels. Low-temperature ductility at -60 °C and resistant to ageing.
Easily weldable in all positions except vertical-down. Very low hydrogen content (according AWS condition HD ≤ 4 ml/100 g weld metal).

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.05**	**0.4**	**1.7**	**0.4**	**2.1**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		s		v	
yield strength R_e N/mm²:		**780**	(≥ 720)	**750**	(≥ 690)	**750**	(≥ 650)
tensile strength R_m N/mm²:		**840**	(790 - 960)	**800**	(760 - 850)	**790**	(730 - 860)
elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 16)	**20**	(≥ 16)	**20**	(≥ 19)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 90)	**80**	(≥ 60)	**80**	(≥ 65)
	- 60 °C:	**60**	(≥ 47)				

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air
v quenched/tempered 920 °C/1h/air and 600 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX EV 85 11018-G E 69 6 Mn2NiCrMo B

ø mm	**L mm**	**Strom**
2.5	350	70 - 100
3.2	350	100 - 140
4.0	450	140 - 180
5.0	450	190 - 230

=+

Preheat, interpass temperature and post weld heat treatment as required by the base metal.

Base Materials

quenched and tempered fine-grained steels up to 720 N/mm² yield strength,
quenched and tempered low-alloyed steels up to 790 N/mm² tensile strength.

S620 QL-S690QL, S620QL1, S690QL1, N-AXTRA 56, 63, 70

Approvals and Certificates

TÜV-D (4313.), DB (10.014.22), ÜZ (10.014/2), ÖBB, UDT, SEPROZ

EN 499:1994: E 46 8 2Ni B 4 2 H5
AWS A5.5-96: E8018-C1H4R

BÖHLER FOX 2.5 Ni

SMAW stick electrode, low-alloyed, cryogenic application

Description

Ni-alloyed basic coated electrode for unalloyed and Ni-alloyed fine grained construction steels. Tough, crack resistant weld deposit. Low temperature toughness to -80 °C.
Good weldability in all position except vertical down. Very low hydrogen content. (according AWS condition HD ≤ 4 ml/100 g weld metal)
Preheat 100 - 150 °C on wall thickness > 15 mm, interpass temperature max. 150 °C. Post weld heat treatment if necessary only as required by the base metal.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.04**	**0.3**	**0.8**	**2.4**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**490**	(≥ 460)	**470**	(≥ 420)
tensile strength R_m N/mm²:		**570**	(550 - 680)	**550**	(540 - 640)
elongation A ($L_0 = 5d_0$) %:		**30**	(≥ 24)	**30**	(≥ 24)
impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 110)	**200**	(≥ 110)
	- 80 °C:	**110**	(≥ 47)		

(*) *u untreated, as-welded*
s stress relieved 580 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identifikation:
FOX 2.5 Ni 8018-C1 E 46 8 2Ni B

ø mm	**L mm**	**amps A**
2.5	350	70 - 100
3.2	350	110 - 140
4.0	450	140 - 180
5.0	450	190 - 230

=+

Preheat, interpass temperature and post weld heat treatment as required by the base metal.

Base Materials

cryogenic constructional steels and Ni-steels, cryogenic steels for ship building

12Ni14, 14Ni6, 10Ni14, 13MnNi6-3, P355NL1 - P460NL1, P355NL2 - P460NL2, S255N - S460N, S355NH - S460NH, S255NL - S460NL, S255NL1 - S380NL1

ASTM A633 Gr. E; A572 Gr. 65; A203 Gr. D; A333 and A334 Gr. 3; A 350 Gr. LF3

Approvals and Certificates

TÜV-D (00147.), DB (10.014.16), ÜZ (10.014/1), ÖBB, ABS (Ni 2.1/2.6), BV (5Y40), WIWEB, CL (0260), DNV (5 YH10), GL (8Y46), LR (5Y40mH15), RINA (5YH5,3H5) Statoil, UDT, SEPROZ

Similar alloy Filler Metals

GTAW rod:	2.5 Ni-IG
SMAW stick electrode:	2.5 Ni-IG
SAW combination:	Ni 2-UP/BB 24

SMAW stick electrode, high strength

Böhler Designation EN 757:1997: AWS A5.5-96:	Analysis all weld metal wt- %	yield strength R_e tensile strength R_m elongation A impact work RT	Application Base metals	Form of supply ø (mm)	Current, Welding position	Approval
FOX EV 85 M – E11018-MH4R	C < 0.05 Si 0.2 Mn 1.5 Cr 0.35 Mo 0.35 Ni 2.2	> 680 N/mm² > 760 N/mm² > 20 % > 100 J	Basic coated electrode for welding of high tensile fine-grained steels.	3.2 / 350 4.0 / 450 5.0 / 450	=+	
FOX EV 100 E 89 4 Mn2Ni1CrMoB42H5 E12018G	C 0.06 Si 0.35 Mn 1.8 Cr 0.7 Mo 0.5 Ni 2.5 V 0.07	> 890 N/mm² > 980 N/mm² 15 % > 47 J	Basic coated electrode for welding of high tensile fine-grained steels. Weld metal is highly crack resistant.	3.2 / 350 4.0 / 450 5.0 / 450	=+	

These electrodes are not regular stock items, available an request only.

EN 12070:1999:	W Mo Si
EN 1668:1997:	W2Mo (for rod)
EN 1668:1997:	W 46 3 W2Mo
AWS A5.28-96:	ER70S-A1 (ER80S-G)
W.Nr.:	1.5424

BÖHLER DMO-IG

GTAW rod, low-alloyed, high temperature, high strength

Description

Copper coated GTAW rod for welding in boiler, pressure vessel, pipeline, and crane construction as well as in structural steel engineering.
Very tough deposit of high crack resistant, non-ageing. Recommended for the temperature range from -30 °C to +500 °C. Good copper bonding with low total copper content. Very good welding and flow characteristics.

Typical Composition of Welding Rod

	C	Si	Mn	Mo
wt-%	**0.1**	**0.6**	**1.2**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a	
yield strength R_e N/mm^2:		**520**	(≥ 480)	**480**	(≥ 400)
tensile strength R_m N/mm^2:		**630**	(570 - 720)	**570**	(≥ 515)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 23)	**26**	(≥ 19)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 180)	**230**	(≥ 200)
	- 45 °C:		(≥ 47)		

(*) *u untreated, as-welded – shielding gas Argon*
a annealed, 620 °C/1 h/furnace down to 300 °C/air – shielding gas Argon

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **WMoSi**
back: **1.5424**

ø mm
1.6
2.0
2.4
3.0
3.2

Preheating, interpass temperature and post weld heat treatment as required by the base metal.

Base Materials

similar alloyed high temperature steels and cast steels, ageing resistant and steels resistant to caustic cracking

S355J2G3, L290 - L415NB, L290 MB - L415MB, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, 16Mo3, 17MnMoV6-4, 22NiMoCr4-7, 20MnMoNi5-5, 15NiCuMoNb5S, 20MnMoNi4-5, GE240 - GE300, 22Mo4, S255N - S460N, P255NH - P460NH

ASTM A335 Gr. P1; A161-94 Gr. T1 A A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1; A217 Gr. WC1

Approvals and Certificates

TÜV-D (0020.), KTA 1408 1 (8066.02), DB (42.014.09), ÜZ (42.014), ÖBB, TÜV-A (75), BV (UP), CL (0483), DNV (I YMS), FI (W MoSi), UDT, ITI (09.004-0), CRS (3)

Similar alloy Filler Metals

Stick electrode:	FOX DMO Kb	SAW combination:	EMS 2 Mo/BB 24
	FOX DMO Ti		EM2 2 Mo/BB 25
SMAW stick electrode:	DMO-IG	Gas welding rod:	DMO

EN 1668:1997: W3Ni1
AWS A5.28-96: ER80S-Ni1

BÖHLER I 52 Ni

GTAW rod, low alloyed, cryogenic application

Description

Ni-alloyed GTAW rod for welding of offshore pipe work and similar high integrity applications. High impact properties down to -50 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Ni
wt-%	**0.07**	**0.7**	**1.60**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**500**	(≥ 470)
tensile strength R_m N/mm^2:		**600**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 24)
impact work ISO-V KV J			
	+20 °C:	**150**	(≥ 47)
	-50 °C:	**90**	

(*) u untreated, as-welded, shielding gas Argon

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W3Ni1**
back: **ER80S-Ni 1**

ø mm
1.6
2.0
2.4
3.0
3.2

Preheating, interpass temperature and post weld heat treatment as required by the base metal.

Base Materials

High strength steels up to S500N
Pipe steels: L290MB – L485MB,
API Spec. 5 L: X52, X56, X60, X65,

Approvals and Certificates

–

EN 1668:1997: W2Ni2 (for rods)
EN 1668:1997: W 46 8 W2Ni2
AWS A5.28-96: ER80S-Ni2

BÖHLER 2.5 Ni-IG

GTAW rod, low-alloyed, cryogenic application

Description

Ni-alloyed copper coated GTAW rod, for welding of cryogenic steels. For thin sheets and root pass welding. Useable down to -80 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Ni
wt-%	**0.1**	**0.6**	**1.1**	**2.4**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**510**	(≥ 470)
tensile strength R_m N/mm^2:		**600**	(550 - 720)
elongation A (L_0 = 5d_0) %:		**26**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**280**	(≥ 200)
	- 60 °C:	**80**	
	- 80 °C:		(≥ 47)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**
rod marking:
front: **W2Ni2**
back: **ER80S-Ni 2**

ø mm
2.0
2.4
3.0

Preheating, interpass temperature and post weld heat treatment as required by the base metal.

Base Materials

cryogenic constructional steels and Ni-steels, cryogenic steels for ship building

12Ni14, 14Ni6, 10Ni14, 13MnNi6-3, P355NL1 - P460NL1, P355NL2 - P460NL2, S255N - S460N, S355NH - S460NH, S255NL - S460NL, S255NL1 - S380NL1

ASTM A633 Gr. E; A572 Gr. 65; A203 Gr. D; A333 and A334 Gr. 3; A 350 Gr. LF3

Approvals and Certificates

TÜV-D (01081.), TÜV-A (254), BV (SA 3 YM; UP), GL (6Y46), Statoil, UDT, SEPROZ

Similar alloy Filler Metals

Stick electrode:	FOX 2.5 Ni
SMAW stick electrode:	2.5 Ni-IG
SAW combination:	Ni 2-UP/BB 24

EN 440:1995:	G 42 4 M G0
	G 42 4 C G0
AWS A5.28-96:	ER80S-G

BÖHLER NiCu 1-IG

GMAW solid wires, low-alloyed, weather resistant

Description

NiCu-alloyed copper coated GMAW wire, for welding of weathering resistant constructional steels, standard constructional steels and special constructional steels.
NiCu 1-IG wire features good weldability in the short arc mode at low voltage and in the spray arc process with high voltage. The mechanical properties of the weld deposit, the freedom of porosity and the bead appearance depend on the type of shielding gas used and on the other welding parameters.
The copper content in the welding wire leads to increased resistance to atmospheric corrosion in the weld deposit.

Typical Composition of Solid Wire

	C	Si	Mn	Ni	Cu
wt-%	**0.1**	**0.5**	**1.1**	**0.9**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u		s	
yield strength R_e N/mm²:		**500**	(≥ 420)	**460**	(≥ 390)
tensile strength R_m N/mm²:		**580**	(500 - 640)	**540**	(470 - 570)
elongation A ($L_0 = 5d_0$) %:		**26**	(≥ 24)	**27**	(≥ 24)
impact work ISO-V KV J	+ 20 °C:	**130**	(≥ 80)	**130**	(≥ 80)
	- 40 °C:		(≥ 47)		(≥ 47)

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2 or 100 % CO_2*
s stress relieved, 600 °C/2 h – shielding gas Ar + 15 - 25 % CO_2 or 100 % CO_2

Operating Data

shielding gases:	ø mm	
Argon + 15 - 25 % CO_2	1.0	**=+**
100 % CO_2	1.2	

Base Materials

weather-resistant constructional steels, special grade constructional steels

S235JRW, S235J2G3 Cu, S355J2G3 Cu, Corten A, Patinax 37, Alcodur 50, Koralpin 52

ASTM A36; A283 Gr. B, C

Approvals and Certificates

DB (42.014.08), ÜZ (42.014/4), ÖBB, UDT

Similar-alloy Filler Metals

SMAW stick electrode: FOX NiCuCr

EN 440:1995:	G3Ni1
EN 440:1995:	G 42 5 M G3Ni1
AWS A5.28-96:	ER80S-G

BÖHLER K NOVA Ni

GMAW solid wire, for automatic welding

Description

GMAW wire micro alloyed, designed for high quality automatic welding of pipelines. An optimum balanced alloying concept ensures good weld metal properties to fulfil the high requirements in the on-offshore pipeline industry. The deposit is extremely crack resistant and the weld metal offers high impact values down to -50 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Ni	Ti
wt-%	**0.06**	**0.70**	**1.50**	**0.90**	**+**

Mechanical Properties of All-weld Metal

(*)		u		u1	
yield strength R_e N/mm^2:		**500**	(≥ 420)	**470**	(≥ 420)
tensile strength R_m N/mm^2:		**590**	(≥ 550)	**560**	(≥ 500)
elongation A ($L_0 = 5d_0$) %:		**24**	(≥ 20)	**25**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 47)	**110**	(≥ 47)
	- 50 °C:	**80**		**45**	

(*) *u untreated, as-welded shielding gas: Ar +15-25 % CO_2*
u1 untreated, as-welded shielding gas: 100 % CO_2

Operating Data

Shielding gases	**ø mm wire**
Argon +15-25 % CO_2	0.9
Argon +0-5 % CO_2 +3-10 % O_2	1.0
100 % CO_2	1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

API5L:	X 42 – X 70 (X 80)
EN 10208-2:	L290MB – L485MB
DIN 17172:	StE290TM up to StE480.7TM

Approvals and Certificates

DNV

EN 12534:1999:	Mn3Ni1Mo (for wire)
EN 12534:1999:	G 55 6 M Mn3Ni1Mo
	G 55 4 C Mn3Ni1Mo
AWS A5.28-96:	ER90S-G

BÖHLER NiMo 1-IG

GMAW solid wires, low-alloyed, high strength

Description

Copper coated GMAW wire for high strength, quenched and tempered fine-grained constructional steels.
The wire is suited for joint welding in boiler, pressure vessel, pipeline, and crane construction as well as in structural steel engineering. The typical composition of the wire fulfils the requirements of the NORSOK-regulation for „water injection systems“.
Due to the precise addition of micro alloying elements NiMo1-IG wire features excellent ductility and crack resistance in spite of its high strength. Good cryogenic impact energy down to -60 °C, low hydrogen contents in the deposit, best feedability and low copper contents are other advantages of this wire.

Typical Composition of Solid Wire

	C	Si	Mn	Mo	Ni
wt-%	**0.08**	**0.6**	**1.8**	**0.3**	**0.9**

Mechanical Properties of All-weld Metal

(*)		u		u2	
yield strength R_e N/mm²:		**620**	(≥ 550)	**590**	(≥ 550)
tensile strength R_m N/mm²:		**700**	(650 - 800)	**680**	(620 - 770)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 20)	**22**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 120)	**120**	(≥ 100)
	- 40 °C:	**110**	(≥ 90)		(≥ 47)
	- 60 °C:		(≥ 47)		

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2

Operating Data

shielding gases: **Argon + 15 - 25 % CO_2**
Argon + 0 - 5 % CO_2 + 3 - 10 % O_2
100 % CO_2

ø mm
(0.9)
1.0
1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

pipe steels and fine grained steels, quenched and tempered fine-grained steels

S380N - S500N, S380NL - S500NL, S500NC - S550NC, N-A-XTRA 56-70, BHV 70, PAS 600, HSM 600, 20MnMoNi5-5

ASTM A517 Gr. A, B, C, E, F, H, J, K, M, P; A225 Gr. C; A633 Gr. E; A572 Gr. 65
API-spec 5L: X70, X80

Approvals and Certificates

DB (42.014.06), ÜZ (42.014/4), ÖBB, GL (4Y56S), UDT, SEPROZ

EN 12534:1999: Mn3Ni2.5CrMo (for wire)
EN 12534:1999: G 69 6 M Mn3Ni2.5CrMo
G 69 4 C Mn3Ni2.5CrMo
AWS A5.28-96: ER110S-G

BÖHLER NiCrMo 2.5-IG

GMAW solid wires, low-alloyed, high strength

Description

GMAW wire for joint welding of high-strength fine-grained constructional steels with stringent requirement on low-temperature toughness down to -60 °C depending on the shielding gas. e.g. in marine engineering for the manufacture of LPG tankers.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.08**	**0.6**	**1.4**	**0.3**	**2.5**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u		u2	
yield strength R_e N/mm²:		**810**	(≥ 750)	**780**	(≥ 720)
tensile strength R_m N/mm²:		**910**	(830 - 980)	**890**	(800 - 950)
elongation A ($L_0 = 5d_0$) %:		**18**	(≥ 16)	**17**	(≥ 16)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 60)	**70**	(≥ 50)
	- 40 °C:				(≥ 47)
	- 60 °C:		(≥ 47)		

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2

Operating Data

shielding gases: **Argon + 15 - 25 % CO_2**
100 % CO_2

ø mm
1.0
1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

quenched and tempered fine-grained steels with high requirements for low-temperature toughness

N-A-XTRA 65-70, USS-T 1

Approvals and Certificates

DB (42.014.07), ÜZ (42.014/4), ÖBB, ABS (XYQ690X-5), BV (UP), DNV (5 Y69), GL (4Y69S), LR (X), UDT, SEPROZ

Similar-alloy Filler Metals

SMAW stick electrode: FOX EV 85
SAW combination: 3NiCrMo 2.5-UP / BB 24

EN 12534:1999: Mn3Ni1CrMo (for wire)
EN 12534:1999: G 69 5 M Mn3Ni1CrMo
AWS A5.28-96: ER110S-G

BÖHLER X 70-IG

GMAW solid wires, low-alloyed, high strength

Description

GMAW wire for the welding of high-strength, heat treated, fine-grained constructional steels with a minimum yield strength of 690 N/mm².
Due to the precise addition of micro-alloying elements X 70-IG wire features excellent ductility and crack resistance in spite of its high strength.
Good cryogenic impact energy down to -50 °C.

Typical Composition of Solid Wire

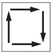
	C	Si	Mn	Cr	Ni	Mo	V
wt-%	**0.1**	**0.6**	**1.6**	**0.25**	**1.3**	**0.25**	**0.1**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**800**	(≥ 690)
tensile strength R_m N/mm²:		**900**	(≥ 790)
elongation A ($L_0 = 5d_0$) %:		**19**	(≥ 16)
impact work ISO-V KV J	+ 20 °C:	**190**	(≥ 170)
	- 50 °C:		(≥ 47)

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*

Operating Data



shielding gas: **Argon + 15 - 25 % CO_2**

ø mm
1.0
1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

high-strength fine-grained steels

S690Q, L690M, N-A-XTRA 70, USS-T1, BH 70 V, HY 100, Pass 700, HSM 700

ASTM A514 Gr. F

Approvals and Certificates

TÜV-D (5547.), DB (42.014.19), ÜZ (42.014/4), ÖBB, TÜV-A (541), ABS (X), BV (UP), DNV (IV Y69), GL (5Y69S), LR (X), RMR (4Y69), UDT, SEPROZ

Similar-alloy Filler Metals

SMAW stick electrode: FOX EV 85
SAW combination: 3NiCrMo 2.5-UP / BB 24

EN 12534:1999: Mn4Ni2CrMo (for wire)
EN 12534:1999: G 89 6 M Mn4Ni2CrMo
AWS A5.28-96: ER120S-G

BÖHLER X 90-IG

GMAW solid wires, low-alloyed, high strength

Description

GMAW wire for the welding of higher-strength, heat treated, fine-grained constructional steels with a minimum yield strength of 890 N/mm^2.
Due to the precise addition of micro-alloying elements X 90-IG wire features excellent ductility and crack resistance in spite of its high strength.
Good cryogenic impact energy down to -60 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.1**	**0.8**	**1.8**	**0.35**	**2.25**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**915**	(≥ 890)
tensile strength R_m N/mm^2:		**960**	(≥ 940)
elongation A (L_0 = 5d_0) %:		**20**	(≥ 16)
impact work ISO-V KV J	+ 20 °C:	**130**	(≥ 100)
	- 60 °C:		(≥ 47)

(*) u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2

Operating Data

shielding gas: **Argon + 15 - 25 % CO_2**

ø mm
1.0
1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

high-strength fine-grained steels

S890Q, XABO 90, OX 1002

Approvals and Certificates

TÜV-D (5611.), DB (42.014.23), ÜZ (42.014/4), ÖBB, TÜV-A (616), GL (6Y89S), UDT, SEPROZ

EN 440:1994:	G2Ni2 (for wire)
EN 440:1994:	G 46 8 M G2Ni2
	G 46 6 C G2Ni2
AWS A5.28-96:	ER80S-Ni2

BÖHLER 2.5 Ni-IG

GMAW solid wires, low-alloyed, cryogenic application

Description

2.5 % Ni-alloyed GMAW wire for high quality welds in the construction of storage tanks and piping systems for cryogenic applications. The weld deposit is noted for its particularly good low temperature an non-ageing properties down to -80 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Ni
wt-%	**0.1**	**0.6**	**1.1**	**2.4**

Mechanical Properties of All-weld Metal

(*)		u		u2	
yield strength R_e N/mm²:		**510**	(≥ 470)	**500**	(≥ 460)
tensile strength R_m N/mm²:		**600**	(550 - 680)	**590**	(520 - 670)
elongation A ($L_0 = 5d_0$) %:		**22**	(≥ 20)	**22**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 120)	**120**	(≥ 80)
	- 60 °C:				(≥ 47)
	- 80 °C:		(≥ 47)		

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
u2 untreated, as-welded – shielding gas 100 % CO_2

Operating Data

shielding gases: **Argon + 15 - 25 % CO_2**
100 % CO_2

ø mm
1.0
1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

cryogenic constructional steels and Ni-steels, cryogenic steels for ship building

12Ni14, 14Ni6, 10Ni14, 13MnNi6-3, P355NL1 - P460NL1, P355NL2 - P460NL2, S255N - S460N, S355NH - S460NH, S255NL - S460NL, S255NL1 - S380NL1

ASTM A633 Gr. E; A572 Gr. 65; A203 Gr. D; A333 and A334 Gr. 3; A 350 Gr. LF3

Approvals and Certificates

TÜV-D (01080.), DB (42.014.16), ÜZ (42.014/4), ÖBB, TÜV-A (732), ABS (XYQ550X-5), BV (SA 3 YM; UP), DNV (5 YMS), GL (6Y38S), LR (5Y40S H15), UDT, SEPROZ

Similar alloy Filler Metals

SMAW stick electrode:	FOX 2.5 Ni
GTAW rod:	2.5 Ni-IG
SAW combination:	Ni 2-UP/BB 24

EN 758:1997: T 50 6 1 Ni P M 1 H5
AWS A5.29-98: E81T1-Ni1MH8

BÖHLER Ti 60-FD

GMAW flux cored wire, low alloyed, rutile type

Description

Rutile based flux-cored wire which provides easy all-position weldability and dependable mechanical properties down to -60 °C.
The fast freezing slag provides a well supported weld pool, allowing welding currents up to 250 A in positional welding. Because it operates in spray arc in all welding positions, welding is comfortable and spatter free. Weld appearance is good, with good tie-in. Thanks to the fast freezing slag system of BÖHLER Ti 60-FD and to good weld pool control, this flux-cored wire is particularly suited for out-of-position welding of butt and fillet joints in high strength steels with yield strength up to 460 N/mm². The flux-cored wire is widely used for offshore constructions, ship building and structures built with high strenght steels.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni
wt-%	**0.06**	**0.45**	**1.2**	**0.85**

Mechanical Properties of All-weld Metal

(*)		u	s
yield strength R_e N/mm²:		**> 500**	**> 500**
tensile strength R_m N/mm²:		**> 560**	**> 560**
elongation A ($L_0 = 5d_0$) %:		**> 19**	**> 24**
impact work ISO-V KV J	+ 20 °C:	**> 120**	**>120**
	- 60 °C:	**≥ 47**	**≥ 47**

(*) *u untreated, as-welded – shielding gas Ar + 15 - 25 % CO_2*
s stress relieved 620 °C/2 h/furnace down to +300 °C – shielding gas Ar + 15 - 25 % CO_2

Operating Data

re-drying: –
shielding gas:
Argon + 15 - 25 % CO_2
Welding with standard welding facilities.

ø mm
1.2
1.6

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

constructional steels, pipe- and vessel steels, cryogenic fine-grained steels and special grades

E295, E335, S355J2G3, C35-C45, L210 - L450NB, L245MB - L450MB, P310GH, P355 NL1 - P460NL1, P355NL2 - P460NL2, S380N - S460N, P355NH-P460NH, S380NL - S460NL, S380NL1 - S460NL2, GE260-GE300

ASTM A516 Gr. 65, A572 Gr. 55, 60, 65, A633 Gr. E, A612, A618 Gr. I, A537 Gr. 1-3.

Approvals and Certificates

CL (0044), LR (DXVuBF, 4Y40SH10)

BÖHLER 3 NiMo 1-UP//BB 24

SAW wire/flux-combination, low-alloyed, high strength

SAW solid wire:
EN 756:2004: SZ3Ni1Mo
AWS A5.23-97: EF3 (mod.)
sub-arc flux:
EN 760:1996: SA FB 1 65 DC H5
wire/flux-combination:
EN 756:2004: S 50 4 FB SZ3Ni1Mo
AWS A5.23-97: F9A4-EF3(mod.)-F3
AWS A5.23M-97: F62A4-EF3(mod.)-F3

Description

Wire /Flux combination for joint welding of high strength and low temperature steels.
The flux reacts metallurgically Mn-neutral.
The sub-arc wire/flux combination produces very good low temperature impact properties down to - 40 °C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (≤ 5 ml/100 g) are further important features. The combination is ideally suited for multi-pass welding of thick plates.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Ni	Mo
Wire %	**0.12**	**0.3**	**1.6**	**1.0**	**0.6**
Weld metal %	**0.08**	**0.45**	**1.55**	**0.95**	**0.55**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**580**	(≥ 560)
tensile strength R_m N/mm^2:		**650**	(620 - 720)
elongation A ($L_0 = 5d_0$) %:		**21**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 160)
	± 0 °C:	**160**	(≥ 140)
	- 20 °C:	**100**	(≥ 80)
	- 40 °C:	**60**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
4.0

=±

Preheating and interpass temperature as required by the base metal.

Base Materials

quenched and tempered fine-grained steels

S380N - S500N, S380NL - S500NL, S500NC - S550NC, N-A-XTRA 56-65, BHV 70, PAS 600, HSM 600, 20MnMoNi5-5

ASTM A517 Gr. A, B, C, E, F, H, J, K, M, P, A225 Gr. C, A633 Gr. E, A572 Gr. 65

Approvals and Certificates

TÜV-D (07807.), UDT
SAW solid wire: TÜV-D (2603.)

SAW solid wire:
EN 756:2004: S Z 3Ni2CrMo
AWS A5.23-97: EM4 (mod.)
sub-arc flux:
EN 760:1996: SA FB 1 65 DC H5
wire/flux-combination:
EN 756:2004: S 69 6 FB SZ3Ni2CrMo
AWS A5.23-97: F11A8-EM4(mod.)-M4
AWS A5.23M-97: F76A6-EM4(mod.)-M4

BÖHLER 3 NiCrMo 2.5-UP//BB 24

SAW wire/flux-combination, low-alloyed, high strength

Description

Wire /Flux combination for joint welding of high strength steels with a minimum yield strength of 690 N/mm².
Depending on the annealing temperature yield strength of approx. 470-600 N/mm² are achievable.
The flux reacts metallurgically Mn-neutral.
The sub-arc wire/flux combination produces very good low temperature impact properties down to -60°C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (≤ 5 ml/100 g). are further important features. The combination is ideally suited for multi-pass welding of thick plates.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
SAW wire wt-%	**0.12**	**0.15**	**1.5**	**0.6**	**2.3**	**0.55**
all-welt metal %	**0.06**	**0.3**	**1.5**	**0.50**	**2.2**	**0.50**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**740**	(≥ 690)
tensile strength R_m N/mm²:		**850**	(780 - 890)
elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 80)
	- 20 °C:	**90**	(≥ 60)
	- 40 °C:	**85**	
	- 60 °C:		(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C / 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
3.0
4.0

=±

Base Materials

quenched and tempered fine-grained steels with high requirements for low-temperature impact work

N-A-XTRA 65-70, USS-T 1 etc.

Approvals and Certificates

UDT

Similar Alloy Filler Metals

SMAW stick electrode:	FOX EV 85
GMAW solid wire:	X 70-IG
	NiCrMo 2.5-IG

SAW solid wire:
EN 756:2004: S2Ni2
AWS A5.23-97: ENi2
sub-arc flux:
EN 760:1996: SA FB 1 65 DC H5
wire/flux-combination:
EN 756:2004: S 46 6 FB S2Ni2
AWS A5.23-97: F8A8-ENi2-Ni2
AWS A5.23M-97: F55A6-ENi2-Ni2

BÖHLER Ni 2-UP//BB 24

SAW wire/flux-combination, low-alloyed, cryogenic application

Description

The weld deposit of the wire/flux combination (as welded and stress relieved condition) is distinguished by excellent welding characteristic, cryogenic toughness and ageing resistance with low hydrogen content in the deposit.
Under optimum conditions (heat input below 18 kJ/cm or after stress relieving) impact strength transition temperature at -80 °C (ISO-V specimen) can be achieved.
The flux reacts metallurgically Mn-neutral. The sub-arc wire/flux combination produces very good low temperature impact properties down to -60 °C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (HD ≤ 5 ml/100 g). are further important features. The combination is ideally suited for multi-pass welding of thick plates.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Ni
SAW wire wt-%	**0.11**	**0.1**	**1.0**	**2.25**
all-weld metal %	**0.07**	**0.25**	**1.05**	**2.2**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		(≥ 480)
tensile strength R_m N/mm²:		(580 - 680)
elongation A ($L_0 = 5d_0$) %:		(≥ 24)
impact work ISO-V KV J	+ 20 °C:	(≥ 130)
	± 0 °C:	(≥ 120)
	- 20 °C:	(≥ 100)
	- 60 °C:	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
3.0

=±

Base Materials

cryogenic constructional steels and Ni-steels, cryogenic steels for ship building
12Ni14, 14Ni6, V10Ni14, 13MnNi6-3, P355NL1 - P460NL1, P355NL2 - P460NL2, S255N - S460N, S355NH - S460NH, S255NL - S460NL, S255NL1 - S380NL1
ASTM A633 Gr. E; A572 Gr. 65; A203 Gr. D; A333 and A334 Gr. 3; A 350 Gr. LF3

Approvals and Certificates

UDT.
SAW solid wire: TÜV-D (2603.), KTA 1408 1 (8058.00), DB (52.014.10), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

Similar alloy Filler Metals

SMAW stick electrode:	FOX 2.5 Ni	SMAW stick electrode:	2.5 Ni-IG
GTAW rod:	2.5 Ni-IG		

Notes

Notes

2.5 Filler Metals for High Temperature and Creep-resistant Steels

Objectives

This section contains detailed product information for filler metals that may be used to weld high temperature and creep-resistant steels.
The high temperature properties of general-purpose constructional steels are no longer adequate at operating temperatures above 350 °C. Creep and flow processes occur in the steel at high temperatures under load as a result of which the load permissible becomes time-related. Therefore steels alloyed with Mo, Cr-Mo and Cr-Mo-V are used.
Small additions of Mo, Cr and V are sufficient up to 550 °C operating temperature. Above 550 °C increased scale resistance is also necessary. Up to approx. 600 °C it is possible to use quenched and tempered 9 % and 12 % chromium steels with additions of Mo, V, Nb and W respectively. Above this temperature special austenitic Cr-Ni steels are used. The basic type contains 16 % chromium and 13 % nickel with additions of Nb. At temperatures above 700 °C only nickel-base alloys with additions of Mo, W and Nb exhibit adequate creep properties.
Basically the choice of the filler metals and the welding technology is always in line with the parent metal used and must be matched to its behaviour.

Contents

Overview – Standard Classifications

Böhler	EN		AWS	
SMAW stick electrodes				
FOX DMO Ti	EN 1599:	E Mo R 1 2	–	
			–	
FOX DMO Kb	EN 1599:	E Mo B 4 2 H5	AWS A5.5-96:	E7018-A1H4R
FOX DCMS Ti	EN 1599:	E CrMo1 R 1 2	AWS A5.5-96:	E8013-B2(mod.)
				E8013-G
FOX DCMS Kb	EN 1599:	E CrMo1 B 4 2 H5	AWS A5.5-96:	E8018-B2H4R
FOX DCMV	EN 1599:	E Z CrMoV1 B 4 2 H5	AWS A5.5-96:	E9018-G
FOX DMV 83 Kb	EN 1599:	E MoV B 4 2 H5	AWS A5.5-96:	E9018-G
FOX CM 2 Kb	EN 1599:	E CrMo2 B 4 2 H5	AWS A5.5-96:	E9018-B3H4R
FOX P 23	EN 1599:	E ZCrWV 21.5 B42 H5	AWS A5.5-96:	E9018-G
FOX P 24	EN 1599:	E ZCrMoVNbB 21 B42 H5	AWS A5.5-96:	E9018-G
FOX CM 5 Kb	EN 1599:	E CrMo5 B 4 2 H5	AWS A5.5-96:	E8018-B6H4R
FOX CM 9 Kb	EN 1599:	E CrMo9 B 4 2 H5	AWS A5.5-96:	E8018-B8
FOX C 9 MV	EN 1599:	E CrMo91 B 4 2 H5	AWS A5.5-96:	E9015-B9
FOX C 9 MVW	EN 1599:	E Z CrMoWVNb 9 1 1 B 4 2 H5	AWS A5.5-96:	E9015-B9(mod.)
FOX P 92	EN 1599:	E Z CrMoWVNb 9 0.5 2 B 4 2 H5	AWS A5.5-96:	E9015-B9(mod.)
FOX 20 MVW	EN 1599:	E CrMoWV12 B 4 2 H5	–	
FOX CN 16/13	EN 1600:	E Z 16 13 Nb B 4 2 H5	–	
FOX CN 18/11	EN 1600:	E 19 9 B 4 2 H5	AWS A5.4-92:	E308-15
FOX E 308 H	EN 1600:	E 19 9 H R 4 2 H5	AWS A5.4-92:	E308H-16
FOX E 347 H	EN 1600:	E 19 9 Nb B	AWS A5.4-92:	E347-15
GTAW rods				
DMO-IG	EN 12070:	W Mo Si	AWS A5.28-96:	ER70S-A1
				ER80S-G
DCMS-IG	EN 12070:	W CrMo1 Si	AWS A5.28-96:	ER80S-G
				ER80S-B2(mod.)
DMV 83-IG	EN 12070:	W MoV Si	AWS A5.28-96:	ER80S-G
CM 2-IG	EN 12070:	W CrMo2 Si	AWS A5.28-96:	ER90S-G
				ER90S-B3(mod.)
P 23-IG	EN 12070:	E ZCrWV 21.5 B42 H5	AWS A5.28-96:	ER90S-G
P 24-IG	EN 12070:	W Z CrMoV 2	AWS A5.28-96:	ER90S-G
CM 5-IG	EN 12070:	W CrMo5 Si	AWS A5.28-96:	ER80S-B6
CM 9-IG	EN 12070:	W CrMo9 Si	AWS A5.28-96:	ER80S-B8
C 9 MV-IG	EN 12070:	W CrMo91	AWS A5.28-96:	ER90S-B9
C 9 MVW-IG	EN 12070:	W Z CrMoWVNb 9 1 1	AWS A5.28-96:	ER90S-B9(mod.)
P 92-IG	EN 12070:	W Z CrMoWVNb 9 0.5 1.5	AWS A5.28-96:	ER90S-B9(mod.)
20 MVW-IG	EN 12070:	W CrMoWV12 Si	–	
CN 16/13-IG	EN 12072:	W Z 16 13 Nb	–	
CN 18/11-IG	EN 12072:	W 19 9 H	AWS A5.9-93:	ER19-10H
ER 308 H-IG	EN 12072:	W 19 9 H	AWS A5.9-93:	ER308H

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	V	T	N	
SMAW stick electrodes											
FOX DMO Ti	0.06	0.3	0.6			0.5					
FOX DMO Kb	0.08	0.4	0.8			0.5					
FOX DCMS Ti	0.06	0.4	0.6	1.1		0.5					
FOX DCMS Kb	0.07	0.4	0.8	1.1		0.5					
FOX DCMV	0.12	0.35	0.9	1.35		1.0		0.22			
FOX DMV 83 Kb	0.05	0.4	1.1	0.4		0.9		0.5			
FOX CM 2 Kb	0.08	0.3	0.8	2.3		1.0					
FOX P 23	0.06	0.2	0.5	2.3			0.04	0.22	1.5		
FOX P 24	0.08	0.4	0.5	2.4		1.0	0.03	0.22			B0.003
FOX CM 5 Kb	0.07	0.4	0.8	5.0		0.5					
FOX CM 9 Kb	0.07	0.4	0.7	9.0		1.0					
FOX C 9 MV	0.09	0.3	0.5	9.0	0.9	0.9	0.05	0.2			
FOX C 9 MVW	0.10	0.25	0.7	8.5	0.7	1.0	0.05	0.2	1.0	0.05	
FOX P 92	0.10	0.3	0.7	9.1	0.7	0.55	0.05	0.2	1.7	0.045	
FOX 20 MVW	0.18	0.3	0.6	11.0	0.6	1.0		0.3	0.5		
FOX CN 16/13	0.15	0.4	3.6	16.0	13.0		1.5				
FOX CN 18/11	0.04	0.3	1.3	19.0	10.3						
FOX E 308 H	0.05	0.6	0.7	19.4	10.4	<0.2					
FOX E 347 H	0.05	0.3	1.3	19.0	10.0		≥8xC				
GTAW rods											
DMO-IG	0.10	0.6	1.2			0.5					
DCMS-IG	0.11	0.6	1.0	1.2		0.5					
DMV 83-IG	0.08	0.6	0.9	0.45		0.85		0.35			
CM 2-IG	0.06	0.7	1.1	2.6		1.0					
P 23-IG	0.07	0.3	0.5	2.2			0.05	0.22	1.7	0.01	
P 24-IG	0.10	0.25	0.55	2.5		1.0	0.05	0.22		Ti0.002	B0.002
CM 5-IG	0.08	0.4	0.5	5.8		0.6					
CM 9-IG	0.07	0.5	0.5	9.0		1.0					
C 9 MV-IG	0.09	0.3	0.5	9.0	0.9	0.9	0.05	0.2			
C 9 MVW-IG	0.11	0.35	0.45	9.0	0.75	0.98	0.06	0.2	1.05	0.07	
P 92-IG	0.10	0.4	0.4	8.6	0.6	0.4	0.05	0.2	1.5	0.05	
20 MVW-IG	0.21	0.4	0.6	11.3		1.0		0.3	0.45		
CN 16/13-IG	0.16	0.6	2.5	16.0	13.5		+				
CN 18/11-IG	0.05	0.4	1.8	18.8	9.3						
ER 308 H-IG	0.06	0.4	1.7	20.0	9.5	0.2					

Overview – Standard Classifications (continued)

Böhler	EN		AWS	
GMAW solid wires				
DMO-IG	EN 12070:	G MoSi	AWS A5.28-96:	ER70S-A1 ER80S-G
DCMS-IG	EN 12070:	G CrMo1Si	AWS A5.28-96:	ER80S-G ER80S-B2(mod.)
DMV 83-IG	EN 12070:	G MoV Si	AWS A5.28-96:	ER80S-G
CM 2-IG	EN 12070:	G CrMo2 Si	AWS A5.28-96:	ER90S-G ER90S-B3(mod.)
CM 5-IG	EN 12070:	G CrMo5 Si	AWS A5.28-96:	ER80S-B6
C 9 MV-IG	EN 12070:	G CrMo 91	AWS A5.28-96:	ER90S-B9
CN 18/11-IG	EN 12072:	G 19 9 H	AWS A5.9-93:	ER19-10H
GMAW flux-cored wires				
C 9 MV-MC	EN 12070:	T CRMO91	AWS A5.28-96:	EC90S-B9
E 308 H-FD	EN 12073:	T Z 19 9 H R M 3 T Z 19 9 H R C 3	AWS A5.22-95:	E308HT0-4 E308HT0-1
E 308 H PW-FD	EN 12073:	T Z 19 9 H P M 1 T Z 19 9 H P C 1	AWS A5.22-95:	E308HT1-4 E308HT1-1
SAW wire/flux-combinations				
EMS 2 Mo	EN 756:	S 2 Mo	AWS A5.23-97:	EA2
EMS 2 Mo/BB 24	EN 756:	S 46 4 FB S2Mo	AWS A5.23-97:	F8A4-EA2-A2 F55A4-EA2-A2
EMS 2 Mo/BB 25	EN 756:	S 46 3 FB S2Mo	AWS A5.23-97:	F8A4-EA2-A2 F55A4-EA2-A2
EMS 2 CrMo	EN 12070:	S CrMo1	AWS A5.23-97:	EB2
EMS 2 CrMo/BB 24	EN 12070/760:	S CrMo1 / SA FB 1	AWS A5.23-97:	F8P4-EB2-B2 F55P4-EB2-B2
EMS 2 CrMo/BB 25	EN 12070/760:	S CrMo1 / SA FB 1	AWS A5.23-97:	F8P4-EB2-B2 F55P4-EB2-B2
CM 2-UP	EN 12070:	S CrMo2	AWS A5.23-97:	EB3
CM 2-UP/BB 24	EN 12070/760:	S CrMo2 / SA FB 1	AWS A5.23-97:	F9P2-EB3-B3 F55P3-EB3-B3
P 23-UP	EN 12070:	S ZCrWV2	AWS A5.23-97:	EG
P 23-UP/BB 430	EN 12070:760:	SA FB 1 55 AC	AWS A5.23-97:	–
P 24-UP	EN 12070:	S ZCrMV2	AWS A5.23-97:	EG
P 24-UP/BB 430	EN 12070:760:	SA FB 1 55 AC	AWS A5.23-97:	–
CM 5-UP	EN 12070:	S CrMo5	AWS A5.23-97:	EB6
CM 5-UP/BB 24	EN 12070/760:	S CrMo5 / SA FB 1	AWS A5.23-97:	F9PZ-EB6-B6 F62PZ-EB6-B6
C 9 MV-UP	EN 12070:	S CrMo91	AWS A5.23-97:	EB9
C 9 MV-UP/BB 910	EN 12070/760:	S CrMo91 / SA FB 2	AWS A5.23-97:	F9PZ-EB9-B9 F62PZ-EB9-B9
P 92-UP	EN 12070: S Z CrMoWVNb 9 0.5 1.5		AWS A5.23-97:	EB9(mod.)
P 92-UP/BB 910	EN 12070/760:	S Z CrMoWVNb 9 0.5 1.5 / SA FB 2	–	
20 MVW-UP	EN 12070:	S CrMoWV12	–	
20 MVW-UP/BB 24	EN 12070/760:	SCrMoWV12/SA FB 2	–	
CN 18/11-UP	EN 12072:	S 19 9 H	AWS A5.9-93:	ER19-10H
CN 18/11-UP/BB 202	EN 12072/760:	S 19 9 H / SA FB 2	–	
Gas welding rods				
DMO	EN 12536:	O IV	AWS A5.2-92:	R60-G
DCMS	EN 12536:	O V	AWS A5.2-92:	R65-G

Overview – Typical Chemical Composition (continued)

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	V	T	N	
GMAW solid wires											
DMO-IG	0.10	0.6	1.2			0.5					
DCMS-IG	0.11	0.6	1.0	1.2		0.5					
DMV 83-IG	0.08	0.6	0.9	0.45		0.85		0.35			
CM 2-IG	0.06	0.7	1.1	2.6		1.0					
CM 5-IG	0.08	0.4	0.5	5.8		0.6					
C 9 MV-IG	0.12	0.3	0.5	9.0	0.7	0.9	0.055	0.2			
CN 18/11-IG	0.05	0.6	1.4	18.8	9.8						
GMAW flux-cored wires											
C 9 MV-MC	0.1	<0.3	0.6	9.0	0.7	1.0	0.055	0.2		0.04	
E 308 H-FD	0.06	0.5	1.1	19.4	10.1						
E 308 H PW-FD	0.06	0.5	1.1	19.4	10.1						
SAW wire/flux-combinations											
EMS 2 Mo	0.12	0.15	1.10			0.50					
EMS 2 Mo/BB 24	0.08	0.25	1.15			0.45					
EMS 2 Mo/BB 25	0.07	0.40	1.50			0.50					
EMS 2 CrMo	0.12	0.15	0.90	1.1		0.50					
EMS 2 CrMo/BB 24	0.08	0.25	1.00	1.0		0.45					
EMS 2 CrMo/BB 25	0.07	0.40	1.35	1.0		0.50					
CM 2-UP	0.11	0.10	0.60	2.6		1.00					
CM 2-UP/BB 24	0.07	0.25	0.80	2.3		0.95					
P 23-UP	0.07	0.22	0.5	2.2			0.05	0.22	1.7	0.01	
P 23-UP/BB 430	0.05	0.27	0.9	2.05			0.04	0.20	1.6	0.01	
P 24-UP	0.10	0.25	0.55	2.5		1.0	0.005	0.24			Ti0.002
P 24-UP/BB 430	0.10	0.25	0.75	2.2		1.0	0.005	0.22			B0.002
CM 5-UP	0.08	0.40	0.50	5.8		0.60					
CM 5-UP/BB 24	0.05	0.50	0.75	5.5		0.55					
C 9 MV-UP	0.12	0.25	0.60	9.0	0.70	0.90	0.06	0.22			
C 9 MV-UP/BB 910	0.11	0.30	0.60	9.0	0.70	0.80	0.05	0.20			
P 92-UP	0.10	0.40	0.40	8.6	0.60	0.40	0.05	0.20	1.50		
P 92-UP/BB 910	0.09	0.45	0.40	8.6	0.60	0.35	0.04	0.20	1.50		
20 MVW-UP	0.27	0.20	0.70	11.3	0.50	0.90		0.30	0.50		
20 MVW-UP/BB 24	0.16	0.30	0.80	10.3	0.40	0.85		0.25	0.45		
CN 18/11-UP	0.05	0.40	1.60	18.8	9.30						
CN 18/11-UP/BB 202	0.04	0.55	1.20	18.4	9.30						
Gas welding rods											
DMO	0.12	0.15	1.0			0.5					
DCMS	0.12	0.15	0.9	1.0		0.5					

EN 1599:1997: E Mo R 1 2

BÖHLER FOX DMO Ti

SMAW stick electrode, low-alloyed, high temperature

Description

Rutile-coated electrode for 0.5 % Mo-alloyed boiler, plates, and tube steels. Approved in long-term condition up to +550 °C service temperature. Specifically preferred for thin walled welds up to 30 mm and root pass welding. It offers excellent striking and restriking characteristics, easy slag removal, smooth beads, AC/DC weldablility and produces first class X-ray quality welds in all positions (except vertical down).

Typical Composition of All-weld Metal

	C	Si	Mn	Mo
wt-%	**0.06**	**0.3**	**0.6**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a	
yield strength R_e N/mm²:		**500**	(≥ 460)	**470**	(≥ 440)
tensile strength R_m N/mm²:		**570**	(≥ 550)	**550**	(≥ 540)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 22)	**23**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**90**	(≥ 47)	**100**	(≥ 47)

(*) *u untreated, as-welded*
a annealed, 620 °C/2 h/furnace down to 300 °C/air

Operating Data

	ø mm	**L mm**	**amps A**
re-drying if necessary: –	2.0	250	60 - 80
electrode identification:	2.5	250/350	80 - 110
FOX DMO Ti E Mo R	3.2	350	110 - 140
	4.0	450	140 - 180

Preheating, interpass temperature, and post weld heat treatment as required by the base metal.

Base Materials

high temperature steels and similar alloyed cast steels

16Mo3, S355J2G3, E295, P255G1TH, L320 - L415NB, L320MB - L415MB, S255N, P295GH, P310GH, P255 - P355N, P255NH - P355NH

ASTM A335 Gr. P 1; A161-94 Gr. T1; A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1

Approvals and Certificates

TÜV-D (0018.), DB (10.014.04), ÜZ (10.014/3), ÖBB, TÜV-A (84), BV (2YM), CL (0746), DNV (X), RMR (-), Statoil, UDT, VUZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMO Kb	SAW combination:	EMS 2 Mo/BB 24
GTAW rod:	DMO-IG		EMS 2 Mo/BB 25
GMAW solid wire:	DMO-IG	Gas welding rod:	DMO

EN 1599:1997: E Mo B 4 2 H5
AWS A5.5-96: E7018-A1H4R

BÖHLER FOX DMO Kb

SMAW stick electrode, low-alloyed, high temperature

Description

Basic coated low-hydrogen electrode for 0.5 % Mo-alloyed boiler, plates, and tube steels. Approved in long-term condition up to +550 °C service temperature.
For high quality welds of long term stressed components with reliable mechanical properties under high and low temperature conditions. Crack resistant, tough and ageing resistant. Very low hydrogen content (acc. AWS condition HD < 4 ml/100 g). Metal recovery approx. 115 %.

Typical Composition of All-weld Metal

	C	Si	Mn	Mo
wt-%	**0.08**	**0.4**	**0.8**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a	
yield strength R_e N/mm^2:		**550**	(≥ 480)	**530**	(≥ 470)
tensile strength Rm N/mm^2:		**600**	(≥ 560)	**580**	(≥ 560)
elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 22)	**26**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 120)	**180**	(≥ 120)
	- 50 °C:		(≥ 32)		

(*) *u untreated, as-welded*
a annealed, 620 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX DMO Kb 7018-A1 E Mo B

ø mm	**L mm**	**amps A**
2.5	250/350	80 - 110
3.2	350	100 - 140
4.0	350/450	130 - 180
5.0	450	190 - 230

=+

Preheat, interpass temperature, and post weld heat treatment as required by the base metal.

Base Materials

high temperature steels and similar alloyed cast steels, steels resistant to caustic cracking and ageing resistant steels
16Mo3,S355J2G3, E295, E335, P255G1TH, L320 - L415NB, L320MB - L415MB, S255N, P295GH, P310GH, 15NiCuMoNb5, 20MnMoNi4-5, 17MnMoV6-4, S255N - S500N, S255NH - S500NH, S255NL - S500NL, GE240 - GE300, 22Mo4, GP240GH
ASTM A335 Gr. P1; A161-94 Gr. T1; A217 Gr. WC1; A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1

Approvals and Certificates

TÜV-D (0019.), KTA 1408 1 (8053.00), DB (10.014.14), ÜZ (10.014/3), ÖBB, TÜV-A (71), ABS (E 7018-A1), CL (0348), DNV (NV 0,3Mo), FI (E Mo B 42 H5), GL (15 Mo 3), RMR (-), Statoil, UDT, LTSS, VUZ, SEPROZ, CRS (3YH10)

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMO Kb	SAW combination:	EMS 2 Mo/BB 24
GTAW rod:	DMO-IG		EMS 2 Mo/BB 25
GMAW solid wire:	DMO-IG	Gas welding rod:	DMO

EN 1599:1997: E CrMo1 R 1 2
AWS A5.5-96: E8013-G
E8013-B2(mod.)

BÖHLER FOX DCMS Ti

SMAW stick electrode, low-alloyed, high temperature

Description

Rutile coated low hydrogen electrode for 1 % Cr 0.5 % Mo alloyed boiler, plate, and tube steels. Approved in long-term condition up to +570 °C service temperature.
Easy to operate. Fully alloyed core wire. Specifically preferred for thin walled welds and root pass welding in all positions (except vertical down). First class X-ray quality.
Post weld tempering at 660-700 °C for at least 1/2 h followed by cooling in furnace down to 300 °C and still air.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo
wt-%	**0.06**	**0.4**	**0.6**	**1.1**	**0.5**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm^2:		**510**	(≥ 490)
tensile strength R_m N/mm^2:		**610**	(≥ 590)
elongation A ($L_0 = 5d_0$) %:		**21**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 47)

(*) *a annealed, 680 °C/2 h/furnace down to 300 °C/air*

Operating Data

	ø mm	**L mm**	**amps A**
re-drying if necessary:			
–	2.5	250	80 - 110
electrode identification:	3.2	350	110 - 140
FOX DCMS Ti 8013-G E CrMo1 R	4.0	350	140 - 180

Preheat and interpass temperatures of 200-250 °C are required for 13CrMo4-5 steels.

Base Materials

high temperature steels and similar alloyed cast steels, case hardening and nitriding steels of similar chemical composition, similar alloyed heat treatable steels with tensile strength up to 780 N/mm^2, steels resistant to caustic cracking.

1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7225 42CrMo4, 1.7728 16CrMoV4, 1.7218 25CrMo4, 1.7258 24CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5

ASTM A193 Gr. B7; A335 Gr. P11 a. P12; A217 Gr. WC6

Approvals and Certificates

TÜV-D (0764.), DB (10.014.05), ÜZ (10.014/3), ÖBB, TÜV-A (90), ABS (Cr 0,8/1,2 Mo), CL (0413), DNV (X), GL (13 CrMo 44), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Kb	SAW combination:	EMS 2 CrMo/BB 24
GTAW rod:	DCMS-IG		EMS 2 CrMo/BB 25
GMAW solid wire:	DCMS-IG	Gas welding rod:	DCMS

EN 1599:1997: E CrMo1 B 4 2 H5
AWS A5.5-96: E8018-B2H4R

BÖHLER FOX DCMS Kb

SMAW stick electrode, low-alloyed, high temperature

Description

Basic coated low hydrogen electrode for 1 % Cr 0.5 % Mo alloyed boiler, plate, and tube steels. Approved in long-term condition up to +570 °C service temperature. Fully alloyed core wire which will provide reliable creep rupture properties for the whole service life of a boiler plant. High ductility and crack resistance. The weld metal deposit is heat treatable. Very low hydrogen content (acc. AWS condition HD < 4 ml/100 g). Metal recovery approx. 115%. Bruscato ≤15ppm. Post weld tempering at 660-700 °C for at least 1/2 h followed by cooling in furnace down to 300 °C and still air.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
wt-%	**0.07**	**0.4**	**0.8**	**1.1**	**0.5**	**≤ 0.010**	**< 0.005**	**≤ 0.005**	**≤ 0.005**

Mechanical Properties of All-weld Metal

(*)	a		v	
yield strength R_e N/mm²:	**530**	(≥ 490)	**380**	(≥ 330)
tensile strength R_m N/mm²:	**630**	(≥ 590)	**520**	(≥ 490)
elongation A ($L_0 = 5d_0$) %:	**23**	(≥ 22)	**28**	(≥ 24)
impact work ISO-V KV J + 20 °C:	**160**	(≥ 100)	**190**	(≥ 100)

(*) *a annealed 680 °C/2 h/furnace down to 300 °C/air*
v quenched/tempered 930 °C/0.5 h/air + 680 °C/10 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX DCMS Kb 8018-B2 E CrMo 1 B

ø mm	**L mm**	**amps A**
2.5	250/350	80 - 110
3.2	350	100 - 140
4.0	350/450	130 - 180
5.0	450	180 - 220

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Preheat and interpass temperature for 13CrMo4-5 steels 200-250 °C.

Base Materials

high temperature steels and similar alloyed cast steels, case hardening and nitriding steels of similar chemical composition, similar alloyed heat treatable steels with tensile strength up to 780 N/mm², steels resistant to caustic cracking.

1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7225 42CrMo4, 1.7728 16CrMoV4, 1.7218 25CrMo4, 1.7258 24CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5

ASTM A193 Gr. B7; A335 Gr. P11 a. P12; A217 Gr. WC6

Approvals and Certificates

TÜV-D (0728.), DB (10.014.32), ÜZ (10.014/3), ÖBB, TÜV-A (14), ABS (E 8018-B2), CL (0066), DNV (NV 1Cr 0,5Mo), FI (E CrMo1 B 42 H5), GL (13 CrMo 44), UDT, LTSS, VUZ, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Ti	SAW combination:	EMS 2 CrMo/BB 24
GTAW rod:	DCMS-IG		EMS 2 CrMo/BB 25
GMAW solid wire:	DCMS-IG	Gas welding rod:	DCMS

EN 1599:1997: E Z CrMoV1 B 4 2 H5
AWS A5.5-96: E9018-G

BÖHLER FOX DCMV

SMAW stick electrode, low-alloyed, high temperature

Description

Basic coated electrode for highly stressed joint and production welds on GS-17 CrMoV 5-10 type high temperature cast steel used in the construction of steam turbines and valve casings. Approved in long-term condition up to +600 °C service temperature.
High creep rupture strength thanks to the C, Cr, Mo and V-content. High fracture toughness, low hydrogen content, good welding characteristics. The deposit is heat treatable. Metal-recovery approx. 115 %.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	V
wt-%	**0.12**	**0.35**	**0.9**	**1.35**	**1.0**	**0.22**

Mechanical Properties of All-weld Metal

(*)		u	a		v
yield strength R_e N/mm²:		**720**	**680**	(≥ 530)	**500**
tensile strength R_m N/mm²:		**1000**	**770**	(≥ 620)	**630**
elongation A ($L_0 = 5d_0$) %:		**12**	**19**	(≥ 17)	**20**
impact work ISO-V KV J	+ 20 °C:	**22**	**90**	(≥ 47)	**155**

(*) *u untreated, as-welded*
a annealed 680 °C/8 h/furnace down to 300 °C/air
v quenched/tempered 940 °C/0.5 h/oil + 720 °C/12 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX DCMV 9018-G E Z CrMoV1 B

ø mm	**L mm**	**amps A**
4.0	450	130 - 180
5.0	450	180 - 230

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Preheat and interpass temperatures 300-350 °C, stress relieving > 20 °C below the tempering temperature of the cast steel, but not less than 680 °C.

Base Materials

similar alloyed high temperature steels and cast steels

1.7706 G17CrMoV5-10

Approvals and Certificates

TÜV-D (6077.), UDT, LTSS, SEPROZ

EN 1599:1997: E MoV B 4 2 H5
AWS A5.5-96: E9018-G

BÖHLER FOX DMV 83 Kb

SMAW stick electrode, low-alloyed, high temperature

Description

Basic coated core wire alloyed stick electrode with special suitability for 14MoV6-3 (1/2 Cr 1 Mo) steels. Approved in long- term condition up to +580 °C service temperature. Crack resistant and ductile deposit, low hydrogen content. Good weldability in all positions except vertical down. Metal recovery approx. 115 %.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	V
wt-%	**0.05**	**0.4**	**1.1**	**0.4**	**0.9**	**0.5**

Mechanical Properties of All-weld Metal

(*)		a		v	
yield strength R_e N/mm^2:		**510**	(≥ 470)	**410**	(≥ 380)
tensile strength R_m N/mm^2:		**660**	(≥ 610)	**580**	(≥ 540)
elongation A ($L_0 = 5d_0$) %:		**22**	(≥ 20)	**26**	(≥ 24)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 110)	**150**	(≥ 110)

(*) *a annealed 720 °C/2 h/furnace down to 300 °C/air*
v quenched/tempered 940 °C/0.5 h/oil + 730 °C/0.5 h/furnace down to 300 °C/air

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
300 - 350 °C, min. 2 h	2.5	250	70 - 100
electrode identification:	3.2	350	110 - 140
FOX DMV 83 Kb 9018-G E MoV B	4.0	350	140 - 180

=+

Preheating and interpass temperatures 200-300 °C. Post weld heat treatment at 700-720 °C for at least 2 hours followed by cooling in furnace down to 300 °C and still air.

Base Materials

similar alloyed high temperature steels and cast steels

1.7715 14MoV6-3, 1.7733 24CrMoV5-5, 1.7709 21CrMoV5-7, 1.8070 21CrMoV5-11, 1.7706 G17CrMoV5-10,

ASTM A389 Gr. C23 a. C24; A405 Gr. P24; UNS I21610

Approvals and Certificates

TÜV-D (1094.), TÜV-A (119), UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod: DMV 83-IG
GMAW solid wire: DMV 83-IG

EN 1599:1997: E CrMo2 B 4 2 H5
AWS A5.5-96: E9018-B3H4R

BÖHLER FOX CM 2 Kb

SMAW stick electrode, low-alloyed, high temperature

Description

Basic coated electrode for 2 1/4 % Cr 1% Mo alloyed boiler, plate and tube steels. Approved in long- term condition up to +600 °C service temperature. Core wire alloyed electrode which will provide reliable creep rupture properties for the whole service life of a boiler plant.
Crack resistant and ductile deposit, high creep rupture strength, low hydrogen content (acc. AWS condition HD < 4 ml/100 g). Good weldability in all positions except vertical down. Deposit is nitridable and heat treatable. Metal recovery approx. 115 %. Brucato ≤ 15 ppm.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
wt-%	**0.07**	**0.3**	**0.8**	**2.3**	**1.0**	**≤ 0.010**	**< 0.005**	**≤ 0.005**	**≤ 0.005**

Mechanical Properties of All-weld Metal

(*)		a		v		a2
yield strength R_e N/mm^2:		**510**	(≥ 440)	**480**	(≥ 400)	(≥ 530)
tensile strength R_m N/mm^2:		**640**	(≥ 570)	**620**	(≥ 570)	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**22**	(≥ 20)	**21**	(≥ 18)	(≥ 17)
impact work ISO-V KV J	+ 20 °C:	**180**	(≥ 100)	**180**	(≥ 100)	

(*) *a annealed 720 °C/2 h/furnace down to 300 °C/air*
a2 annealed, 700 °C/1 h/furnace down to 200 °C/air
v quenched/tempered, 930 °C/0.5 h/oil + 730 °C/0.5 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX CM 2 Kb 9018-B3 E CrMo2 B

ø mm	**L mm**	**amps A**
2.5	250	80 - 110
3.2	350	100 - 140
4.0	350/450	130 - 180
5.0	450	180 - 230

=+

Preheating and interpass temperatures 200-350 °C. Post weld annealing at 700-750 °C at least 1 hour followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels, QT-steels similar alloyed up to 980 N/mm^2 tensile strength, similar alloyed case hardening steels, nitriding steels

1.7380 10CrMo9-10, 1.8075 10CrSiMoV7, 1.7379 G17CrMo9-10

ASTM A335 Gr. P22; A217 Gr. WC 9

Approvals and Certificates

TÜV-D (0722.), DB (10.014.30), ÜZ (10.014/3), ÖBB, TÜV-A (13), ABS (E 9018-B3), CL (0908), DNV (NV 2,25Cr 1Mo), FI (E CrMo2 B 42 H5), GL (10 CrMo 9 10), UDT, VUZ, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CM 2 Ti	GMAW solid wire:	CM 2-IG
GTAW rod:	CM 2-IG	SAW combination:	CM 2-UP/BB 24

EN 1599:1997:	E ZCrWV 2 1.5 B42 H5
AWS A5.5: 1996:	E9018-G

BÖHLER FOX P 23

SMAW stick electrode
low-alloyed, high temperature

Description

Basic coated core wire alloyed stick electrode for welding bainitic steels such as P23/T23 (ASTM A 213, code case 2199), pipe material. For high quality welds, which will provide reliable creep rupture properties for the whole service life of a boiler plant.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	W	V	Nb
wt-%	**0.06**	**0.2**	**0.5**	**2.3**	**1.5**	**0.22**	**0.04**

Mechanical Properties of All-weld Metal

(*)	a	
yield strength R_e N/mm²:	**520**	(≥ 400)
tensile strength R_m N/mm²:	**620**	(≥ 510)
elongation A (L_0=5d_0) %:	**19**	(≥ 17)
impact work ISO-V KV J	**130**	(≥ 47)

(*) a annealed 740°C/2 h

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:	2.5	250	80-110
300-350°C, min. 2 h	3.2	350	100-140
electrode identification:	4.0	350	130-180
FOX P 23 9018-G E ZCrWV 2 1.5 B			

=+

Preheat and interpass temperature depends on wall thickness.

Base Materials

HCM2S, P/T23 ASTM A 213 code case 2199

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

GTAW rod:	P 23-IG
SAW combination:	P 23-UP/BB 430

EN 1599:1997: EZ CrMoVNbB 21 B42 H5
AWS A5.5:1996: E 9018-G

BÖHLER FOX P 24

SMAW stick electrode
low-alloyed, high temperature

Description

Basic coated core wire alloyed stick electrode for welding bainitic steels like 7CrMoVTiB10-10. For high quality welds, which will provide reliable creep rupture properties for the whole service life of a boiler plant.

Typical Analysis of All-weld Metal

	C	Si	Mn	Cr	Mo	V	Nb	B
wt-%	**0.08**	**0.4**	**0.5**	**2.4**	**1.0**	**0.22**	**0.03**	**0.003**

Mechanical Properties of All-weld Metal

(*)	a	
yield strength R_e N/mm²:	**560**	(≥ 450)
tensile strength R_m N/mm²:	**660**	(≥ 585)
elongation A (L_0=5d_0) %:	**18**	(≥ 15)
impact work ISO-V KV J	**100**	(≥ 47)

(*) a annealed 740°C/2 h

Operating Data

re-drying if necessary:	ø mm	L mm	amps A
300-350°C, min. 2 h	2.5	250	80-110
electrode identification:	3.2	350	100-140
FOX P 24 9018-G EZCrMoVNbB 2 1 B	4.0	350	130-180

=+

Preheat and interpass temperature depends on wall thickness.

Base Materials

7CrMoVTiB10-10, P24 acc. to ASTM A 213 Draft

Approvals and Certificates

TÜV-D (10454.)

Same Alloy Filler Metals

GTAW rod: P 24-IG
SAW combination: P 24-UP/BB 430

EN 1599:1997: E CrMo 5 B 4 2 H5
AWS A5.5-96: E8018-B6H4R

BÖHLER FOX CM 5 Kb

SMAW stick electrode, high-alloyed, high temperature

Description

Basic coated core wire alloyed electrode for high temperature steels and steels for hot hydrogen service. Preferably used for X12CrMo5 (5 Cr 0.5 Mo) steels. Approved in long-term condition up to +650 °C service temperature.
High crack resistance, very low hydrogen content (acc. AWS condition HD < 4 ml/100 g). Good weldability in all positions except vertical down. The deposit is heat treatable. Metal recovery approx. 115 %.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo
wt-%	**0.07**	**0.4**	**0.8**	**5.0**	**0.5**

Mechanical Properties of All-weld Metal

(*)	a		v		a2
yield strength R_e N/mm²:	**520**	(≥ 420)	**440**	(≥ 390)	(≥ 460)
tensile strength R_m N/mm²:	**620**	(≥ 590)	**580**	(≥ 570)	(≥ 550)
elongation A ($L_0 = 5d_0$) %:	**21**	(≥ 18)	**26**	(≥ 18)	(≥ 19)
impact work ISO-V KV J + 20 °C:	**90**	(≥ 80)	**110**	(≥ 80)	

(*) *a annealed 730 °C/2 h/furnace down to 300 °C/air*
a2 annealed, 760 °C/1 h/furnace down to 200 °C/air
v quenched/tempered, 960 °C/0.5 h/oil + 730 °C/0.5 h/furnace down to 300 °C/air

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
300 - 350 °C, min. 2 h	2.5	250	70 - 90
electrode identification:	3.2	350	110 - 130
FOX CM 5 Kb 8018-B6 E CrMo 5 B	4.0	350	140 - 170

=+

Preheat and interpass temperatures 300-350 °C. Post weld annealing at 730-760 °C for at least 1 hour followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels, QT-steels similar alloyed up to 1180 N/mm² tensile strength.

1.7362 X12CrMo5, 1.7363 GX12CrMo5

ASTM A213 Gr. T5; A217 Gr. C5; A335 Gr. P5

Approvals and Certificates

TÜV-D (0725.), TÜV-A (695), CL (0160), UDT, LTSS, VUZ, SEPROZ

Same Alloy Filler Metals

GTAW rod:	CM 5-IG
GMAW solid wire:	CM 5-IG
SAW combination:	CM 5-UP/BB 24

EN 1599:1997: E CrMo9 B 4 2 H5
AWS A5.5-96: E8018-B8

BÖHLER FOX CM 9 Kb

SMAW stick electrode, high-alloyed, high temperature

Description

Basic coated alloyed core wire electrode for high temperature steels and steels for hot hydrogen service, particularly in the petrochemical industry. Preferably used for 9% Cr 1% Mo steels (e.g. X12CrMo9-1). Approved in long-term condition up to + 650 °C service temperature.
The weld metal is heat treatable. Metal recovery approx. 115 %.
Detailed information on welding technology available on request.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo
wt-%	**0.07**	**0.4**	**0.7**	**9.0**	**1.0**

Mechanical Properties of All-weld Metal

(*)	a		v	
yield strength R_e N/mm²:	**610**	(≥ 550)	**600**	(≥ 550)
tensile strength R_m N/mm²:	**730**	(≥ 690)	**730**	(≥ 690)
elongation A (L_0=5d_0) %:	**20**	(≥ 19)	**25**	(≥ 19)
impact work ISO-V KV J + 20 °C:	**70**	(≥ 55)	**100**	(≥ 55)

(*) *a annealed, 760 °C/1 h/furnace down to 300 °C/air*
v quenched/tempered, 930 °C/10 min/air + 740 °C/2 h/air

Operating Data

re-drying if necessary:
300 - 350 °C, mind. 2 h
electrode identification:
FOX CM 9 Kb 8018-B8 E CrMo9 B

ø mm	L mm	amps A
2.5	250	70 - 90
3.2	350	100 - 130
4.0	350	130 - 160

=+

Preheating and interpass temperatures 250-350 °C. Post weld annealing at 710-760°C for at least 1 hr followed by cooling in furnace down to 300 °C and still air.

Base Materials

highly high temperature steels, same alloyed

1.7386 X12CrMo9-1, 1.7388 X7CrMo9-1, 1.7389 GX12CrMo10

ASTM A217 Gr. C12; A 234 Gr. WP9; A335 Gr. P9

Approvals and Certificates

TÜV-D (2183.), TÜV-A (522), UDT, VUZ, SEPROZ

Same Alloy Filler Metals

GTAW rod: CM 9-IG

EN 1599:1997: E CrMo91 B 4 2 H5
AWS A5.5-96: E9015-B9

BÖHLER FOX C 9 MV

SMAW stick electrode, high-alloyed, creep resistant

Description

Basic coated core wire alloyed electrode suited for high temperature martensitic 9-12 % chromium steels, especially for T 91 and P91 steels and operating temperatures up to +620 °C (approved up to +650 °C). High creep rupture strength and good toughness properties under long term stresses. Low hydrogen content. The electrode is suitable in all positions except vertical down. It features excellent striking and re-striking properties.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Nb	V
wt-%	**0.09**	**0.3**	**0.5**	**9.0**	**0.9**	**0.9**	**0.05**	**0.2**

Mechanical Properties of All-weld Metal

(*)		a1	
yield strength R_e N/mm²:		**500**	(≥ 415)
tensile strength R_m N/mm²:		**720**	(≥ 585)
elongation A ($L_0 = 5d_0$) %:		**19**	(≥ 17)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 41)

(*) *a1 annealed, 760 °C/2 h/furnace down to 300 °C/air*

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX C 9 MV 9015-B9 E CrMo91 B

ø mm	**L mm**	**amps A**
2.5	250	60 - 80
3.2	350	90 - 120
4.0	350	110 - 140
5.0	450	150 - 180

=+

Preheating and interpass temperature 200-300 °C. After welding the joint should be cooled down below 80 °C to finish the martensite transformation. A cooling down to room temperature is possible up to a wall thickness of 45 mm. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates up to 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h. For optimised toughness values a welding technology should be applied which produces thin welding layers (app. 2 mm).

Base Materials

similar alloyed creep resistant steels

1.4903 X10CrMoVNb9-1

ASTM A199 Gr. T91; A335 Gr. P91 (T91); A213/213M Gr. T91

Approvals and Certificates

TÜV-D (6762.), CL (1267), UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod:	C 9 MV-IG	GMAW solid wire:	C 9 MV-IG
GMAW wire:	C 9 MV-IG	GMAW metal cored wire:	C 9 MV-MC
		SAW combination:	C 9 MV-UP/BB 910

EN 1599:1997: E Z CrMoWVNb 9 1 1 B 4 2 H5
AWS A5.5-96: E9015-B9 (mod.)

BÖHLER FOX C 9 MVW

SMAW stick electrode, high-alloyed, creep resistant

Description

Basic coated core wire alloyed Cr-Mo-Ni-V-W-Nb-electrode for the welding of high temperature martensitic steels like e.g. X11CrMoWVNb9-1-1 (P911/T911). Approved in long-term condition up to +650 °C service temperature. Good welding properties in all positions except vertical down.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	W	V	N	Nb
wt-%	**0.1**	**0.25**	**0.7**	**8.5**	**1.0**	**0.7**	**1.0**	**0.2**	**0.05**	**0.05**

Mechanical Properties of All-weld Metal

(*)			a
yield strength R_e N/mm^2:		**560**	(≥ 530)
tensile strength R_m N/mm^2:		**720**	(≥ 700)
elongation A ($L_0 = 5d_0$) %:		**15**	(≥ 15)
impact work ISO-V KV J	+ 20 °C:	**40**	(≥ 27)

(*) *a annealed, 760 °C/2 h/furnace down to 300 °C/air*

Operating Data

	ø mm	**L mm**	**amps A**
re-drying if necessary:			
300 - 350 °C, min. 2 h	3.2	350	90 - 120
electrode identification:	4.0	350	110 - 140
FOX C 9 MVW E Z CrMoWVNb 9 1 1 B	5.0	450	150 - 180

=+

Preheating and interpass temperature 200-300 °C. After welding the joint should be cooled down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered.
The following post weld heat treatment is recommended: annealing 760 °C/ min. 2 hrs, max. 10 hrs, heating and cooling rates up to 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h.
For optimised toughness values a welding technology should be applied which produces thin welding layers (app. 2 mm).

Base Materials

similar alloyed creep resistant steels

1.4905 X11CrMoWVNb9-1-1

ASTM A335 Gr. P911; A213 Gr. T911

Approvals and Certificates

TÜV-D (9176.), UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod:	C 9 MVW-IG
SAW combination:	C 9 MVW-UP/BB 910

EN 1599:1997: E Z CrMoWVNb 9 0,5 2 B 4 2 H5
AWS A5.5-96: E9015-B9(mod.)

BÖHLER FOX P 92

SMAW stick electrode, high-alloyed, creep resistant

Description

Basic coated Cr-Mo-Ni-V-W-Nb alloyed stick electrode suited for welding of high temperature steel 9%Cr-1.5% W-Mo-Nb-N. Approved in long-term condition up to + 650 °C service temperature. The stick electrode features a stable arc, good striking and re-striking properties, low spatter loss and an easy removable slag.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	W	V	N	Nb
wt-%	**0.1**	**0.3**	**0.7**	**9.1**	**0.55**	**0.7**	**1.7**	**0.2**	**0.045**	**0.05**

Mechanical Properties of All-weld Metal

(*)	a		a2	a2 (650 °C test temp)	
yield strength R_e N/mm²:	**690**	(≥ 560)	**630**	**230**	(≥ 125)
tensile strength R_m N/mm²:	**810**	(≥ 720)	**760**	**330**	
elongation A ($L_0 = 5d_0$) %:	**19**	(≥ 15)	**20**	**22**	
impact work ISO-V KV J + 20 °C:	**55**	(≥ 41)	**80**		
0 °C:			**50**		

(*) *a annealed 760 °C/2 h/furnace down to 300 °C/air*
a2 annealed 760 °C/6 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX P 92 E Z CrMoWVNb9 0.5 2 B

ø mm	**L mm**	**amps A**
3.2	350	90 - 120
4.0	350	110 - 140

=+

Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C, to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered.
The following postweld heat treatment is recommended: Annealing 760 °C/min. 2 hours, max. 10 hours, heating/cooling rate up to 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h. In case of heat treatments less than 2 hours the requirements have to be proved by a procedure test.
For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).

Base Materials

similar alloyed creep resistant steels

NF 616

ASTM A335 Gr. P 92 (T92); A213 Gr. T92

Approvals and Certificates

TÜV-D (9291.), UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod:	P 92-IG	SAW combination:	P 92-UP/BB 910

EN 1599:1997: E CrMoWV 12 B 4 2 H5

BÖHLER FOX 20 MVW

SMAW stick electrode, high-alloyed, creep resistant

Description

Basic coated, core wire alloyed electrode for high temperature, heat treatable 12 % chromium steels in turbine and boiler construction as well as in the chemical industry. Preferably used for X20CrMoV12-1. Approved in long-term condition up to +650 °C service temperature.
High creep rupture strength and excellent toughness under long term stresses. Optimum chemical composition ensures a high quality weld metal. Low hydrogen content (HD < 5 ml/100 g). Good weldability in all positions except vertical down. The weld metal deposit is heat treatable.
Metal recovery approx. 115 %.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	V	W
wt-%	**0.18**	**0.3**	**0.6**	**11.0**	**0.6**	**1.0**	**0.3**	**0.5**

Mechanical Properties of All-weld Metal

(*)		a		v	
yield strength R_e N/mm^2:		**610**	(≥ 590)	**590**	(≥ 550)
tensile strength R_m N/mm^2:		**800**	(≥ 700)	**790**	(≥ 740)
elongation A ($L_0 = 5d_0$) %:		**18**	(≥ 15)	**18**	(≥ 15)
impact work ISO-V KV J	+ 20 °C:	**45**	(≥ 35)	**45**	(≥ 35)

(*) *a annealed 760 °C/4 h/furnace down to 300 °C/furnace down to 300 °C/air*
v quenched/tempered 1050 °C/0.5 h/oil + 760 °C/2 h/furnace down to 300 °C/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX 20 MVW E CrMoWV12 B

ø mm	**L mm**	**amps A**
2.5	250	60 - 80
3.2	350	90 - 120
4.0	350	110 - 140
5.0	450	150 - 180

=+

Preheating and interpass temperatures 400-450 °C (austenitic welding) or 250-300 °C (martensitic welding). Root passes should principally be welded in the martensitic range. Lower preheat and interpass temperatures are possible, yet must be approved by practical welding tests and process qualification tests.
After welding cooling down to 90±10 °C, followed by tempering at 720-760 °C for three minutes / mm wall thickness (at least for 2 hours). Tempering, if specified, at 1050 °C for 1/2 hour/oil and annealing at 760 °C for 2 hours.

Base Materials

similar alloyed creep resistant steels

1.4922 X20CrMoV12-1, 1.4935 X20CrMoWV12-1, 1.4923 X22CrMoV12-1,
1.4913 X19CrMoVNb11-1 (Turbotherm, 20 MVNb), 1.4931 GX22CrMoV12-1

Approvals and Certificates

TÜV-D (01082.), KTA 1408 1 (8088.00), DB (10.014.31), ÜZ (10.014/3), ÖBB, TÜV-A (81), CL (0218), UDT, LTSS, SEPROZ

Same Alloy Filler Metals

GTAW rod:	20 MVW-IG
SAW combination:	20 MVW-UP/BB 24

EN 1600: E Z 16 13 Nb B 4 2 H5

BÖHLER FOX CN 16/13

SMAW stick electrode, high-alloyed, creep resistant

Description

Basic coated core wire alloyed electrode for high quality weld joints in high efficiency boilers and turbine components. Approved in long-term condition up to +800 °C.
Fully austenitic weld deposit. Insusceptible to embrittlement and resistant to hot cracking.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.15**	**0.4**	**3.6**	**16.0**	**13.0**	**1.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**450**	(≥ 300)
tensile strength R_m N/mm²:		**600**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**31**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 50)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
250 - 300 °C, min. 2 h	2.5	250	60 - 80
electrode identification:	3.2	350	80 - 110
FOX CN 16/13 E Z 16 13 Nb B	4.0	350	110 - 140

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Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. Low heat input is recommended. Interpass temperatures should not exceed 150 °C.

Base Materials

similar alloyed creep resistant steels

1.4961 X8CrNiNb16-13, 1.4910 X3CrNiMoN17-13, 1.4981 X8CrNiMoNb16-16
1.4988 X8CrNiMoVNb16-13, 1.4878 X12CrNiTi18-9

Approvals and Certificates

TÜV-D (0550.), UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod: CN 16/13-IG

EN 1600:1997: E 19 9 B 4 2 H5
AWS A5.4-92: E308-15

BÖHLER FOX CN 18/11

SMAW stick electrode, high-alloyed, creep resistant

Description

Basic coated, core wire alloyed electrode with controlled delta ferrite content (3-8 FN) for austenitic CrNi steels with increased carbon contents (e.g. 1.4948 / 304H), in the boiler, reactor and turbine fabrication. Approved in long-term condition up to +700 °C service temperature (300 °C in the case of wet corrosion). Resistant to hot cracking, scaling and corrosion. Excellent weldability in all positions except vertical down. Also suitable for German material no. 1.4551 and no. 1.4550, which are approved for temperatures up to +550 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	FN
wt-%	**0.05**	**0.3**	**1.3**	**19.0**	**10.3**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 350)
tensile strength R_m N/mm²:		**580**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**85**	(≥ 70)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:	ø mm	L mm	amps A
250 - 300 °C, min. 2 h	2.5	250	50 - 80
electrode identification:	3.2	350	80 - 100
FOX CN 18/11 308-15 E 19 9 B	4.0	350	110 - 140

=+

Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C
Interpass temperature should not exceed 200 °C.

Base Materials

similar alloyed creep resistant steels

1.4948 X6CrNi18-11, 1.4949 X3CrNiN18-11
AISI 304H, 321H, 347H

Approvals and Certificates

TÜV-D (0138.), KTA 1408 1 (8067.00), TÜV-A (447), CL (0332), UDT, LTSS, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 308 H	GMAW flux cored wire:	E 308 H-FD
GTAW rod:	ER 308 H-IG		E 308 H PW-FD
	CN 18/11-IG	SAW combination:	CN 18/11-UP/BB 202
GMAW solid wire:	CN 18/11-IG		

EN 1600:1997: E 19 9 H R 4 2 H5
AWS A5.4-92: E308H-16

BÖHLER FOX E 308 H

SMAW stick electrode, high-alloyed, creep resistant

Description

Rutile-basic coated, core wire alloyed electrode for the use of high temperature CrNi austenitic steel for service temperatures up to +700 °C. Specially designed for the base metal AISI 304H (W. no. 1.4948). Controlled ferrite content of 3-8 FN. The deposit is insusceptible to embrittlement and scaling. Excellent weldability in all position except vertical down.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	FN
wt-%	**0.05**	**0.6**	**0.7**	**19.4**	**10.4**	**0.2**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**420**	(≥ 350)
tensile strength R_m N/mm^2:		**580**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:	**ø mm**	**L mm**	**amps A**
120 - 200 °C, min. 2 h	2.5	300	45 - 75
electrode identification:	3.2	350	70 - 110
FOX E 308 H-16 E 19 9 H R	4.0	350	110 - 145

=+ ∼

Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C, Interpass temperature should not exceed 200 °C.

Base Materials

similar alloyed creep resistant steels

1.4948 X6CrNi18-11, 1.4878 X12CrNiTi18-9

AISI 304, 304H, 321H, 347H

Approvals and Certificates

UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 18/11	GMAW flux cored wire:	E 308 H-FD
GTAW rod:	ER 308 H-IG		E 308 H PW-FD
	CN 18/11-IG	SAW combination:	CN 18/11-UP/BB 202
GMAW solid wire:	CN 18/11-IG		

EN 1600: 1997:	E 19 9 Nb B
AWS A5.4-92:	E 347-15

BÖHLER FOX E 347 H

SMAW stick electrode
high-alloyed, creep resistant

Description

Basic coated, core wire alloyed electrode for the use of high temperature CrNi austenitic steel for service temperatures exceeding +400 °C. Specially designed for the base metal AISI 347H. Controlled ferrite content of 3-8 FN. The deposit is less susceptible to embrittlement and is scaling resistant. Excellent weldability in all position except vertical down.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb	FN
wt-%	**0.05**	**0.3**	**1.3**	**19.0**	**10.0**	**≥8xC**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 350)
tensile strength R_m N/mm²:		**620**	(≥ 560)
elongation A (L_0=5d_0) %:		**35**	(≥ 30)
impact work ISO-V KV J	+20 °C:	**85**	

(*) u untreated, as-welded

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
–	2.5	300	50- 80
electrode identification:	3.2	350	75-110
FOX E 347 H-15 E 19 9 Nb B	4.0	350	110-145

=+

Base Materials

similar alloyed creep resistant steels
AISI 347H, AISI 321H

Approvals and Certificates

–

EN 12070:1999: W Mo Si
EN 1668:1997: W2Mo (for rod)
EN 1668:1997: W 46 3 W2Mo
AWS A5.28-96: ER70S-A1 (ER80S-G)
W.Nr.: 1.5424

BÖHLER DMO-IG

GTAW rod, low-alloyed, high temperature (high strength)

Description

Copper coated GTAW rod for welding in boiler, pressure vessel, pipeline, and crane construction as well as in structural steel engineering. Very tough deposit of high crack resistant, non-ageing. Recommended for the temperature range from -30 °C to +500 °C. Good copper bonding with low total copper content. Very good welding and flow characteristics.

Typical Composition of Welding Rod

	C	Si	Mn	Mo
wt-%	**0.1**	**0.6**	**1.2**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a	
yield strength R_e N/mm^2:		**520**	(≥ 480)	**480**	(≥ 400)
tensile strength R_m N/mm^2:		**630**	(≥ 570)	**570**	(≥ 515)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 23)	**26**	(≥ 19)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 180)	**230**	(≥ 200)
	- 30 °C:		(≥ 47)		

(*) *u untreated, as-welded – shielding gas Argon*
a annealed, 620 °C/1 h/furnace down to 300 °C/air – shielding gas Argon

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **WMoSi**
back: **1.5424**

ø mm
1.6
2.0
2.4
3.0
3.2

=–

Preheat, interpass temperature and post weld heat treatment as required by the base metal. For high strength applications please consult us.

Base Materials

similar alloyed high temperature steels and cast steels, ageing resistant and steels resistant to caustic cracking

16Mo3, S355J2G3, L320 - L415NB, L320 MB - L415MB, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, 17MnMoV6-4, 22NiMoCr4-7, 20MnMoNi5-5, 15NiCuMoNb5, 20MnMoNi4-5, GE240 - GE300, 22Mo4, S255N - S460N, P255NH - P460NH

ASTM A335 Gr. P1; A161-94 Gr. T1; A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1; A217 Gr. WC1

Approvals and Certificates

TÜV-D (0020.), KTA 1408 1 (8066.02), DB (42.014.09), ÜZ (42.014), ÖBB, TÜV-A (75), BV (UP), CL (0483), DNV (I YMS), FI (W MoSi), UDT, CRS (3)

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMO Kb	SAW combination:	EMS 2 Mo/BB 24
	FOX DMO Ti		EMS 2 Mo/BB 25
GMAW solid wire:	DMO-IG	Gas welding rod:	DMO

EN 12070:1999: W CrMo1 Si
AWS A5.28-96: ER80S-G
ER80S-B2 (mod.)
W.Nr.: 1.7339

BÖHLER DCMS-IG

GTAW rod, low-alloyed, high temperature

Description

GTAW rod for 1.25 % Cr 0.5 % Mo alloyed boiler, plate and tube steels as well as for the welding of quenched and tempered and case hardening steels. Preferably used for the steels 13CrMo4-5 or ASTM A335 P11/P12. Approved in long-term condition up to + 570 °C service temperature. The deposit is noted for its good mechanical properties and good toughness. Further, good resistance to cracking, when attacked by caustic soda, and the fact that it is suitable for nitriding, quenching and tempering are additional features. The values of the creep rupture strength lay within the scatter band of the material 13CrMo4-5. Brucato ≤ 15 ppm.
Very good operating characteristics.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
wt-%	**0.11**	**0.6**	**1.0**	**1.2**	**0.5**	**≤ 0.012**	**≤ 0.010**	**≤ 0.005**	**≤ 0.006**

Mechanical Properties of All-weld Metal

(*)	a1		a2	
yield strength R_e N/mm^2:	**490**	(≥ 440)	**510**	(≥ 470)
tensile strength R_m N/mm^2:	**590**	(≥ 520)	**620**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:	**25**	(≥ 22)	**22**	(≥ 19)
impact work ISO-V KV J + 20 °C:	**250**	(≥ 47)	**200**	

a1 annealed, 680 °C/2 h/furnace down to 300 °C/air – shielding gas Argon
a2 annealed, 620 °C/1 h/furnace down to 320 °C/air – shielding gas Argon

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W CrMo1 Si**
back: **1.7339**

ø mm
1.6
2.0
2.4
3.0

=–

Preheat, interpass temperature and post weld heat treatment as required by the base metal. Preheating and interpass temperature for 13CrMo4-5 (P11/P12), 200-250 °C. Tempering at 660-700 °C at least 1/2 hr followed by cooling in furnace down to 300 °C and still air.

Base Materials

similar alloyed high temperature steels and cast steels, case hardening and nitriding steels of similar chemical composition, steels resistant to caustic cracking

1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7225 42CrMo4, 1.7728 16CrMoV4, 1.7218 25CrMo4, 1.7258 24CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5

ASTM A193 Gr. B7; A217 Gr. WC6; A335 Gr. P11 a. P 12

Approvals and Certificates

TÜV-D (0727.), TÜV-A (91), FI (W CrMo1Si), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Kb	SAW combination:	EMS 2 CrMo/BB 24
	FOX DCMS Ti		EMS 2 CrMo/BB 25
GMAW solid wire:	DCMS-IG	Gas welding rod:	DCMS

EN 12070:1999: W MoV Si
AWS A5.28-96: ER80S-G
W.Nr.: 1.5407

BÖHLER DMV 83-IG

GTAW rod, low-alloyed, high temperature

Description

GTAW rod specially designed for the base metal 14MoV6-3 (1/2 Cr 1/2 Mo 1/4 V). Approved in long-term condition up to +560 °C service temperature. Tough, cracking resistant deposit with good creep rupture strength.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo	V
wt-%	**0.08**	**0.6**	**0.9**	**0.45**	**0.85**	**0.35**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**520**	(≥ 470)
tensile strength R_m N/mm²:		**670**	(≥ 580)
elongation A ($L_0 = 5d_0$) %:		**24**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**220**	(≥ 47)

(*) *a annealed, 700 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon** **ø mm** 2.4

rod marking:
front: **W MoV Si**
back: **1.5407**

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Preheating and interpass temperatures 200-300 °C. Tempering at 700-720 °C at least 2 hrs followed by cooling in furnace down to 300 °C and still air.

Base Materials

similar alloyed high temperature steels and cast steels

1.7715 14MoV6-3, 1.7733 24CrMoV5-5, 1.7709 21CrMoV5-7, 1.8070 21CrMoV5-11, 1.7706 G17CrMoV5-10,

ASTM A389 Gr. C23 a. C24; A405 Gr. P24; UNS I21610

Approvals and Certificates

TÜV-D (1093.), TÜV-A (120), UDT, LTSS, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMV 83 Kb
GTAW rod:	DMV 83-IG
GMAW solid wire:	DMV 83-IG

EN 12070:1999: W CrMo2 Si
AWS A5.28-96: ER90S-G
ER90S-B3(mod.)
W.Nr.: 1.7384

BÖHLER CM 2-IG

GTAW rod, low-alloyed, high temperature

Description

GTAW rod for 2.25 Cr 1 % Mo alloyed boiler, plate and tube steels as well as in oil refineries. Preferably used for base metal 10CrMo9-10 (ASTM A335 P22). Approved in long-term condition up to +600 °C service temperature. Also for similarly alloyed quenched and tempered steels as well as case hardening steels. The weld metal meets all prerequisites for reliable long term creep properties without embrittlement due to very low content of trace elements. Brucato ≤ 15 ppm. Very good operating characteristics.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
wt-%	**0.06**	**0.7**	**0.95**	**2.6**	**1.0**	**≤ 0.010**	**≤ 0.010**	**≤ 0.005**	**≤ 0.006**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**470**	(≥ 420)
tensile strength R_m N/mm²:		**600**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**190**	(≥ 47)

(*) *a annealed, 720 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W CrMo2 Si**
back: **1.7384**

ø mm
1.6
2.0
2.4
3.0

=–

Preheating and interpass temperature 200-350 °C. Tempering at 700-750 °C at least 1 hr followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels, similar alloyed case hardening steels, nitriding steels

1.7380 10CrMo9-10, 1.8075 10CrSiMoV7, 1.7379 G17CrMo9-10

ASTM A335 Gr. P22; A217 Gr. WC 9

Approvals and Certificates

TÜV-D (1564.), TÜV-A (89), CL (0899), FI (W CrMo2Si), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX CM 2 Kb

GMAW solid wire: CM 2-IG
SAW combination: CM 2-UP/BB 24

EN 12070:1999: E ZCrWV 21,5 B42 H5
AWS A5.28:1996 ER90S-G

BÖHLER P 23-IG

GTAW rod
low-alloyed, high temperature

Description

For manual or automatic GTAW-welding of creep resistant steels such as HCM2S (P23/T23 acc. to ASTM A 213 code case 2199), pipe or tube material.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	W	V	Nb	N	B
wt-%	**0.07**	**0.3**	**0.5**	**2.2**	**1.7**	**0.22**	**0.05**	**0.01**	**0.002**

Mechanical Properties of All-weld Metal

(*)	u	a
yield strength R_e N/mm²:	**585**	**450**
tensile strength R_m N/mm²:	**650**	**585**
elongation A (L_0=5d_0) %:	**15**	**17**
impact work ISO-V KV J	**100**	**120**

(*) *u untreated, as-welded – shielding gas Argon*
a annealed 740°C/2 h

Operating Data

Shielding gas:
100% Argon
rod marking:
W Cr2WV/T23

ø mm	L mm	Spools
1.0		BS300
1.2		BS300
1.6	1000	
2.0	1000	
2.4	1000	
3.2	1000	

Base Materials

HCM2S, P/T23 ASTM A 213 code case 2199

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW stick electrode: FOX P 23
SAW combination: P 23-UP/BB 430

EN 12070:1999:	W Z CrMoV 2
AWS A5.28:1996	E 90S-G

BÖHLER P 24-IG

GTAW rod
low-alloyed, high temperature

Description

For manual or automatic GTAW-welding of creep resistant steels such as 7CrMoVTiB10-10 (P24/T24 acc. to ASTM A 213 Draft), pipe or tube material.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo	Nb	V	Ti	B
wt-%	**0.10**	**0.25**	**0.55**	**2.5**	**1.0**	**0.05**	**0.22**	**0.002**	**0.002**

Mechanical Properties of All-weld Metal

(*)	u	a
yield strength R_e N/mm^2:	**600**	**540**
tensile strength R_m N/mm^2:	**700**	**620**
elongation A (L_0=5d_0) %:	**15**	**20**
impact work ISO-V KV J	**100**	**120**

(*) *u untreated, as-welded – shielding gas Argon*
a annealed 740 °C/2 h

Operating Data

Shielding gas:
100% Argon
rod marking:
W CrMoVTiB/T24

ø mm	L mm	Spools
1.0		BS300
1.2		BS300
1.6	1000	
2.0	1000	
2.4	1000	
3.2	1000	

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Preheat and interpass temperature depends on wall thickness.

Base Materials

7CrMoVTiB10-10, P24 acc. to ASTM A 213 Draft

Approvals and Certificates

TÜV (10455.)

Same Alloy Filler Metals

SMAW stick electrode:	FOX P 24
SAW combination:	P 24-UP/BB 430

EN 12070:1999: W CrMo5 Si
AWS A5.28-96: ER80S-B6
W.Nr.: 1.7373

BÖHLER CM 5-IG

GTAW rod, high-alloyed, high temperature

Description

GTAW rod for 5 % Cr 0.5 % Mo steels and steels for hot hydrogen service, particularly for application in oil refineries and the base metals X12CrMo5 / P5. Approved in long-term condition up to +650 °C service temperature.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo
wt-%	**0.08**	**0.4**	**0.5**	**5.8**	**0.6**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**510**	(≥ 470)
tensile strength R_m N/mm²:		**620**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 47)

(*) *a annealed, 730 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W CrMo5 Si**
back: **ER80S-B6**

ø mm
1.6
2.0
2.4
3.0

=–

Preheating and interpass temperatures 300-350 °C. Tempering at 730-760 °C at least 1 hr followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels

1.7362 X12CrMo5, 1.7363 GX12CrMo5

ASTM A213 Gr. T5; A217 Gr. C5; A335 Gr. P5

Approvals and Certificates

TÜV-D (0724.), TÜV-A (524), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CM 5 Kb
GMAW solid wire:	CM 5-IG
SAW combination:	CM 5-UP/BB 24

EN 12070:1999: W CrMo9 Si
AWS A5.28-96: ER80S-B8

BÖHLER CM 9-IG

GTAW rod, high-alloyed, high temperature

Description

GTAW rod for 9 % Cr 1 % Mo high temperature steels and steels for hot hydrogen service, particularly for application in oil refineries and the base metals X12CrMo9-1 (P9). Approved in long-term condition up to +600 °C service temperature.

Typical Composition of Welding Rod

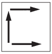
	C	Si	Mn	Cr	Mo
wt-%	**0.07**	**0.5**	**0.5**	**9.0**	**1.0**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**530**	(≥ 450)
tensile strength R_m N/mm²:		**670**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**24**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**250**	(≥ 47)

(*) *a annealed, 760 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*

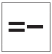
Operating Data



shielding gas: **100 % Argon**

rod marking:
front: **W CrMo9 Si**
back: **ER80S-B8**

ø mm
1.6
2.0
2.4



Preheating and interpass temperature 250-350 °C. Tempering at 710-760 °C for at least 1 hr followed by cooling in furnace down to 300 °C/air. For detailed information about the welding technology please contact our service departments.

Base Materials

similar alloyed creep resistant steels

1.7386 X12CrMo9-1, 1.7388 X7CrMo9-1, 1.7389 GX12CrMo10

ASTM A217 Gr. C12; A 234 Gr. WP9; A335 Gr. P9

Approvals and Certificates

TÜV-D (2182.), TÜV-A (523), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX CM 9 Kb

EN 12070:1999: W CrMo91
AWS A5.28-96: ER90S-B9
W.Nr.: 1.4903

BÖHLER C 9 MV-IG

GTAW rod, high-alloyed, creep resistant

Description

GTAW rod for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels T91/P91. Approved in long-term condition up to +650 °C service temperature.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	V	Nb
wt-%	**0.12**	**0.3**	**0.5**	**9.0**	**0.7**	**0.9**	**0.2**	**0.055**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**660**	(≥ 520)
tensile strength R_m N/mm²:		**760**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**17**	(≥ 16)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 50)

(*) *a annealed, 760 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **WCrMo91**
back: **ER 90S-B9**

ø mm
2.0
2.4
3.0

=–

Preheating and interpass temperature 200-300 °C. After welding, the weld joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/hr, above 550 °C max. 80 °C/hr. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).

Base Materials

similar alloyed creep resistant steels

1.4903 X10CrMoVNb9-1

ASTM A199 Gr. T91; A335 Gr. P91; A213/213M Gr. T91

Approvals and Certificates

TÜV-D (07106.), CL (1225), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX C 9 MV
GMAW solid wire: C 9 MV-IG
GMAW metal cored wire: C 9 MV-MC
SAW combination: C 9 MV-UP/BB 910

EN 12070: 1999: W Z CrMoWVNb 911
AWS A5.28-96: ER90S-B9(mod.)

BÖHLER C 9 MVW-IG

GTAW rod,
high-alloyed, creep resistant

Description

GTAW-rod for high temperature, creep resistant martensitic 9 % chromium steels, especially designed for the steel P 911 according to ASTM A335. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 200-300 °C. After welding the joint should be cooled down below 80°C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/ min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/h, above 550 °C max. 80 °C/hr. For optimised toughness values a welding technology should be applied which produces thin welding layers (app. 2 mm).

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	V	Nb	W	N
wt-%	**0.11**	**0.35**	**0.45**	**9.0**	**0.75**	**0.98**	**0.2**	**0.06**	**1.05**	**0.04**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm^2:		**660**	(≥ 560)
tensile strength R_m N/mm^2:		**790**	(≥ 720)
elongation A (L_0=5d_0) %:		**16**	(≥ 15)
impact work ISO-V KV J	+20 °C:	**50**	(≥ 41)

(*) a annealed 760 °C/2 h/furnace down to 300 °C/air – shielding gas 100 % Argon

Operating Data

Shielding gas:
100 % Argon
front: E 911
back: –

ø mm
2.0
2.4

=–

Base Materials

similar alloyed creep resistant steels
1.4905 X11CrMoWVNb9-1-1,
ASTM A335 Gr. P911, A213 Gr. T911

Approvals and Certificates

TÜV-D (9177.), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX C 9 MVW

EN 12070:1999: W Z CrMoWVNb 9 0.5 1.5
AWS A5.28-96: ER90S-B9(mod.)

BÖHLER P 92-IG

GTAW rod, high-alloyed, creep resistant

Description

GTAW rod especially designed for the welding of a 9 % Cr 1.5 % W Mo-Nb-N / P92, NF616-steels. Approved in long-term condition up to +650 °C service temperature.

Typical Composition of Welding Rod

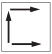
	C	Si	Mn	Cr	Ni	Mo	V	Nb	W	N
wt-%	**0.10**	**0.4**	**0.4**	**8.6**	**0.6**	**0.4**	**0.2**	**0.05**	**1.5**	**0.05**

Mechanical Properties of All-weld Metal

(*)	a		a2	a2 (650 °C test temp.)	
yield strength R_e N/mm²:	**710**	(≥ 560)	**650**	**230**	(≥ 125)
tensile strength R_m N/mm²:	**820**	(≥ 720)	**770**	**340**	
elongation A ($L_0 = 5d_0$) %:	**19**	(≥ 15)	**20**	**21**	
impact work ISO-V KV J + 20 °C:	**77**	(≥ 41)	**70**		

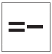
(*) *a annealed 760 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*
a2 annealed 760 °C/6 h/furnace down to 300 °C/air – shielding gas Argon

Operating Data



shielding gas:
100 % Argon
rod marking:
front: **P 92**
back: –

ø mm
2.0
2.4



Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered.
The following postweld heat treatment is recommended: Annealing 760 °C/min. 2 hours, max. 10 hours, heating/cooling rate below 550 °C max. 150 °C/h, above 550 °C max. 80 °C/h. In case of heat treatments less than 2 hours the requirements have to be proved by a procedure test.
For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).

Base Materials

similar alloyed creep resistant steels

NF 616

ASTM A335 Gr. P 92 (T92); A213 Gr. T92

Approvals and Certificates

TÜV-D (9292.), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX P 92 SAW combination: P 92-UP/BB 910

EN 12070:1999: W CrMoWV12 Si
W.Nr: 1.4937

BÖHLER 20 MVW-IG

GTAW rod, high-alloyed, creep resistant

Description

GTAW rod for creep resistant, quenched and tempered 12 % Cr steels in turbine and boiler fabrication and in the chemical industry. Preferably used for the base metal X20CrMoV12-1. Approved in long-term condition up to +650 °C service temperature. The deposit exhibits high creep rupture strength and good toughness properties under long term stresses.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo	V	W
wt-%	**0.21**	**0.4**	**0.6**	**11.3**	**1.0**	**0.3**	**0.45**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**610**	(≥ 590)
tensile strength R_m N/mm²:		**780**	(≥ 700)
elongation A ($L_0 = 5d_0$) %:		**18**	(≥ 15)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 35)

(*) *a annealed, 760 °C/2 h/furnace down to 300 °C/air – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W CrMoWV12 Si**
back: **1.4937**

ø mm
2.0
2.4

=–

Preheating and interpass temperatures 400-450 °C (austenitic welding) or 250-300 °C (martensitic welding). Root passes should principally be welded in the martensitic range. Lower preheat and interpass temperatures are possible, yet must be approved by practical welding tests and process qualification tests. After welding cooling down to 90±10 °C, followed by tempering at 720-760 °C for three minutes / mm wall thickness (at least for 2 hours). Tempering, if specified, at 1050 °C for 1/2 hour/oil and annealing at 760 °C for 2 hours.

Base Materials

similar alloyed creep resistant steels

1.4922 X20CrMoV12-1, 1.4935 X20CrMoWV12-1, 1.4923 X22CrMoV12-1
1.4913 X19CrMoVNb11-1 (Turbotherm, 20 MVNb), 1.4931 GX22CrMoV12-1

Approvals and Certificates

TÜV-D (01083.), KTA 1408 1 (8087.00), DB (42.014.24), ÜZ (42014/3), ÖBB, TÜV-A (82), CL (0437), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX 20 MVW	SAW combination:	20 MVW-UP/BB 24

EN 12072:1999: W Z 16 13 Nb
W.Nr: 1.4961 / 1.4948 (mod.)

BÖHLER CN 16/13-IG

GTAW rod, high-alloyed, creep resistant

Description

GTAW rod for high quality weld joints in high efficiency boilers and turbine components. Approved in long-term condition up to +750 °C service temperature.
Fully austenitic weld deposit. Insusceptible to embrittlement and resistant to hot cracking.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.16**	**0.6**	**2.5**	**16.0**	**13.5**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 390)
tensile strength R_m N/mm²:		**630**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 50)

(*) *u untreated, as-welded - shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

ø mm
2.0

rod marking:
front: **W Z 16 13 Nb**
back: **1.4961**

=–

Preheating is not required, low heat input is recommended, interpass temperature should not exceed 150 °C.

Base Materials

similar alloyed creep resistant steels

1.4961 X8CrNiNb16-13, 1.4910 X3CrNiMoN17-13, 1.4981 X8CrNiMoNb16-16, 1.4988 X8CrNiMoVNb16-13, 1.4878 X12CrNiTi18-9

Approvals and Certificates

TÜV-D (2728.), TÜV-A (566), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 16/13

EN 12072:1999:	W 19 9 H
AWS A5.9-93:	ER19-10H
W.Nr.:	1.4948 (mod.)

BÖHLER CN 18/11-IG

GTAW rod, high-alloyed, creep resistant

Description

GTAW rod with controlled delta ferrite content (3-8 FN) for austenitic CrNi steels with increased carbon contents (e.g. 1.4948 / 304H), in the boiler, reactor and turbine fabrication. Approved in long-term condition up to +700 °C service temperature (300 °C in the case of wet corrosion). Steels to German material no. 1.4550 and 1.4551 which are approved for the high temperature range up to +550 °C, can also be welded.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	FN
wt-%	**0.05**	**0.4**	**1.6**	**18.8**	**9.3**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**420**	(≥ 400)
tensile strength R_m N/mm^2:		**620**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 100)
	- 10 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W 19 9 H**
back: **ER19-10H**

ø mm
2.0
2.4
3.0

=−

Interpass temperature should not exceed 200 °C.

Base Materials

similar alloyed creep resistant steels

1.4948 X6CrNi18-11, 1.4949 X3CrNiN18-11

AISI 304H, 321H, 347H

Approvals and Certificates

TÜV-D (0139.), KTA 1408 1 (8068.00), TÜV-A (448), CL (0749), UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 308 H FOX CN 18/11	GMAW flux cored wire:	E 308 H-FD E 308 H PW-FD
GTAW rod:	ER 308 H-IG	SAW combination:	CN 18/11-UP/BB 202
GMAW solid wire:	CN 18/11-IG		

EN 12072:1999: W 19 9 H
AWS A5.9-93: ER308H
W.Nr.: 1.4948 (mod.)

BÖHLER ER 308 H-IG

GTAW rod, high-alloyed, creep resistant

Description

GTAW rod for high quality joints on high temperature austenitic CrNi-steels, for service temperature up to +700 °C.
The controlled ferrite content ensures hot cracking resistance. The deposit is largely insusceptible to embrittlement.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	FN
wt-%	**0.06**	**0.4**	**1.7**	**20.0**	**9.5**	**0.2**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 350
tensile strength R_m N/mm²:		≥ 550
elongation A ($L_0 = 5d_0$) %:		≥ 35
impact work ISO-V KV J	+ 20 °C:	≥ 70

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**

rod marking:
front: **W 19 9 H**
back: **ER 308 H**

ø mm
1.6
2.0
2.4

=–

The interpass temperature should not exceed 200 °C.

Base Materials

similar alloyed creep resistant steels

1.4948 X6CrNi18-11, 1.4878 X12CrNiTi18-9

AISI 304/304H, 321H, 347H

Approvals and Certificates

–

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 308 H FOX CN 18/11	GMAW flux cored wire:	E 308 H-FD E 308 H PW-FD
GTAW rod:	CN 18/11-IG	SAW combination:	CN 18/11-UP/BB 202
GMAW solid wire:	CN 18/11-IG		

EN 12070:1999: G MoSi
AWS A5.28-96: ER70S-A1 (ER80S-G)
W.Nr.: 1.5424

BÖHLER DMO-IG

GMAW solid wire, low-alloyed, high temperature

Description

GMAW wire for 0.5 % Mo alloyed boiler, plate and tube steels as well as in pressure vessel and structural steel engineering. Highly-quality, very tough deposit of high cracking resistance, non-ageing. Approved in long-term condition up to +550 °C service temperature, low temperature toughness to -40 °C. The wire shows good feeding and welding characteristics, resulting in smooth welding and wetting behaviour. Uniform copper bonding with low total copper content.

Typical Composition of Solid Wire

	C	Si	Mn	Mo
wt-%	**0.1**	**0.6**	**1.2**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		u2		a	
yield strength R_e N/mm²:		**500**	(≥ 470)	**470**	(≥ 450)	**450**	(≥ 400)
tensile strength R_m N/mm²:		**620**	(≥ 550)	**590**	(≥ 520)	**570**	(≥ 515)
elongation A (L_0 = 5d_0) %:		**25**	(≥ 22)	**23**	(≥ 20)	**25**	(≥ 19)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 120)	**160**		**150**	(≥ 120)
	- 40 °C:		(≥ 47)		(≥ 47)		

(*) *u untreated, as-welded - shielding gas Ar + 18 % CO_2*
u2 untreated, as-welded - shielding gas 100 % CO_2
a annealed, 620 °C/1 h/furnace down to 300 °C/air – shielding gas Ar + 18 % CO_2

Operating Data

shielding gases:	**ø mm**
Argon + 15 - 25 % CO_2	0.8
100 % CO_2	1.0
	1.2

=+

Preheating, interpass temperature and post weld heat treatment as required by the base metal.

Base Materials

high temperature steels and similar alloyed cast steels, ageing resistant and steels resistant to caustic cracking

16Mo3, S355J2G3, L320 - L415NB, L320 MB - L415MB, P255G1TH, P235GH, P265GH, P295GH, P310GH, P255NH, 17MnMoV6-4, 22NiMoCr4-7, 20MnMoNi5-5, 15NiCuMoNb5, 20MnMoNi4-5, GE240-GE300, 22Mo4, S255N - S460N, P255NH-P460NH

ASTM A335 Gr. P1; A161-94 Gr. T1 A A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1; A217 Gr. WC1

Approvals and Certificates

TÜV-D (0021.), DB (42.014.09), ÜZ (42.014/3), ÖBB, TÜV-A (76), CL (0216), FI (G MoSi), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMO Kb	SAW combination:	EMS 2 Mo/BB 24
	FOX DMO Ti		EMS 2 Mo/BB 25
GTAW rod:	DMO-IG	Gas welding rod:	DMO

EN 12070:1999:	G CrMo1Si
AWS A5.28-96:	ER80S-G
	ER80S-B2(mod.)
W.Nr.:	1.7339

BÖHLER DCMS-IG

GMAW solid wire, low-alloyed, high temperature

Description

GMAW wire for 1.25 % Cr 0.5 % Mo alloyed boiler, plate and tube steels as well as for the welding of quenched and tempered and case hardening steels. Preferably used for the steels 13CrMo4-5 or ASTM A335 P11/P12. Approved in long-term condition up to +570 °C service temperature. The deposit is noted for its good mechanical properties and good toughness. Further, good resistance to cracking, when attacked by caustic soda, and the fact that it is suitable for nitriding, quenching and tempering are additional features. The values of the creep rupture strength lay within the scatter band of the material 13CrMo4-5. The wire shows very good feeding characteristics, resulting in smooth welding and wetting behaviour. Uniform copper bonding with low total copper content.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
wt-%	**0.11**	**0.6**	**1.0**	**1.2**	**0.5**	**≤ 0.012**	**< 0.010**	**≤ 0.005**	**≤ 0.006**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**460**	(≥ 420)
tensile strength R_m N/mm²:		**570**	(≥ 500)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 47)

*) *a annealed, 680 °C/2 h/furnace down to 300 °C/air – shielding gas Ar + 18 % CO_2*

Operating Data

shielding gases:	**ø mm**
Argon + 15 - 25 % CO_2	0.8
100 % CO_2	1.0
Using 100 % CO_2 the mechanical	1.2
properties can be different	1.6

=+

Preheat, interpass temperature and post weld heat treatment as required by the base metal. Preheating and interpass temperature for 13CrMo4-5 (P11/P12), 200-250 °C. Tempering at 660-700 °C at least 1/2 hr, followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels, case hardening and nitriding steels of similar chemical composition, similar alloyed heat treatable steels with tensile strength up to 780 N/mm², steels resistant to caustic cracking

1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7225 42CrMo4, 1.7728 16CrMoV4, 1.7218 25CrMo4, 1.7258 24CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5

ASTM A193 Gr. B7; A335 Gr. P11 a. P12; A217 Gr. WC6

Approvals and Certificates

TÜV-D (1091.), DB (42.014.15), ÜZ (42.014/3), ÖBB, TÜV-A (92), FI (G CrMo1Si), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Kb	SAW combination:	EMS 2 CrMo/BB 24
	FOX DCMS Ti		EMS 2 CrMo/BB 25
GTAW rod:	DCMS-IG	Gas welding rod:	DCMS

EN 12070:1999: G MoV Si
AWS A5.28-96: ER80S-G
W.Nr.: 1.5407

BÖHLER DMV 83-IG

GMAW solid wire, low-alloyed, high temperature

Description

GMAW wire for boiler, plate and tube steels. Designed specially for 14MoV6-3 (1/2 Cr 1/2 Mo 1/4 V). Approved in long-term condition up to +560 °C service temperature. Tough, cracking resistant deposit with good creep rupture strength. The wire shows very good feeding characteristics, resulting in smooth welding and wetting behaviour.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo	V
wt-%	**0.08**	**0.6**	**0.9**	**0.45**	**0.85**	**0.35**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm^2:		**610**	(≥ 550)
tensile strength R_m N/mm^2:		**710**	(≥ 630)
elongation A (L_0 = 5d_0) %:		**20**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**80**	(≥ 47)

(*) *a annealed, 700 °C/2 h/furnace down to 300 °C/air – shielding gas Ar + 18 % CO_2*

Operating Data

shielding gases:	**ø mm**
Argon + 15 - 25 % CO_2	1.2
100 % CO_2	

=+

Using 100% CO_2 the mechanical properties can be different.
Preheating and interpass temperatures 200-300 °C. Tempering at 700-720 °C for at least 2 hrs followed by cooling in furnace down to 300 °C and still air.

Base Materials

similar alloyed high temperature steels and cast steels

1.7715 14MoV6-3, 1.7733 24CrMoV5-5, 1.7709 21CrMoV5-7, 1.8070 21CrMoV5-11, 1.7706 G17CrMoV5-10,

ASTM A389 Gr. C23 a. C24; A405 Gr. P24; UNS I21610

Approvals and Certificates

TÜV-D (1322.), TÜV-A (121), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMV 83 Kb
GTAW rod:	DMV 83-IG

EN 12070:1999:	G CrMo2 Si
AWS A5.28-96:	ER90S-G
	ER90S-B3(mod.)
W.Nr.:	1.7384

BÖHLER CM 2-IG

GMAW solid wire, low-alloyed, high temperature

Description

GMAW for 2.25 Cr 1 % Mo alloyed boiler, plate and tube steels as well as in oil refineries e.g. in crack plants. Preferably used for the base metal 10CrMo9-10 (ASTM A335 Gr. P22) Approved in long-term condition up to +600 °C service temperature. Also for similar alloyed quenched and tempered steels and case hardening steels. The deposit is noted for its good mechanical properties and cracking resistance, but also for its creep rupture strength which is within the scatter band of 10CrMo9-10. The wire shows very good feeding characteristics, resulting in smooth welding and wetting behaviour.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo
wt-%	**0.06**	**0.7**	**1.1**	**2.6**	**1.0**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm^2:		**440**	(≥ 400)
tensile strength R_m N/mm^2:		**580**	(≥ 500)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 47)

(*) *a annealed, 720 °C/2 h/furnace down to 300 °C/air – shielding gas Ar + 18 % CO_2*

Operating Data

shielding gases:	**ø mm**
Argon + 15 - 25 % CO_2	0.8
100 % CO_2	1.0
	1.2

=+

Using 100% CO_2 the mechanical properties can be different.

Preheating and interpass temperature 200-350 °C. Tempering at 700-750 °C for at least 1 hr followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels, QT-steels similar alloyed up to 980 N/mm^2 tensile strength, similar alloyed case hardening steels, nitriding steels

1.7380 10CrMo9-10, 1.8075 10CrSiMoV7, 1.7379 G17CrMo9-10

ASTM A335 Gr. P22; A217 Gr. WC 9

Approvals and Certificates

TÜV-D (1085.), TÜV-A (88), FI (G CrMo2Si), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CM 2 Kb
GTAW rod:	CM 2-IG
SAW combination:	CM 2-UP/BB 24

EN 12070:1999: G CrMo5 Si
AWS A5.28-96: ER80S-B6
W.Nr.: 1.7373

BÖHLER CM 5-IG

GMAW solid wire,
high-alloyed, high temperature

Description

GMAW wire suitable for 5 % Cr 0.5 % Mo alloyed steels and steels for hot hydrogen service, particularly in oil refineries. Preferably used for steel grades as X12CrMo5 and P5 at service temperatures up to +600 °C.
The wire shows very good feeding characteristics, resulting in smooth welding and flow behaviour. Uniform copper bonding with low total copper content.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo
wt-%	**0.08**	**0.4**	**0.5**	**5.8**	**0.6**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm^2:		**520**	(≥ 400)
tensile strength R_m N/mm^2:		**620**	(≥ 530)
elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**200**	(≥ 47)

(*) *a annealed, 730 °C/2 h/furnace down to 300 °C/air – shielding gas Ar + 18 % CO_2*

Operating Data

shielding gas:	**ø mm**
Argon + 15 - 25 % CO_2	1.2

=+

Preheating and interpass temperatures 300-350 °C. Tempering at 730-760 °C for at least 1 hr followed by cooling in furnace down to 300 °C and still air.

Base Materials

high temperature steels and similar alloyed cast steels, QT-steels similar alloyed up to 1180 N/mm^2

1.7362 X12CrMo5, 1.7363 GX12CrMo5

ASTM A213 Gr. T5; A217 Gr. C5; A335 Gr. P5

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW stick electrode:	FOX CM 5 Kb
GTAW rod:	CM 5-IG
SAW combination:	CM 5-UP/BB 24

EN 12070: 1999: G CrMo91
AWS A5.28-96: ER90S-B9
W.Nr.: 1.4903

BÖHLER C 9 MV-IG

GMAW solid wire
high-alloyed, creep resistant

Description

GMAW wire for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels T91/P91. Approved in long-term condition up to +650 °C service temperature. Preheating and interpass temperature 200-300 °C. After welding, the weld joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered. The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/hr, above 550 °C max. 80 °C/hr.
For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).

Typical composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	V	Nb
wt-%	**0.12**	**0.3**	**0.5**	**9.0**	**0.7**	**0.9**	**0.2**	**0.055**

Mechanical Properties of All-weld Metal

		a	
yield strength R_e N/mm²:		**660**	(≥ 520)
tensile strength R_m N/mm²:		**760**	(≥ 620)
elongation A (L_0=5d_0) %:		**17**	(≥ 16)
impact work ISO-V KV J	+20 °C:	**55**	(≥ 50)

a annealed 760 °C/2 h/furnace down to 300 °C/air – shielding gas Argon +2.5 % CO_2

Operating Data

Shielding gas:
Argon + 2.5 % CO_2

ø mm
1.0
1.2

=–

Base Materials

similar alloyed creep resistant steels
1.4903 X10CrMoVNb9-1
ASTM A199 Gr. T91, A335 Gr. P91, A213/213M Gr. T91

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW stick electrode:	FOX C 9 MV
GTAW rod:	C 9 MV-IG
GMAW metal cored wire:	C 9 MV-MC
SAW combination:	C 9 MV-UP/BB 910

EN 12072:1999:	G 19 9 H
AWS A5.9-93:	ER19-10H
W.Nr:	1.4948 (mod.)

BÖHLER CN 18/11-IG

GMAW solid wire,
high-alloyed, creep resistant

Description

GMAW wire with controlled delta ferrite content (3-8 FN) for austenitic CrNi steels with increased carbon contents (e.g. 1.4948 / 304H), in the boiler, reactor and turbine fabrication. Approved in long-term condition up to +700 °C service temperature (300 °C in the case of wet corrosion).

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	FN
wt-%	**0.05**	**0.4**	**1.4**	**18.8**	**9.8**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**400**	(≥ 350)
tensile strength R_m N/mm²:		**580**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 70)
	- 10 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 2.5 % CO_2*

Operating Data

shielding gas:	ø mm
Argon + max. 2.5 % CO_2	1.2

=+

Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. Interpass temperature should not exceed 200 °C. Steels to German material no. 1.4550 and 1.4551 which are approved for the high temperature range up to +550 °C, can also be welded.

Base Materials

similar alloyed creep resistant steels

1.4948 X6CrNi18-11, 1.4949 X3CrNiN18-11

AISI 304H, 321H, 347H

Approvals and Certificates

TÜV-D (4466.), CL (0011), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 308 H FOX CN 18/11	GMAW flux cored wire:	E 308 H-FD E 308 H PW-FD
GTAW rod:	ER 308 H-IG CN 18/11-IG	SAW combination:	CN 18/11-UP/BB 202

EN 12070: 2000: T CrMo91
AWS A5.28-96: EC90S-B9

BÖHLER C 9 MV-MC

Metal cored wire,
high-alloyed, creep resistant

Description

Metal cored wire for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels T91/P91. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm), also a decisive influence on toughness values is given by the used shielding gas.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	V	Nb	N
wt-%	**0.10**	**<0.3**	**0.6**	**9.0**	**0.7**	**1.0**	**0.2**	**0.055**	**0.04**

Mechanical Properties of All-weld Metal

		a	
yield strength R_e N/mm²:		**690**	(≥ 520)
tensile strength R_m N/mm²:		**760**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**18**	(≥ 17)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 47)

a annealed 760°C/3 h/furnace down to 300 °C/air – shielding gas Argon + 2.5 % *CO_2*

Operating Data

shielding gases:
Argon + 2.5 % CO_2 or
Argon + 15 - 20 % CO_2

ø mm	amps A	voltage V
1.2	150 - 290	18 - 30

=+

Welding with conventional or pulsed power sources (preferably slightly trailing torch position, angel appr. 80 °). Recommended stick out 18-20 mm and length of arc 3-5 mm.
Preheating and interpass temperature 200-300 °C. After welding, the weld joint should cool down below 80 °C to finish the martensite transformation. In case of greater wall thickness or complex components the possibility of residual stresses must be considered.
The following post weld heat treatment is recommended: annealing 760 °C/min. 2 hrs, max. 10 hrs, heating and cooling rates below 550 °C max. 150 °C/hr, above 550 °C max. 80 °C/hr.
Positional weldability of metal cored wires is similar to solid wires.

Base Materials

similar alloyed creep resistant steels

1.4903 X10CrMoVNb9-1

ASTM A199 Gr. T91, A335 Gr. P91, A213/213M Gr. T91

Approvals and Certificates

TÜV-D (4466.), CL (0011), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX C 9 MV	GTAW rod:	C 9 MV-IG
SAW combination:	C 9 MV-UP/BB 910	GMAW solid wire:	C 9 MV-IG

EN 12073:1999: T Z 19 9 H R M 3
T Z 19 9 H R C 3
AWS A5.22-95: E308HT0-4
E308HT0-1

BÖHLER E 308 H-FD

GMAW flux cored wire, high-alloyed, creep resistant

Description

BÖHLER E 308 H-FD is a flux cored wire with rutile slag characteristic for GMAW of austenitic CrNi steels like 1.4948 / AISI 304H. This wire is designed mainly for downhand and horizontal welding positions. The weld metal is suitable for service temperatures up to approx. +700 °C. This product achieves high productivity and is easy to operate achieving excellent welding characteristics, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money.
The weld deposit is scaling resistant and because of the controlled low delta ferrite content high resistant against sigma phase embrittlement.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	FN
wt-%	**0.06**	**0.5**	**1.1**	**19.4**	**10.1**	**3-8**

Mechanical Properties of All-weld Metal

(*)	u		u/500 °C
yield strength R_e N/mm^2:	**390**	(≥ 350)	**310**
tensile strength R_m N/mm^2:	**585**	(≥ 550)	**440**
elongation A ($L_0 = 5d_0$) %:	**42**	(≥ 30)	**30**
impact work ISO-V KV J + 20 °C:	**80**	(≥ 47)	

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying:	**ø mm**	**amps A**	**voltage V**
possible, 150 °C / 24 h	1.2	125 - 280	20 - 34

=+

shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2
welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V, gasflow should be 15-18 l/min

Base Materials

similar alloyed creep resistant steels
1.4948 X6CrNi18-11, 1.4878 X12CrNiTi18-9
AISI 304, 304H, 321H, 347H

Approvals and Certificates

UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 18/11 FOX E 308 H	GMAW solid wire:	CN 18/11-IG
		GMAW fluxcored wire:	E 308 H PW-FD
GTAW rod:	CN 18/11-IG ER 308 H-IG	SAW combination:	CN 18/11-UP/BB 202

EN 12073:1999: T Z 19 9 H P M 1
T Z 19 9 H P C 1
AWS A5.22-95: E308HT1-4
E308HT1-1

BÖHLER E 308 H PW-FD

GMAW flux cored wire, high-alloyed, high temperature

Description

Rutile flux cored welding wire with fast freezing slag providing excellent positional welding characteristics with fast travel speeds. It is designed for welding of creep resistant austenitic CrNi-steel like 1.4989 / AISI 304H and service temperatures up to +700 °C.
It is easy to use and operates with a powerful penetrating spray arc transfer and minimum spatter formation. This flux cored welding wire offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable.
Additional cost effective benefits are offered through use of less expensive shielding gases, good wetting characteristics (less grinding), little bead oxidation (less pickling expenses), easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work).
The weld deposit is scaling resistant, and because of the controlled low delta ferrite content high resistant against sigma phase embrittlement.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	FN
wt-%	**0.06**	**0.5**	**1.1**	**19.4**	**10.1**	**3-8**

Mechanical Properties of All-weld Metal

(*)	u		u/500 °C
yield strength R_e N/mm²:	**390**	(≥ 350)	**310**
tensile strength R_m N/mm²:	**585**	(≥ 550)	**440**
elongation A ($L_0 = 5d_0$) %:	**42**	(≥ 30)	**30**
impact work ISO-V KV J + 20 °C:	**90**	(≥ 47)	

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	110 - 210	20 - 31

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for all welding positions; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V, gasflow should be 15-18 l/min.

Base Materials

similar alloyed creep resistant steels
1.4948 X6CrNi18-11, 1.4878 X12CrNiTi18-9
AISI 304, 304H, 321H, 347H

Approvals and Certificates

–

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 18/11 FOX E 308 H
GTAW rod:	CN 18/11-IG ER 308 H-IG
GMAW solid wire:	CN 18/11-IG
GMAW flux-cored wire:	E 308 H-FD
SAW combination:	CN 18/11-UP/BB 202

SAW solid wire: EN 756:2004: S 2 Mo
AWS A5.23-97: EA2
sub-arc flux: EN 760:1996: SA FB 1 65 DC H5
wire/flux-combination:
EN 756:2004: S 46 4 FB S2Mo
AWS A5.23-97: F8A4-EA2-A2
AWS A5.23M-97: F55A4-EA2-A2

BÖHLER EMS 2 Mo // BB 24

SAW wire/flux-combination, low-alloyed, high temperature

Description

Sub arc wire/flux combination suited for fine-grained constructional steels of increased strength and for 0.5 % Mo alloyed boiler, plate and tube steels. Approved in long-term condition up to + 550 °C service temperature. The metallurgical behaviour of the flux BÖHLER BB 24 is neutral. The sub-arc wire/flux combination produces very good low temperature impact properties down to -40 °C. Excellent slag detachability, smooth beads, good wetting and low hydrogen contents (≤ 5 ml/100 g) are further important features. The combination is ideally suited for multi-pass welding of thick plates. For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Mo
SAW wire wt-%	**0.12**	**0.15**	**1.10**	**0.50**
all-weld metal %	**0.08**	**0.25**	**1.15**	**0.45**

Mechanical Properties of All-weld Metal

(*)		u	a	n + a
yield strength R_e N/mm²:		≥ 470	≥ 470	≥ 280
tensile strength R_m N/mm²:		≥ 550	≥ 550	≥ 440
elongation A ($L_0 = 5d_0$) %:		≥ 24	≥ 24	≥ 26
impact work ISO-V KV J	+ 20 °C:	≥ 140	≥ 165	≥ 125
	± 0 °C:	≥ 120		
	- 20 °C:	≥ 80		
	- 40 °C:	≥ 47		

(*) *u untreated, as-welded*
a stress relieved, 580 - 620 °C/2 h/furnace down to 300 °C/air
n + a normalised 920 °C and annealed 620 °C

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
2.0
2.5
3.0
4.0

=±

Base Materials

high temperature steels and similar alloyed cast steels, ageing resistant and steels resistant to caustic cracking, high temperature constructional steels with comparable yield strength 16Mo3, S275JR, S275J2G3, S355J2G3, P275T1-P355T1, P275T2-P355T2, P255G1TH, S255N, P295GH, P310GH, P315N-P420N, P315NH-P420NH BHW 2.5, WB 25; ASTM A335 Gr. P1; A161-94 Gr. T1; A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1; A217 Gr. WC1, API, 5L: X52-X65

Approvals and Certificates

TÜV-D (7810.), UDT; **SAW solid wire:** TÜV-D (02603.), KTA 1408 1 (8058.00/8060.01), DB (52.014.06), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMO Kb	GMAW solid wire:	DMO-IG
	FOX DMO Ti	Gas welding rod:	DMO
GTAW rod:	DMO-IG		

SAW solid wire: EN 756:2004: S 2 Mo
AWS A5.23-97: EA2
sub-arc flux: EN 760:1996: SA FB 1 68 DC H5
wire/flux-combination:
EN 756:2004: S 46 3 FB S2Mo
AWS A5.23-97: F8A4-EA2-A2
AWS A5.23M-97: F55A4-EA2-A2

BÖHLER EMS 2 Mo // BB 25

SAW wire/flux-combination, low-alloyed, high temperature

Description

The sub-arc wire/flux combination is suited for fine-grained constructional steels of increased strength and for 0.5 % Mo alloyed boiler, plate and tube steels. Approved in long-term condition up to +550 °C service temperature. The flux is active and shows some pick-up of silicon and manganese. The sub-arc wire/flux combination produces higher strength values with very good low temperature impact properties down to -20 °C. For information regarding the sub-arc welding flux BÖHLER BB 25 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Mo
SAW wire wt-%	**0.12**	**0.15**	**1.1**	**0.5**
all-weld metal %	**0.07**	**0.40**	**1.5**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**500**	(≥ 460)
tensile strength R_m N/mm²:		**600**	(≥ 530)
elongation A ($L_0 = 5d_0$) %:		**30**	
impact work ISO-V KV J	+ 20 °C:	**120**	
	± 0 °C:	**100**	
	- 20 °C:	**70**	
	- 40 °C:	**40**	

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
2.0
2.5
3.0
4.0

=±

Base Materials

high temperature steels and similar alloyed cast steels, ageing resistant and steels resistant to caustic cracking, high temperature constructional steels with comparable yield strength 16Mo3, S275JR, S275J2G3, S355J2G3, P275T1-P355T1, P275T2-P355T2, P255G1TH, S255N, P295GH, P310GH, P315N-P420N, P315NH-P420NH BHW 2.5, WB 25
ASTM A335 Gr. P1; A161-94 Gr. T1; A182M Gr. F1; A204M Gr. A, B, C; A250M Gr. T1; A217 Gr. WC1

Approvals and Certificates

TÜV-D (5678.), TÜV-A (618), UDT; **SAW solid wire:** TÜV-D (02603.), KTA 1408 1 (8058.00/8060.01), DB (52.014.06), ÜZ (52.014/1), ÖBB, TÜV-A (391), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX DMO Kb
FOX DMO Ti
GMAW solid wire: DMO-IG
Gas welding rod: DMO
GTAW rod: DMO-IG

BÖHLER EMS 2 CrMo // BB 24

SAW wire/flux-combination, low-alloyed, high temperature

SAW solid wire: EN 12070:1999: S CrMo1
AWS A5.23-97: EB2
sub-arc flux: EN 760:1996: SA FB 1 65 DC H5
wire/flux-combination:
AWS A5.23-97: F8P4-EB2-B2
AWS A5.23M-97: F55P4-EB2-B2

Description

Sub arc wire / flux combination suited for 1 % Cr 0.5 % Mo alloyed boiler, plate and tube steels. Approved in long-term condition up to +570 °C service temperature. Brucato ≤ 15 ppm.
The metallurgical behaviour of the flux BÖHLER BB 24 is neutral.
The sub-arc wire/flux combination produces smooth beads, good wetting, excellent slag detachability, and low hydrogen contents (≤ 5 ml/100 g). are further important features. The combination is ideally suited for multi-pass welding of thick plates.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
SAW wire wt-%	**0.12**	**0.15**	**0.9**	**1.2**	**0.50**				
all-weld metal %	**0.08**	**0.25**	**1.0**	**1.1**	**0.45**	**≤ 0.012**	**≤ 0.010**	**≤ 0.005**	**≤ 0.005**

Mechanical Properties of All-weld Metal

(*)		a	n + a
yield strength R_e N/mm^2:		≥ 460	≥ 330
tensile strength R_m N/mm^2:		≥ 550	≥ 480
elongation A ($L_0 = 5d_0$) %:		≥ 22	30
impact work ISO-V KV J	+ 20 °C:	≥ 47	120

(*) *a annealed, 680 °C/2 h/furnace down to 300 °C/air*
n + a normalised 920 °C and annealed 680 °C/2 h

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
2.5
3.0
4.0

=±

Preheating, interpass temperature and post weld heat treatment are determined by the base metal.

Base Materials

high temperature steels and similar alloyed cast steels, case hardening and nitriding steels of similar chemical composition, similar alloyed heat treatable steels with tensile strength up to 780 N/mm^2, steels resistant to caustic cracking
1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7225 42CrMo4, 1.7728 16CrMoV4, 1.7218 25CrMo4, 1.7258 24CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5
ASTM A193 Gr. B7; A335 Gr. P11 a. P12; A217 Gr. WC6

Approvals and Certificates

TÜV-D (7809.), UDT
SAW solid wire: TÜV-D (02605.), TÜV-A (393), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Kb	GMAW solid wire:	DCMS-IG
	FOX DCMS Ti	Gas welding rod:	DCMS
GTAW rod:	DCMS-IG	SAW comb.:	EMS 2CrMo / BB25

SAW solid wire:
EN 12070:1999: S CrMo1
AWS A5.23-97: EB2
sub-arc flux: EN 760:1996: SA FB 1 68 DC H5
wire/flux-combination:
AWS A5.23-97: F8P4-EB2-B2
AWS A5.23M-97: F55P4-EB2-B2

BÖHLER EMS 2 CrMo // BB 25

SAW wire/flux-combination, low alloyed, creep resistant

Description

This welding consumable is suited for welding of creep resistant boiler plate, vessel and pipe construction. Approved in long-term condition up to +570 °C service temperature. Brucato ≤ 15 ppm. The flux is active and shows some pick-up of silicon and manganese. For information regarding the sub-arc welding flux BÖHLER BB 25 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
SAW wire wt-%	**0.12**	**0.15**	**0.9**	**1.15**	**0.5**				
all-weld metal %	**0.07**	**0.40**	**1.35**	**1.25**	**0.5**	**≤ 0.012**	**≤ 0.010**	**≤ 0.005**	**≤ 0.005**

Mechanical Properties of All-weld Metal

(*)		a
yield strength R_e N/mm^2:		**580**
tensile strength R_m N/mm^2:		**630**
elongation A ($L_0 = 5d_0$) %:		**24**
impact work ISO-V KV J	+ 20 °C:	**120**
	- 20 °C:	**50**

(*) *a annealed, 620 °C/1 h/furnace down to 300 °C/air*

Operating Data

re-drying of sub-arc flux:	**ø mm**
300 - 350 °C, 2 h - 10 h	2.5
max. amperage of sub-arc flux: **800 A**	3.0
	4.0

=±

Preheating, interpass temperature and post weld heat treatment are determined by the base metal.

Base Materials

high temperature steels and similar alloyed cast steels, case hardening and nitriding steels of similar chemical composition, similar alloyed heat treatable steels with tensile strength up to 780 N/mm^2, steels resistant to caustic cracking

1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7225 42CrMo4, 1.7728 16CrMoV4, 1.7218 25CrMo4, 1.7258 24CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5,

ASTM A193 Gr. B7; A335 Gr. P11 a. P12; A217 Gr. WC6

Approvals and Certificates

TÜV-D (5677.), TÜV-A (620), ABS (X), UDT
SAW solid wire: TÜV-D (02605.), TÜV-A (393), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Kb	GMAW solid wire:	DCMS-IG
	FOX DCMS Ti	Gas welding rod:	DCMS
GTAW rod:	DCMS-IG	SAW comb.:	EMS 2CrMo / BB24

SAW solid wire: EN 12070:1999: S CrMo2
AWS A5.23-97: EB3
sub-arc flux: EN 760:1996: SA FB 1 65 DC H5
wire/flux-combination:
AWS A5.23-97: F9P2-EB3-B3
AWS A5.23M-97: F55P0-EB3-B3

BÖHLER CM 2-UP // BB 24

SAW wire/flux-combination, low-alloyed, high temperature

Description

Sub-arc wire/flux combination suited for 2.25 % Cr 1 % Mo alloyed boiler, plate and tube steels and also particularly for cracking plants in the crude oil industry. Approved in long-term condition up to +600 °C service temperature. Brucato ≤15 ppm.
The deposit is noted for its excellent mechanical properties. Easy slag detachability and smooth bead surface are additional quality features of this combination. For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	P	As	Sb	Sn
SAW wire wt-%	**0.11**	**0.10**	**0.6**	**2.6**	**1.00**				
all-weld metal %	**0.07**	**0.25**	**0.8**	**2.3**	**0.95**	**≤ 0.012**	**≤ 0.015**	**≤ 0.005**	**≤ 0.001**

Mechanical Properties of All-weld Metal

(*)		a
yield strength R_e N/mm²:		≥ 460
tensile strength R_m N/mm²:		≥ 530
elongation A ($L_0 = 5d_0$) %:		≥ 22
impact work ISO-V KV J	+ 20 °C:	≥ 47

(*) *a annealed, 670 - 720 °C/2 h/furnace down to 300 °C/air*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
2.5
3.0
4.0

=±

Preheating, interpass temperature and post weld heat treatment are determined by the base metal.

Base Materials

high temperature steels and similar alloyed cast steels, QT-steels similar alloyed up to 980 N/mm² tensile strength, similar alloyed case hardening steels, nitriding steels

1.7380 10CrMo9-10, 1.8075 10CrSiMoV7, 1.7379 G17CrMo9-10

ASTM A335 Gr. P22; A217 Gr. WC 9

Approvals and Certificates

TÜV-D (7812.), UDT
SAW solid wire: TÜV-D (02605.), KTA 1408 1 (8060.01), TÜV-A (393), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX CM 2 Kb

GTAW rod: CM 2-IG
GMAW solid wire: CM 2-IG

Wire	
EN 12070:1999:	S ZCrWV2
AWS A5.23:1997:	EG
Flux	
EN 760:1996:	SA FB 1 55 AC

BÖHLER P 23-UP/BB 430

Flux/wire-combination
low alloyed, creep resistant

Description

Böhler B 23-UP is a matching filler metal for welding high temperature and creep resistant steels such as HCM2S (P23/T23 acc. to ASTM A213 code case 2199), pipe or tube material. BB 430 is an agglomerated welding flux of the fluoride-basic type with high basicity. (2.9)

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	V	Ti	B
wt-%	**0.05**	**0.3**	**0.5**	**2.2**	**1.0**	**0.22**	**0.05**	**0.003**
	0.05	**0.27**	**0.9**	**2.05**	**1.6**	**0.20**	**0.04**	**0.01**

Mechanical Properties of All-weld Metal

(*)	a
yield strength R_e N/mm²:	≥ 400
tensile strength R_m N/mm²:	≥ 600
elongation A (L_0=5d_0) %:	≥ 15
impact work ISO-V KV J	≥ 100

(*) a annealed 740 °C/2 h

Operating Data

re-drying:
300-350 °C, 2-10 h

ø mm	**Spools**
2.0	K435-70
2.5	K435-70
3.0	K435-70

=+

From undamaged steel containers - without redrying
Preheat and interpass temp.: 200-300 °C. Heat input ≤ 2.0 kJ/mm.

Base Materials

ASTM A213: P23/T23

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW stick electrode:	FOX P 23
GTAW rod:	P 23-IG

BÖHLER P 24-UP/BB 430

Flux/wire-combination
low alloyed, creep resistant

Wire:	
EN 12070:1999:	S Z CrMV2
AWS A5.23:1997	EG
Flux:	
EN 760:1996:	SA FB 1 55 AC

Description

Böhler P 24-UP is a matching filler metal for welding high temperature and creep resistant steels such as 7CrMoVTiB (P24/T24 acc. to ASTM A213). The chemistry of the wire will be optimized with respect to the creep rupture properties. Böhler B 430 is an agglomerated welding flux of the fluoride-basic type with high basicity. Grain size: EN 760: 3-16 (0.3-1.6 mm).

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	V	Nb	Ti	B
wt-%	**0.10**	**0.25**	**0.55**	**2.5**	**1.0**	**0.24**	**0.05**	**0.002**	**0.002**
	0.10	**0.25**	**0.75**	**2.2**	**1.0**	**0.22**	**0.05**	**0.002**	**0.002**

Mechanical Properties of All-weld Metal

(*)	a
yield strength R_e N/mm²:	≥ 500
tensile strength R_m N/mm²:	≥ 620
elongation A ($L_0=5d_0$) %:	≥ 15
impact work ISO-V KV J	≥ 100

(*) a annealed 740°C/ 2 h

Operating Data

Redrying:	ø mm	Spools
300-350 °C, 2-10 h	2.0	K435-70
	2.5	K435-70
	3.0	K435-70

=+

Preheating and interpass temp.: 200-300 °C. Heat input ≤ 2.0 kJ/mm.

Base Materials

7CrMoVTiB10-10, P24 acc. to ASTM A 213 Draft

Approvals and Certificates

TÜV-D (10456.)

Same Alloy Filler Metals

SMAW stick electrode:	FOX P 24
GTAW rod:	P 24-IG

SAW solid wire:	EN 12070:1999:	S CrMo5
	AWS A5.23-97:	EB6
sub-arc flux:	EN 760:1996:	SA FB 1 65 DC H5
wire/flux-combination:		
	AWS A5.23-97:	F9PZ-EB6-B6
	AWS A5.23M-97:	F62PZ-EB6-B6

BÖHLER CM 5-UP // BB 24

SAW wire/flux-combination, high-alloyed, high temperature

Description

Sub arc wire /flux combination suited for 5 % Cr 0.5 % Mo alloyed steels, particularly for hot hydrogen service. High temperature strength at service temperatures up to +600 °C.
The weld deposit exhibits good mechanical properties. Easy slag detachability and smooth bead surface are additional quality features.
For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo
SAW wire wt-%	**0.08**	**0.4**	**0.50**	**5.8**	**0.60**
all-weld metal %	**0.05**	**0.5**	**0.75**	**5.5**	**0.55**

Mechanical Properties of All-weld Metal

(*)		a
yield strength R_e N/mm^2:		≥ 450
tensile strength R_m N/mm^2:		≥ 590
elongation A ($L_0 = 5d_0$) %:		≥ 18
impact work ISO-V KV J	+ 20 °C:	≥ 47

(*) *a annealed 740 °C/4 h/furnace down to 300 °C/air*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
4.0

=±

Preheating and interpass temperature and post weld heat treatment are determined by the base metal.

Base Materials

similar alloyed high temperature steels and cast steels

1.7362 X12CrMo5, 1.7363 GX12CrMo5

ASTM A213 Gr. T5; A217 Gr. C5; A335 Gr. P5

Approvals and Certificates

UDT
SAW solid wire: TÜV-D (02605.), TÜV-A (393), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CM 5 Kb
GTAW rod:	CM 5-IG
GMAW solid wire:	CM 5-IG

SAW solid wire:	EN 12070:1999:	S CrMo91
	AWS A5.23-97:	EB9
sub-arc flux:	EN 760:1996:	SA FB 2 55 DC H5
wire/flux-combination:		
	AWS A5.23-97:	F9PZ-EB9-B9
	AWS A5.23M-97:	F62PZ-EB9-B9

BÖHLER C 9 MV-UP // BB 910

SAW wire/flux-combination, high-alloyed, creep resistant

Description

Sub-arc wire/flux combination suited for creep resistant 9 % Cr steels, especially for P91 acc. ASTM A335. Approved in long-term condition up to +650 °C service temperature. The wire and flux are precisely balanced to consistently meet the highest technical requirements. For information regarding the sub-arc welding flux BÖHLER BB 910 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	V	Nb
SAW wire wt-%	**0.12**	**0.25**	**0.6**	**9.0**	**0.7**	**0.9**	**0.22**	**0.06**
all-weld metal %	**0.11**	**0.30**	**0.6**	**9.0**	**0.7**	**0.8**	**0.20**	**0.05**

Mechanical Properties of All-weld Metal

(*)	a	
yield strength R_e N/mm²:	**610**	(≥ 550)
tensile strength R_m N/mm²:	**740**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:	**20**	(≥ 15)
impact work ISO-V KV J	**40**	

(*) *a annealed, 760 °C/2 h/furnace down to 300 °C/air*

Operating Data

re-drying of sub-arc flux:	**ø mm**
300 - 350 °C, 2 h - 10 h	2.5
max. amperage of sub-arc flux: **800 A**	3.0

=±

Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C in order to finish the martensitic transformation. Pipe welds with wall thickness up to 45 mm can be cooled down to room temperature. For heavier wall thicknesses or stressed components, unfavourable possible stress condition must be considered. The recommended post weld heat treatment is annealing after welding at 760 °C/min. 2 hrs, max. 10 hrs, heating/cooling-rates below 550 °C max. 150 °C/hr, above 550 °C max 80 °C/hr.
For optimised toughness properties a technology which ensures thin welding layers is recommended.

Base Materials

similar alloyed creep resistant steels

1.4903 X10CrMoVNb9-1

ASTM A199 Gr. T91; A335 Gr. P91; A213/213M Gr. T91

Approvals and Certificates

TÜV-D (09229.), CL (1487), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX C 9 MV	GMAW solid wire:	C 9 MV–IG
GTAW rod:	C 9 MV-IG	GMAW metal cored wire:	C 9 MV-MC

SAW solid wire: EN 12070:1999: S Z CrMoWVNb9 0.5 1.5
AWS A5.23-97: EB9(mod.)
sub-arc flux: EN 760:1996: SA FB 2 55 DC H5

BÖHLER P 92-UP // BB 910

SAW wire/flux-combination, high-alloyed, creep resistant

Description

Sub-arc wire/flux combination designed for 9 % Cr creep resistant steel, especially for P92/NF616. Approved in long-term condition up to +650 °C service temperature. For information regarding the sub-arc welding flux BÖHLER BB 910 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	V	W	Nb
SAW wire wt-%	**0.10**	**0.40**	**0.4**	**8.6**	**0.40**	**0.6**	**0.2**	**1.5**	**0.05**
all-weld metal %	**0.09**	**0.45**	**0.4**	**8.6**	**0.35**	**0.6**	**0.2**	**1.5**	**0.04**

Mechanical Properties of All-weld Metal

(*)	a	
yield strength R_e N/mm^2:	**660**	(≥ 550)
tensile strength R_m N/mm^2:	**780**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:	**20**	(≥ 15)
impact work ISO-V KV J	**60**	

(*) *a annealed, 760 °C/2 h/furnace down to 300 °C/air*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C / 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
3.0

=±

Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C in order to finish the martensite transformation. Pipe welds with wall thickness up to 45 mm can be cooled down to room temperature For heavier wall thicknesses or stressed components, unfavourable possible stress condition must be considered. The recommended post weld heat treatment is annealing at 760 °C/min. 2 hrs, max. 10 hrs., heating/cooling rates below 550 °C max. 150 °C/hr, above 550 °C max 80 °C/hr.
For optimised toughness properties a technology which ensures thin welding layers is recommended.

Base Materials

similar alloyed creep resistant steels

NF 616

ASTM A335 Gr. P 92 (T92); A213/213M Gr. T92

Approvals and Certificates

TÜV-D (09390.), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX P 92 GTAW rod: P 92-IG

SAW solid wire:
EN 12070:1999: S CrMoWV12
sub-arc flux:
EN 760:1996: SA FB 2 65 DC H5

BÖHLER
20 MVW-UP // BB 24

SAW wire/flux-combination, high-alloyed, creep resistant

Description

Suited for analogous and similar creep resistant steels in turbine and steam boiler construction as well as in the chemical industry. Approved in long-term condition up to +650 °C service temperature. For information regarding the sub-arc welding flux BÖHLER BB 24 see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	V	W
SAW wire wt-%	**0.27**	**0.2**	**0.7**	**11.3**	**0.90**	**0.5**	**0.24**	**0.50**
all-weld metal %	**0.16**	**0.3**	**0.8**	**10.3**	**0.85**	**0.4**	**0.22**	**0.45**

Mechanical Properties of All-weld Metal

(*)	a
yield strength R_e N/mm²:	≥ 550
tensile strength R_m N/mm²:	≥ 660
elongation A ($L_0 = 5d_0$) %:	≥ 15
impact work ISO-V KV J	≥ 47

(*) *a annealed, 760 °C/4 h/furnace down to 300 °C/air*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
3.0

=±

Preheating and interpass temperature 400-450 °C (austenitic welding) or 250-300 °C (martensitic welding). Root passes should principally be welded in the martensitic range. Lower preheat and interpass temperatures are possible, yet must be approved by practical welding tests and process qualification tests.
After welding cooling to 90±10 °C, followed by tempering at 760 °C for three minutes / mm wall thickness at least for 2 hours. Tempering, if specified, at 1050 °C for 1/2 hour/oil and annealing at 760 °C for 2 hours. Further details on the welding technology available on request.

Base Materials

similar alloyed creep resistant steels

1.4935 X20CrMoWV12-1, 1.4922 X20CrMoV12-1, 1.4923 X22CrMoV12-1
1.4913 X19CrMoVNb11-1 (Turbotherm, 20 MVNb), 1.4931 GX22CrMoV12-1

Approvals and Certificates

TÜV-D (07813.), UDT
SAW solid wire: TÜV-D (07813.), KTA 1408 1 (8060.01), TÜV-A (393), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX 20 MVW
GTAW rod:	20 MVW-IG

SAW solid wire:
EN 12072:1999: S 19 9 H
AWS A5.9-93: ER19-10H
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER
CN 18/11-UP // BB 202

SAW wire/flux-combination, high-alloyed, creep resistant

Description

Sub-arc wire/flux combination for high quality joint weld on high temperature austenitic CrNi-steels at service temperature up to +700 °C (+300 °C in the case of wet corrosion). The controlled ferrite content (3-8 FN) ensures hot cracking resistance. The deposit is insusceptible to sigma phase embrittlement. For information regarding the sub-arc welding flux BÖHLER BB 202 see our detailed data sheet. Steels to German material no. 1.4550 and 1.4551 which are approved for the high temperature range up to +550 °C, can also be welded.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	FN
SAW wire wt-%	**0.05**	**0.40**	**1.6**	**18.8**	**9.3**	
all-weld metal %	**0.05**	**0.55**	**1.2**	**18.4**	**9.3**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		≥ 320
tensile strength R_m N/mm^2:		≥ 550
elongation A ($L_0 = 5d_0$) %:		≥ 35
impact work ISO-V KV J	+ 20 °C:	≥ 80

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h - 10 h
max. amperage of sub-arc flux: **800 A**

ø mm
3.0

=±

Preheating is not required, only in case of wall thickness above 25 mm preheat up to 150 °C. The interpass temperature should not exceed 200 °C.

Base Materials

similar alloyed creep resistant steels

1.4948 X6CrNi18-11, 1.4949 X3CrNiN18-11

AISI 304H, 321H, 347H

Approvals and Certificates

UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 308 H FOX CN 18/11	GMAW solid wire:	CN 18/11-IG
GTAW rod:	ER 308 H-IG CN 18/11-IG	GMAW flux-cored wire:	E 308 H-FD E 308 H PW-FD

EN 12536:2000: O IV
AWS A5.2-92: R 60-G
W.Nr.: 1.5425

BÖHLER DMO

Gas welding rod, low-alloyed, high temperature

Description

Mo-alloyed gas welding rod recommended for mild steels and 0.5 % Mo alloyed steels. High viscous weld puddle. Easy to operate. Approved in long-term condition up to +500 °C service temperature.

Typical Composition of Welding Rod

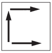
	C	Si	Mn	Mo
wt-%	**0.12**	**0.15**	**1.0**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**330**	(≥ 295)
tensile strength R_m N/mm^2:		**470**	(≥ 440)
elongation A (L_0 = 5d_0) %:		**24**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 39)

(*) *u untreated, as-welded*

Operating Data



rod marking:
front: **O IV**
back: **R60-G**

ø mm
2.0
2.5
3.2
4.0

Preheating and post weld heat treatment as required by the base metal.

Base Materials

high temperature steels, same alloyed

16Mo3, P285NH, P295NH, P255G1TH, P295GH

ASTM A335 Gr. P1, A36 Gr. all; A283 Gr. B, C, D; A285 Gr. B; A414 Gr. C; A442 Gr. 60; A515 Gr. 60; A516 Gr. 55, 60; A570 Gr. 33, 36, 40

Approvals and Certificates

TÜV-D (0146.), DB (70.014.03), ÜZ (./.), ÖBB, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DMO Kb	GMAW solid wire:	DMO-IG
	FOX DMO Ti	SAW combination:	EMS 2 Mo/BB 24
GTAW rod:	DMO-IG		EMS 2 Mo/BB 25

EN 12536:2000: O V
AWS A5.2-92: R 65-G
W.Nr.: 1.7346

BÖHLER DCMS

Gas welding rod, low-alloyed, high temperature

Description

CrMo-alloyed gas welding rod for high temperature boiler and tube steels equivalent to 13CrMo4-5 (1.25 % Cr 0.5 % Mo). Approved in long-term condition up to +500 °C service temperature. High viscous weld puddle.

Typical Composition of Welding Rod

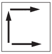
	C	Si	Mn	Cr	Mo
wt-%	**0.12**	**0.15**	**0.9**	**1.2**	**0.5**

Mechanical Properties of All-weld Metal

(*)		a
yield strength R_e N/mm^2:		≥ 315
tensile strength R_m N/mm^2:		≥ 490
elongation A ($L_0 = 5d_0$) %:		≥ 18
impact work ISO-V KV J	+ 20 °C:	≥ 47

(*) *a annealed, 680 °C, 2 h/furnace down to 300 °C/air*

Operating Data



rod marking:
front: **O V**
back: **R65-G**

ø mm
2.5
3.0

Wall thicknesses over 6 mm should be preheated to 100-200 °C and tempered at 660-700 °C for at least 1/2 hours followed by cooling in still air.

Base Materials

high temperature steels same alloyed, steels resistant to caustic cracking

1.7335 13CrMo4-5, 1.7205 15CrMo5, 1.7354 G22CrMo5-4, 1.7357 G17CrMo5-5, 16CrMoV4, ASTM A335 Gr. P 11 a. P 12; A193 Gr. B7; A217 Gr. WC6

Approvals and Certificates

TÜV-D (1363.), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX DCMS Kb	GMAW solid wire:	DCMS-IG
	FOX DCMS Ti	SAW combination:	EMS 2 CrMo/BB 24
GTAW rod:	DCMS-IG		EMS 2 CrMo/BB 25

Notes

Notes

Notes

2.6. Filler Metals for Stainless and Corrosion Resistant Steels

Objectives

This section provides detailed product information for filler metals to join corrosion resistant and highly corrosion resistant steels.

The corrosion resistance of these steels, which is based on the passivating effect of chromium due to the formation of dense, adhesive, thin passive films, is brought about by Cr contents above 12 %. Mo increases the passivating effect still further. It is possible to differentiate between ferritic, martensitic and austenitic steels according to the microstructure in the as-used condition.

Due to their special characteristics austenitic CrNi(Mo) steels are used in the most varied branches like the chemical and petrochemical plant engineering, the pulp and paper or textile industry, for offshore engineering, shipbuilding seawater desalination, the food processing industry, etc. They are primarily used for the fabrication of storage tanks, reactors and pressure vessels as well as piping systems.

The choice of filler metal and welding technology should be matched to the metallurgical behaviour of the parent metal and the component's corrosion requirements.

Contents

Overview – Standard Classifications

Böhler	EN	AWS
SMAW stick electrodes		
FOX CN 13/4	EN 1600: E 13 4 B 6 2	AWS A5.4-92: E410NiMo-25
FOX CN 13/4 SUPRA	EN 1600: E 13 4 B 4 2	AWS A5.4-92: E410NiMo-15
FOX KW 10	EN 1600: E 13 B 2 2	AWS A5.4-92: E410-15(mod.)
FOX SKWA	EN 1600: E 17 B 2 2	AWS A5.4-92: E430-15
FOX SKWAM	EN 1600: E Z 17 Mo B 2 2	–
FOX CN 16/6 M-HD	EN 1600: E Z 16 6 Mo B 6 2 H5	–
FOX CN 17/4 PH	EN 1600: E Z 17 4 Cu B 4 3 H5	AWS A5.4-92: E630-15(mod.)
FOX EAS 2	EN 1600: E 19 9 L B 2 2	AWS A5.4-92: E308L-15
FOX EAS 2-A	EN 1600: E 19 9 L R 3 2	AWS A5.4-92: E308L-17
FOX EAS 2-VD	EN 1600: E 19 9 L R 1 5	AWS A5.4-92: E308L-17
FOX SAS 2	EN 1600: E 19 9 Nb B 2 2	AWS A5.4-92: E347-15
FOX SAS 2-A	EN 1600: E 19 9 Nb R 3 2	AWS A5.4-92: E347-17
FOX EAS 4 M	EN 1600: E 19 12 3 LB 2 2	AWS A5.4-92: E316L-15
FOX EAS 4 M-A	EN 1600: E 19 12 3 L R 3 2	AWS A5.4-92: E316L-17
FOX EAS 4 M-VD	EN 1600: E 19 12 3 L R 1 5	AWS A5.4-92: E316L-17
FOX EAS 4 M-TS	EN 1600: E 19 12 3 L R 1 2	AWS A5.4-92: E316L-16(mod.)
FOX SAS 4	EN 1600: E 19 12 3 Nb B 2 2	AWS A5.4-92: E318-15
FOX SAS 4-A	EN 1600: E 19 12 3 Nb R 3 2	AWS A5.4-92: E318-17
FOX EAS 2 Si	EN 1600: E Z 19 14 Si B 2 2	–
FOX E317 L	–	AWS A5.4-92: E317L-17
FOX ASN 5	EN 1600: E 18 16 5 N L B 2 2	AWS A5.4-92: E317LN-15(mod.)
FOX ASN 5-A	EN 1600: E 18 16 5 N L R 3 2	AWS A5.4-92: E317LN-17(mod.)
FOX AM 400	EN 1600: E Z 22 18 4 L B 2 2	–
FOX EASN 25 M	EN 1600: EZ 25 22 2 NL B 2 2	–
FOX CN 20/25 M	EN 1600: E 20 25 5 Cu N L B 2 2	AWS A5.4-92: E385-15(mod.)
FOX CN 20/25 M-A	EN 1600: E 20 25 5 Cu N L R 3 2	AWS A5.4-92: E385-17(mod.)
FOX CN 22/9 N-B	EN 1600: E 22 9 3 L B 2 2	AWS A5.4-92: E2209-15
FOX CN 22/9 N	EN 1600: E 22 9 3 L R 3 2	AWS A5.4-92: E2209-17
FOX CN 25/9CuT	EN 1600: E 25 9 4 N L B 2 2	AWS A5.9-93: E2553-15(mod.)
GTAW rods		
CN 13/4-IG	EN 12072: W 13 4	AWS A5.9-93: ER410 NiMo(mod.)
EAS 2-IG	EN 12072: W 19 9 L	AWS A5.9-93: ER308L
SAS 2-IG	EN 12072: W 19 9 Nb	AWS A5.9-93: ER347
EAS 4 M-IG	EN 12072: W 19 12 3 L	AWS A5.9-93: ER316L
SAS 4-IG	EN 12072: W 19 12 3 Nb	AWS A5.9-93: ER318
EASN 2 Si-IG	EN 12072: W Z 19 13 Si NL	–
ASN 5-IG	EN 12072: W Z 18 16 5 NL	AWS A5.9-93: ER317LN(mod.)
AM 400-IG	EN 12072: W Z 22 17 8 4 NL	–
EASN 25 M-IG	EN 12072: W 25 22 2 NL	–
CN 20/25 M-IG	EN 12072: W Z 20 25 5 Cu NL	AWS A5.9-93: ER385(mod.)
CN 22/9 N-IG	EN 12072: W 22 9 3 NL	AWS A5.9-93: ER2209
CN 25/9 CuT-IG	EN 12072: W 25 9 4 NL	AWS A5.9-93: ER2553(mod.)

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	T	N	Cu	Co
SMAW stick electrodes											
FOX CN 13/4	0.035	0.3	0.5	12.2	4.5	0.5					
FOX CN 13/4 SUPRA	0.03	0.3	0.6	12.5	4.5	0.5					
FOX KW 10	0.08	0.7	0.8	13.5							
FOX SKWA	0.08	0.3	0.3	17.0							
FOX SKWAM	0.22	0.4	0.4	17.0		1.3					
FOX CN 16/6 M-HD	0.03	0.3	0.6	15.5	5.8	1.1					
FOX CN 17/4 PH	0.04	0.3	0.6	16.0	4.9	0.4	0.2			3.2	
FOX EAS 2	0.03	0.4	1.3	19.5	10.5						
FOX EAS 2-A	0.03	0.8	0.8	19.8	10.2						
FOX EAS 2-VD	0.02	0.7	0.7	19.5	10.5						
FOX SAS 2	0.03	0.4	1.3	19.8	10.5		+				
FOX SAS 2-A	0.03	0.8	0.8	19.5	10.0		+				
FOX EAS 4 M	0.03	0.4	1.2	18.8	11.5	2.7					
FOX EAS 4 M-A	0.03	0.8	0.8	18.8	11.7	2.7					
FOX EAS 4 M-VD	0.03	0.7	0.7	19.0	12.0	2.7					
FOX EAS 4 M-TS	0.03	0.8	0.7	19.0	11.5	2.7					
FOX SAS 4	0.03	0.4	1.3	18.8	11.5	2.7	+				
FOX SAS 4-A	0.03	0.8	0.8	19.0	11.5	2.7	+				
FOX EAS 2 Si	<0.025	4.5	1.2	19.0	14.8						
FOX E317L	0.03	0.8	0.8	19.0	13.0	3.6			+		
FOX ASN 5	≤0.04	0.5	2.5	18.5	17.0	4.3			0.15		
FOX ASN 5-A	≤0.035	0.7	1.1	18.0	16.0	4.5			0.13		
FOX AM 400	≤0.04	0.8	7.5	21.8	18.3	3.7			0.20		
FOX EASN 25 M	≤0.035	0.4	5.5	25.0	22.0	2.2			0.14		
FOX CN 20/25 M	≤0.04	0.4	4.0	20.0	25.0	6.5			0.14	1.4	
FOX CN 20/25 M-A	≤0.03	0.7	2.0	20.5	25.0	6.2			0.17	1.6	
FOX CN 22/9 N-B	≤0.03	0.3	1.1	23.0	8.8	3.2			0.16		
FOX CN 22/9 N	≤0.03	0.9	0.8	23.0	9.0	3.2			0.17		
FOX CN 25/9CuT	0.03	0.5	1.1	25.0	9.3	3.7		0.6	0.22	0.7	
GTAW rods											
CN 13/4-IG	0.02	0.7	0.7	12.3	4.7	0.5					
EAS 2-IG	0.02	0.5	1.7	20.0	10.0						
SAS 2-IG	0.05	0.5	1.8	19.5	9.5		+				
EAS 4 M-IG	0.02	0.5	1.7	18.5	12.3	2.6					
SAS 4-IG	0.04	0.4	1.7	19.5	11.5	2.7	+				
EASN 2 Si-IG	≤0.015	4.6	0.7	19.5	13.4				0.12		
ASN 5-IG	0.02	0.2	5.0	19.0	16.5	4.1			0.16		
AM 400-IG	0.03	0.7	7.5	21.5	17.5	3.6			0.22		
EASN 25 M-IG	0.025	0.2	6.0	25.0	22.5	2.2			0.13		
CN 20/25 M-IG	≤0.02	0.7	4.7	20.0	25.4	6.2			0.12	1.5	
CN 22/9 N-IG	0.02	0.4	1.7	22.5	8.8	3.2			0.15		
CN 25/9 CuT-IG	0.02	0.3	0.8	25.5	9.5	3.7		0.6	0.22	0.6	

Overview – Standard Classifications (continued)

Böhler	EN	AWS	
GMAW solid wires			
KW 5 Nb-IG	EN 12072: G Z 13 Nb L	AWS A5.9-93:	ER409 Cb
CAT 430 L Cb-IG	EN 12072: G Z 18 Nb L	AWS A5.9-93:	ER430(mod.)
CAT 439 L Ti-IG	EN 12072: G Z 18 Ti L	AWS A5.9-93:	ER430(mod.)
CN 13/4-IG	EN 12072: G 13 4	AWS A5.9-93:	ER410NiMo (mod.)
KW 10-IG	EN 12072: G Z 13	AWS A5.9-93:	ER410(mod.)
KWA-IG	EN 12072: G 17	AWS A5.9-93:	ER430(mod.)
SKWA-IG	EN 12072: G Z 17 Ti	AWS A5.9-93:	ER430(mod.)
SKWAM-IG	EN 12072: G Z 17 Mo H	–	
EAS 2-IG (Si)	EN 12072: G 19 9 L Si	AWS A5.9-93:	ER308LSi
SAS 2-IG (Si)	EN 12072: G 19 9 NbSi	AWS A5.9-93:	ER347Si
EAS 4 M-IG (Si)	EN 12072: G 19 12 3 L Si	AWS A5.9-93:	ER316LSi
SAS 4-IG (Si)	EN 12072: G 19 12 3 NbSi	AWS A5.9-93:	ER318(mod.)
ASN 5-IG (Si)	EN 12072: G Z 18 16 5 NL	AWS A5.9-93:	ER317LN(mod.)
AM 400-IG	EN 12072: G Z 22 17 8 4 NL	–	
CN 20/25 M-IG (Si)	EN 12072: G Z 20 25 5 Cu NL	AWS A5.9-93:	ER385(mod.)
CN 22/9 N-IG	EN 12072: G 22 9 3 NL	AWS A5.9-93:	ER2209
CN 25/9 CuT-IG	EN 12072: G 25 9 4 NL	AWS A5.9-93:	ER2553(mod.)
GMAW flux cored wires			
CN 13/4-MC	EN 12073: T 13 4 MM 2	AWS A5.22-95:	EC410NiMo(mod.)
CN 13/4-MC (F)	EN 12073: T 13 4 MM 2	AWS A5.9-93:	EC410NiMo(mod.)
EAS 2-MC	EN 12073: T 19 9 L MM 1	AWS A5.9-93:	EC308L(mod.)
EAS 4M-MC	EN 12073: T 19 12 3 L MM 1	AWS A5.22-95:	EC316L(mod.)
EAS 2-FD	EN 12073: T 19 9 L R M 3	AWS A5.22-95:	E308LT0-4
	T 19 9 L R C 3		E308LT0-1
EAS 2 PW-FD	EN 12073: T 19 9 L P M 1	AWS A5.22-95:	E308LT1-4
	T 19 9 L P C 1		E308LT1-1
SAS 2-FD	EN 12073: T 19 9 Nb R M 3	AWS A5.22-95:	E347T0-4
	T 19 9 Nb R C 3		E347T0-1
SAS 2 PW-FD	EN 12073: T 19 9 Nb P M 1	AWS A5.22-95:	E347T1-4
	T 19 9 Nb P C 1		E347T1-1
EAS 4 M-FD	EN 12073: T 19 12 3 L R M 3	AWS A5.22-95:	E316LT0-4
	T 19 12 3 L R C 3		E316LT0-1
EAS 4 PW-FD	EN 12073: T 19 12 3 L P M 1	AWS A5.22-95:	E316LT1-4
	T 19 12 3 L P C 1		E316LT1-1
SAS 4-FD	EN 12073: T 19 12 3 Nb R M 3		
	T 19 12 3 Nb R C 3		
SAS 4 PW-FD	EN 12073: T 19 12 3 Nb R M 1		
	T 19 12 3 Nb R C 1		
E 317L-FD	EN 12073: TZ 19 13 4 L R M 3	AWS A5.22-95:	E317LT0-4
	TZ 19 13 4 L R C 3	AWS A5.22-95:	E317LT0-1
E 317L PW-FD	EN 12073: TZ 19 13 4 L P M 1	AWS A5.22-95:	E317LT1-4
	TZ 19 13 4 L P C 1	AWS A5.22-95:	E317LT1-1
CN 22/9 N-FD	EN 12073: T 22 9 3 LN R M 3	AWS A5.22-95:	E2209T0-4
	T 22 9 3 LN R C 3		E2209T0-1
CN 22/9 PW-FD	EN 12073: T 22 9 3 LN P M 1	AWS A5.22-95:	E2209T1-4
	T 22 9 3 LN P C 1		E2209T1-1

Overview – Typical Chemical Composition (continued)

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	Ti	N	Cu	T
GMAW solid wires											
KW 5 Nb-IG	0.05	0.6	0.6	11.5			+				
CAT 430 L Cb-IG	<0.02	0.5	0.5	18.0			>12xC				
CAT 439 L Ti-IG	0.03	0.8	0.8	18.0				>12xC			
CN 13/4-IG	≤0.02	0.7	0.6	12.3	4.7	0.5					
KW 10-IG	0.08	1.1	0.6	14.5							
KWA-IG	0.06	0.6	0.6	17.5							
SKWA-IG	0.07	0.6	0.6	17.5				+			
SKWAM-IG	0.20	0.7	0.7	17.0		1.1					
EAS 2-IG (Si)	0.02	0.8	1.7	20.0	10.2						
SAS 2-IG (Si)	0.03	0.9	1.3	19.4	9.7		+				
EAS 4 M-IG (Si)	0.02	0.8	1.7	18.4	11.8	2.8					
SAS 4-IG (Si)	0.035	0.8	1.4	19.0	11.5	2.8	+				
ASN 5-IG (Si)	0.03	0.7	7.0	19.0	17.5	4.3			0.16		
AM 400-IG	0.03	0.7	7.5	21.5	17.5	3.6			0.22		
CN 20/25 M-IG (Si)	0.02	0.7	4.7	20.0	25.4	6.2			0.12	1.5	
CN 22/9 N-IG	0.015	0.4	1.7	22.6	8.8	3.2			0.15		
CN 25/9 CuT-IG	0.02	0.3	0.8	25.3	9.5	3.7			0.22	0.6	0.6
GMAW flux cored wires											
CN 13/4-MC	0.025	0.7	0.9	12.0	4.6	0.6					
CN 13/4-MC (F)	≤0.03	0.7	0.9	12.2	4.6	0.6					
EAS 2-MC	≤0.03	0.6	1.4	19.8	10.2						
EAS 4M-MC	≤0.03	0.6	1.4	18.8	12.2	2.7					
EAS 2-FD	0.03	0.6	1.5	19.8	10.2						
EAS 2 PW-FD	0.03	0.7	1.5	19.8	10.2						
SAS 2-FD	0.03	0.7	1.4	19.0	10.4		+				
SAS 2 PW-FD	0.03	0.7	1.4	19.0	10.4		+				
EAS 4 M-FD	0.03	0.7	1.5	19.0	12.0	2.7					
EAS 4 PW-FD	0.03	0.7	1.5	19.0	12.0	2.7					
SAS 4-FD	0.03	0.6	1.3	18.8	12.2	2.6	+				
SAS 4 PW-FD	0.03	0.6	1.3	18.8	12.2	2.6	+				
E 317L-FD	≤0.035	0.7	1.3	18.5	13.3	3.4					
E 317L PW-FD	≤0.035	0.7	1.3	18.5	13.3	3.4					
CN 22/9 N-FD	0.03	0.8	0.9	22.7	9.0	3.2			0.13		
CN 22/9 PW-FD	0.03	0.8	0.9	22.7	9.0	3.2			0.13		

Overview – Standard Classifications (continued)

Böhler	EN	AWS	
SAW wire/flux-combinations			
CN 13/4-UP	EN 12072: S 13 4	AWS A5.9-93:	ER410NiMo(mod.)
CN 13/4-UP/BB 203	EN 12072/760: S 13 4 / SA FB 2	AWS:	ER410NiMo(mod.)
SKWAM-UP	EN 12072: S 17 Mo H	AWS A5.9-93:	–
SKWAM-UP/BB 203	EN 12072/760: SA FB 2 DC	AWS:	–
EAS 2-UP	EN 12072: S 19 9 L	AWS A5.9-93:	ER308L
EAS 2-UP/BB 202	EN 12072/760: S 19 9 L / SA FB 2	AWS:	ER308L
SAS 2-UP	EN 12072: S 19 9 Nb	AWS A5.9-93:	ER347
SAS 2-UP/BB 202	EN 12072/760: S 19 9 Nb / SA FB 2	AWS:	ER347
EAS 4 M-UP	EN 12072: S 19 12 3 L	AWS A5.9-93:	ER316L
EAS 4 M-UP/BB 202	EN 12072/760: S 19 12 3L / SA FB 2	AWS:	ER316L
SAS 4-UP	EN 12072: S 19 12 3 Nb	AWS A5.9-93:	ER318
SAS 4-UP/BB 202	EN 12072/760: S 19 12 3Nb/SA FB 2	AWS:	ER318
ASN 5 SY-UP/BB 202	EN 12072: –	AWS A5.9-93:	ER317L
ASN 5 SY-UP/BB 202	EN 12072/760: SA FB 2 DC	AWS:	–
ASN 5-UP	EN 12072: S 18 16 5 NL	AWS A5.9-93:	ER317LN(mod.)
ASN 5-UP/BB 203	EN 12072/760: S 18 16 5 NL / SA FB 2	AWS:	ER317LN(mod.)
CN 22/9 N-UP	EN 12072: S 22 9 3 NL	AWS A5.9-93:	ER2209
CN 22/9 N-UP/BB 202	EN 12072/760: S 22 9 3NL/SA FB 2	AWS:	ER2209

Overview – Typical Chemical Composition (continued)

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	Ti	N	Cu	
SAW wire/flux-combinations											
CN 13/4-UP	≤0.02	0.70	0.6	12.2	4.8	0.5					
CN 13/4-UP/BB 203	0.025	0.75	0.6	12.1	4.7	0.5					
SKWAM-UP	0.16	0.6	0.7	17.0		1.1					
SKWAM-UP/BB 203	0.15	0.6	0.7	16.5		1.1					
EAS 2-UP	≤0.02	0.45	1.7	20.1	9.8						
EAS 2-UP/BB 202	≤0.02	0.60	1.3	19.8	9.8						
SAS 2-UP	≤0.05	0.50	1.7	19.5	9.5		0.60				
SAS 2-UP/BB 202	0.045	0.65	1.3	19.3	9.5		0.50				
EAS 4 M-UP	≤0.02	0.45	1.7	18.5	12.2	2.8					
EAS 4 M-UP/BB 202	≤0.02	0.60	1.3	18.3	12.2	2.7					
SAS 4-UP	0.03	0.50	1.7	19.6	11.4	2.7	0.55				
SAS 4-UP/BB 202	0.025	0.65	1.3	18.8	11.4	2.7	0.45				
ASN 5 SY-UP	≤0.03	0.5	1.6	19.0	13.5	3.6					
ASN 5 SY-UP/BB 202	≤0.03	0.6	1.2	18.5	13.4	3.5					
ASN 5-UP	≤0.02	0.20	5.0	19.0	16.5	4.0			0.15		
ASN 5-UP/BB 203	≤0.02	0.20	4.5	18.5	16.3	4.0			0.14		
CN 22/9 N-UP	≤0.02	0.40	1.7	23.0	9.0	3.2			0.15		
CN 22/9 N-UP/BB 202	0.015	0.55	1.3	22.5	8.9	3.1			0.14		

EN 1600:1997: E 13 4 B 6 2
AWS A5.4-92: E 410 NiMo-25

BÖHLER FOX CN 13/4

SMAW stick electrode, high-alloyed, stainless

Description

Basic coated low-hydrogen electrode suited for similar soft martensitic and martensitic-ferritic rolled, forged, and cast steels. Mainly used in the construction of hydro turbines, compressors. Resistant to corrosion from water, steam and sea water atmosphere. Thanks to an optimum balance of alloying components the weld deposit yields very good ductility and toughness & cracking resistance despite of its high strength.
Excellent operating characteristics, easy slag removal, and smooth bead appearance. Metal recovery approx. 130 %. Positional weldability is offered up to ø 3.2 mm electrodes.
BÖHLER FOX CN 13/4 as well as the GTAW-rod BÖHLER CN 13/4-IG and the analogous GMAW wire are very popular in the construction of hydro turbines.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.035**	**0.3**	**0.5**	**12.2**	**4.5**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a		q	
yield strength R_e N/mm²:		**890**	(≥ 830)	**680**	(≥ 610)	**670**	(≥ 560)
tensile strength R_m N/mm²:		**1090**	(≥ 1000)	**910**	(≥ 830)	**850**	(≥ 780)
elongation A ($L_0 = 5d_0$) %:		**12**	(≥ 8)	**17**	(≥ 15)	**18**	(≥ 16)
impact work ISO-V KV J	+ 20 °C:	**32**	(≥ 24)	**66**	(≥ 47)	**95**	(≥ 60)
(*)	*- 20 °C:*			**55**			
	- 60 °C:			**50**			

u untreated, as-welded;
a annealed, 600 °C/2 h/air; q: quenched/tempered, 950 °C/0.5 h/air + 600 °C/2 h/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX CN 13/4 410 NiMo-25 E 13 4 B

ø mm	L mm	amps A
2.5	350	60 - 90
3.2	450	90 - 130
4.0	450	120 - 170
5.0	450	160 - 220

=+

Preheating and interpass temperatures of heavy-wall components 100 - 160 °C. Maximum heat input 15 kJ/cm. Post weld heat treatment at 580 - 620 °C.

Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNi13-4, 1.4414 GX4CrNiMo13-4

ACI Gr. CA 6 NM, S41500

Approvals and Certificates

TÜV-D (3232.), UDT, LTSS, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4 SUPRA	Metal cored wire:	CN 13/4-MC
GTAW rod:	CN 13/4-IG		CN 13/4-MC (F)
GMAW solid wire:	CN 13/4-IG	SAW combination:	CN 13/4-UP/BB 203

EN 1600:1997: E 13 4 B 4 2
AWS A5.4-92: E 410 NiMo-15

BÖHLER FOX CN 13/4 SUPRA

SMAW stick electrode, high-alloyed, stainless

Description

Basic coated core wire alloyed low-hydrogen electrode suited for welding similar soft-martensitic and martensitic-ferritic rolled, forged, and cast steels. Mainly used in the construction of hydro turbines, compressors. Resistant to corrosion from water, steam, and sea water atmosphere. Thanks to an optimum balance of alloying components the weld deposit yields very good ductility and toughness & cracking resistance despite of its high strength.
Excellent slag removability, smooth bead appearance. Out of position weldable except vertical down.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.3**	**0.6**	**12.5**	**4.5**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a		q	
yield strength R_e N/mm²:		**880**	(≥ 830)	**680**	(≥ 610)	**670**	(≥ 560)
tensile strength R_m N/mm²:		**1060**	(≥ 1000)	**930**	(≥ 830)	**850**	(≥ 760)
elongation A ($L_0 = 5d_0$) %:		**13**	(≥ 8)	**18**	(≥ 15)	**18**	(≥ 16)
impact work ISO-V KV J	+ 20 °C:	**35**	(≥ 30)	**70**	(≥ 55)	**105**	(≥ 70)
	- 20 °C:			**60**			
	- 60 °C:			**55**			

(*) *u untreated, as-welded*
a annealed, 600 °C/2 h/air
q quenched/tempered , 950 °C/0.5 h/air + 600 °C/2 h/air

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX CN 13/4 SUPRA 410NiMo-15 E 13 4 B

ø mm	L mm	amps A
3.2	350	90 - 110
4.0	350	120 - 145

=+

Preheating and interpass temperatures of heavy-wall components 100 - 160 °C. Maximum heat input 15 kJ/cm. Post weld heat treatment at 580 - 620 °C.

Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNi13-4, 1.4414 GX4CrNiMo13-4

ACI Gr. CA 6 NM, S41500

Approvals and Certificates

TÜV-D (9081.), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4	Metal cored wire:	CN 13/4-MC
GTAW rod:	CN 13/4-IG		CN 13/4-MC (F)
GMAW solid wire:	CN 13/4-IG	SAW combination:	CN 13/4-UP/BB 203

EN 1600:1997: E 13 B 2 2
AWS A5.4-92: E 410-15 (mod.)

BÖHLER FOX KW 10

SMAW stick electrode, high-alloyed, stainless

Description

Basic coated core wire alloyed low-hydrogen electrode with good operating characteristics in all positions except vertical-down. Mainly used for surfacing on sealing faces of gas, water and steam valves to meet stainless and wear resistant overlays for instance. In the machined condition, at least a two layer build up should remain. Joint welding of similar, stainless and heat resistant chromium steels provides matching colour of weld metal with very good ability to polishing. Retention of hardness up to +450 °C, scaling resistant up to +900 °C. Preheating and interpass temperature 200 - 300 °C, post weld heat treatment at 700 - 750 °C depending on the weld job.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr
wt-%	**0.08**	**0.7**	**0.8**	**13.5**

Mechanical Properties of All-weld Metal

(*)	u	a	
yield strength R_e N/mm²:		**530**	(≥ 450)
tensile strength R_m N/mm²:		**700**	(≥ 640)
elongation A ($L_0 = 5d_0$) %:		**17**	(≥ 15)
Brinell-hardness HB:	**350**	**210**	

(*) *u untreated, as-welded*
a annealed, 750 °C/2 h/furnace

The hardness of the deposit ist greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness.

Operating Data

re-drying if necessary:	**ø mm**	**L mm**	**amps A**
120 - 200 °C, min. 2 h	2.5	300	60 - 80
electrode identification:	3.2	350	80 - 100
FOX KW 10 E 13 B	4.0	350	110 - 130

=+

Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed

joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents ≤ 0.20 % (repair welding); heat resistant Cr-steels of similar chemical composition. Be careful with dilution and welding technology.

1.4006 X12Cr13, 1.4021 X20Cr13

AISI 410, 420

Approvals and Certificates

UDT, SEPROZ

Same Alloy Filler Metals

GMAW solid wire: KW 10-IG

EN 1600:1997: E 17 B 2 2
AWS A5.4-92: E 430-15

BÖHLER FOX SKWA

SMAW stick electrode, high-alloyed, stainless

Description

Basic coated core wire alloyed low-hydrogen electrode with good operating characteristics in all positions except vertical-down. Mainly used for surfacing on sealing faces of gas, water and steam valves to meet stainless and wear resistant overlays for instance. In the machined condition, at least a two layer build up should remain. Joint welding of similar, stainless and heat resistant chromium steels provides matching colour of weld metal with very good ability to polishing. Hydrogen content in weld deposit < 5 ml/100 g.
Preheating and interpass temperature 200 - 300 °C, post weld heat treatment at 730 - 800 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr
wt-%	**0.08**	**0.3**	**0.3**	**17.0**

Mechanical Properties of All-weld Metal

(*)	u	a	
yield strength R_e N/mm²:		**370**	(≥ 340)
tensile strength R_m N/mm²:		**560**	(≥ 530)
elongation A ($L_0 = 5d_0$) %:		**23**	(≥ 18)
Brinell-hardness HB:	**250**	**200**	

(*) *u untreated, as-welded*
a annealed, 750 °C/2 h/furnace

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX SKWA 430-15 E 17 B

ø mm	L mm	amps A
2.5	300	60 - 80
3.2	350	80 - 110
4.0	350	110 - 140
5.0	450	140 - 180

=+

The hardness of the deposit ist greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness.

Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed.

joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents up to 0.20 % (repair welding). Be careful with dilution and welding technology.

1.4510 X3CrTi17

AISI 430Ti, 431

Approvals and Certificates

KTA 1408.1 (8098.00), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode: FOX SKWAM

GMAW solid wire: KWA-IG
SKWA-IG
SKWAM-IG

EN 1600:1997: E Z 17 Mo B 2 2

BÖHLER FOX SKWAM

SMAW stick electrode, high-alloyed, stainless

Description

Basic coated core wire alloyed low-hydrogen electrode with good operating characteristics in all positions except vertical-down. Mainly used for surfacing on sealing faces of gas, water and steam valves to meet stainless and wear resistant overlays for instance. In the machined condition, at least a two layer build up should remain.
Joint welding of similar, stainless and heat resistant chromium steels provides matching colour of weld metal with very good ability to polishing.
Hydrogen content in weld deposit <5 ml/100 g. Weld metal retention of hardness up to +500 °C. Scaling resistant up to +900 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo
wt-%	**0.22**	**0.4**	**0.4**	**17.0**	**1.3**

Mechanical Properties of All-weld Metal

(*)	u	a
Brinell-hardness HB:	**400**	**250**

(*) *u untreated, as-welded*
a annealed, 700° C/2 h/furnace

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX SKWAM E Z 17 Mo B

ø mm	**L mm**	**amps A**
2.5	300	60 - 80
3.2	350	80 - 110
4.0	350	110 - 140
5.0	450	140 - 180

=+

Preheating as required by the base metal, with temperatures between 100 and 200 °C being generally sufficient (for joint welding operations 250 - 400 °C). Annealing at 650 - 750 °C may be carried out to improve the toughness values in the weld metal and in the transition zone of the base metal.

The hardness of the deposit ist greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness.

Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed.

joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents up to 0.20 % (repair welding). Be careful with dilution and welding technology

Approvals and Certificates

KTA 1408.1 (8043.01), DB (30.014.12-20.014.08), ÜZ (30014), ÖBB, UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SKWA
GMAW solid wire:	KWA-IG
	SKWA-IG
	SKWAM-IG

EN 1600:1997: E Z 16 6 Mo B 6 2 H5

BÖHLER FOX CN 16/6 M-HD

SMAW stick electrode, high-alloyed, corrosion resistant

Description

Basic coated, high efficiency electrode for welding of soft martensitic forged and cast steels. The high chromium content enhances the corrosion resistance in water, steam and sea atmosphere. Main applications are found in turbines, pumps-and combustion building. Popular in hydro turbine engineering.
The electrode shows very good features in regard to arc stability, weld puddle control, slag detachability and seam cleanliness. Suitable for all positions except vertical down (positional welding up to ø 3.2 mm). Metal recovery approx. 135 %. Low hydrogen is a essential and necessary prerequisite of this product.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.3**	**0.6**	**15.5**	**5.8**	**1.1**

Mechanical Properties of All-weld Metal

(*)		u	s1	s2	s
yield strength R_e N/mm^2:		**520**	**650**	**640**	**680**
tensile strength R_m N/mm^2:		**1050**	**920**	**920**	**880**
elongation A ($L_0 = 5d_0$) %:		**13**	**15**	**16**	**24**
hardness Hv HV10:		**370**	**340**	**330**	**295**
impact work ISO-V KV J	+ 20 °C:	**28**	**42**	**48**	**75**

(*) *u untreated, as-welded*
s1 annealed, 580 °C/4 h/air
s2 annealed, 590 °C/8 h/furnace down to 300 °C/air
s solution annealed, 1030 °C/1 h/air + 590 °C/8 h/furnace down to 300 °C/air

The hardness of the deposit ist greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness. The maximum interpass temperature should not exceed +120 °C.

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:	**ø mm**	**L mm**	**amps A**
300 - 350 °C, min 2 h	2.5	350	70 - 95
electrode identification:	3.2	450	110 - 140
FOX CN 16/6 M-HD EZ16 6 Mo B	4.0	450	140 - 180
	5.0	450	180 - 230

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Base Materials

soft-martensitic forge steels and cast steels, same-alloyed

1.4405 GX5CrNiMo16-5, 1.4418 X4CrNiMo16-5

Approvals and Certificates

UDT, SEPROZ

EN 1600:1997: E Z 17 4 Cu B 4 3 H5
AWS A5.4-92: E630-15 (mod.)

BÖHLER FOX CN 17/4 PH

SMAW stick electrode, high-alloyed, corrosion resistant

Description

Basic coated electrode with strength properties for joint and fabrication welding of analogous precipitation hardening Cr-Ni-Cu-alloyed rolled-, forged- and cast steels.
Popular for components in the paper industry, rotors of compressors, fan blades, press plates in the plastic processing industry and for the aerospace industry.
The electrode shows very good features in regard to arc stability, weld puddle control, slag detachability and seam cleanliness. Lowest hydrogen content in the deposit is a prerequisite (HD < 5 ml/100 g). The electrode is suitable for welding in all positions except vertical down.
The interpass temperature has to be kept very low (max. 80 °C). With the use of the proper PWHT (solution annealing + precipitation hardening impact values down to -50 °C are still achievable).

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Cu	Nb
wt-%	**0.04**	**0.3**	**0.6**	**16.0**	**4.9**	**0.4**	**3.2**	**0.2**

Mechanical Properties of All-weld Metal

(*)		u	a1	a2	a3	s1	s2
yield strength R_e N/mm²:		**440**	**940**	**830**	**630**	**920**	**650**
tensile strength R_m N/mm²:		**800**	**1030**	**1110**	**940**	**1030**	**890**
elongation A ($L_0 = 5d_0$) %:		**4**	**10**	**8**	**15**	**17**	**18**
hardness HRC:		**32-39**	**37-40**	**–**	**29-31**	**–**	**27-29**
impact work ISO-V KV J	+ 20 °C:	**35-40**	**20**	**15**	**24-30**	**60-66**	**69-75**
	- 50 °C:						**55**

(*) *u untreated, as-welded* *a1 annealed, 540 °C/3 h/air*
a2 annealed, 480 °C/1 h/air *a3 annealed, 760 °C/2 h/air + 620 °C/4 h/air*
s1 solution annealed, 1040 °C/2 h/air + 580 °C/4 h/air
s2 solution annealed, 1040 °C/0.5 h/air + 760 °C/2 h/air + 620 °C/4 h/air

The hardness of the deposit ist greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness.

Operating Data

re-drying if necessary:
300 - 350 °C, min. 2 h
electrode identification:
FOX CN 17/4 PH E Z 17 4 Cu B

ø mm	L mm	amps A
3.2	350	90 - 110
4.0	350	120 - 140

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Base Materials

precipitation hardening forged steels and cast steels, same-alloyed

1.4540 X4CrNiCuNb16-4, 1.4540 GX4CrNiCuNb16-4, 1.4542 X5CrNiCuNb16-4, 1.4548 X5CrNiCuNb17-4-4

J92180 Gr. CB Cu-1; S17400 Type 630; SAE J467 17-4PH

Approvals and Certificates

UDT, SEPROZ

EN 1600:1997: E 19 9 L B 2 2
AWS A5.4-92: E 308L-15

BÖHLER FOX EAS 2

SMAW stick electrode, high-alloyed, chemical resistant

Description

Basic coated core wire alloyed stainless steel electrode with low carbon content. Preferably used for 1.4306 / 304L / 304LN steel grades.
Designed to produce high quality weld deposit with reliable toughness values down to –196 °C. 100 % X-ray safety together with very good root pass and positional welding characteristics. Good gap bridging ability, easy weld pool and slag control. Easy slag removal even in narrow preparations result in clean bead surfaces with minimum post weld cleaning. Resistant to intergranular corrosion up to +350 °C.
Ideal electrode for welding on site. Electrodes are packed in hermetically sealed tins and have a moisture resistant coating.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.03**	**0.4**	**1.3**	**19.5**	**10.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**430**	(≥ 350)
tensile strength R_m N/mm^2:		**580**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**42**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 90)
	- 196 °C:		(≥ 34)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
–
electrode identification:
FOX EAS 2 308L-15 E 19 9 L B

ø mm	L mm	amps A
2.5	300	50 - 80
3.2	350	80 - 110
4.0	350	110 - 140

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Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10

AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C o. D

Approvals and Certificates

TÜV-D (0152.), DB (30.014.10), ÜZ (30.014), ÖBB, TÜV-A (95), CL (1407), Statoil, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2-A	Metal cored wire:	EAS 2-MC
	FOX EAS 2-VD	Flux cored wire:	EAS 2-FD
GTAW rod:	EAS 2-IG		EAS 2 PW-FD
GMAW solid wire:	EAS 2-IG (Si)	SAW combination:	EAS 2-UP/BB 202

EN 1600:1997: E 19 9 L R 3 2
AWS A5.4-92: E 308L-17

BÖHLER FOX EAS 2-A

SMAW stick electrode, high-alloyed, chemical resistant

Description

Rutile coated core wire alloyed stainless steel electrode. Preferably used for 1.4306 / 304L / 304LN steel grades.
BÖHLER FOX EAS 2-A is noted for its superior welding characteristics and metallurgy. Can be used on AC or DC. Other characteristics include high current carrying capacity, minimum spatter formation, self releasing slag, smooth and clean weld profile, safety against formation of porosity due to moisture resistant coating and packaging into hermetically sealed tins.
Resistant to intergranular corrosion up to +350 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.03**	**0.8**	**0.8**	**19.8**	**10.2**

Mechanical Properties of All-weld Metal

(*)		u		sa
yield strength R_e N/mm²:		**430**	(≥ 350)	
tensile strength R_m N/mm²:		**560**	(≥ 520)	
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 35)	
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 47)	
	- 120 °C:		(≥ 32)	
	- 196 °C:			(≥ 32)

(*) *u untreated, as-welded*
sa solution annealed and quenched

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX EAS 2-A 308L-17 E 19 9 L R

ø mm	**L mm**	**amps A**
1.5	250	25 - 40
2.0	300	40 - 60
2.5	250/350	50 - 90
3.2	350	80 - 120
4.0	350	110 - 160
5.0	450	140 - 200

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Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10

AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (1095.), DB (30.014.15), ÜZ (30.014), ÖBB, TÜV-A (96), ABS (E 308L-17), CL (0942), GL (4306), Statoil, UDT, VUZ, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	Metal cored wire:	EAS 2-MC
	FOX EAS 2-VD	Flux cored wire:	EAS 2-FD
GTAW rod:	EAS 2-IG		EAS 2 PW-FD
GMAW solid wire:	EAS 2-IG (Si)	SAW combination:	EAS 2-UP/BB 202

EN 1600:1997: E 19 9 L R 1 5
AWS A5.4-92: E 308L-17

BÖHLER FOX EAS 2-VD

SMAW stick electrode, high-alloyed, chemical resistant

Description

Core wire alloyed rutile-basic coated stainless steel electrode especially designed for vertical-down welding in the sheet metal fabrication.
Highly economical due to fast travel speeds. 50 % time saving is achieved compared to welding in vertical up position with same electrode diameter. The extremely low heat helps to reduce distortion and associated straightening work.
The product is resistant to intergranular corrosion up to service temperatures of +350 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.02**	**0.7**	**0.7**	**19.5**	**10.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**470**	(≥ 350)
tensile strength R_m N/mm^2:		**600**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**36**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 47)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX EAS 2-VD 308L-17 E 19 9 L R

ø mm	**L mm**	**amps A**
2.5	300	75 - 85
3.2	300	105 - 115

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Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10

AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	Metal cored wire:	EAS 2-MC
	FOX EAS 2-A	Flux cored wire:	EAS 2-FD
GTAW rod:	EAS 2-IG		EAS 2 PW-FD
GMAW solid wire:	EAS 2-IG (Si)	SAW combination:	EAS 2-UP/BB 202

EN 1600:1997: E 19 9 Nb B 2 2
AWS A5.4-92: E 347-15

BÖHLER FOX SAS 2

SMAW stick electrode, high-alloyed, chemical resistant

Description

Stabilised core wire alloyed stainless steel electrode with basic coating mainly for Ti and Nb stabilised 1.4541 / 321 / 347 CrNi-steel grades. Designed to produce first class weld deposits with reliable CVN toughness values down to -196 °C. 100 % X-ray safety together with very good root pass and positional welding characteristics, good gap bridging ability, easy weld pool and slag control as well as easy slag removal even in narrow preparations resulting in clean bead surfaces and minimum post weld cleaning. An excellent electrode for welding on site and for heavy and rigid components. The product is resistant to intergranular corrosion up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.03**	**0.4**	**1.3**	**19.8**	**10.5**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**470**	(≥ 390)
tensile strength R_m N/mm^2:		**640**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**36**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 80)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
–
electrode identification:
FOX SAS 2 347-15 E 19 9 Nb B

ø mm	**L mm**	**amps A**
2.5	300	50 - 80
3.2	350	80 - 110
4.0	350	110 - 140

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Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11,
1.4301 X5CrNi18-10,
1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (1282.), DB (30.014.04), ÜZ (30.014), ÖBB, TÜV-A (73), ABS (Cr18/21, Ni8/11, TaNb.1.1), GL (4550), UDT, LTSS, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SAS 2-A	GMAW solid wire:	SAS 2-IG (Si)
GTAW rod:	SAS 2-IG	Flux cored wire:	SAS 2-FD
			SAS 2-PW-FD
		SAW combination:	SAS 2-UP/BB 202

EN 1600:1997: E 19 9 Nb R 3 2
AWS A5.4-92: E 347-17

BÖHLER FOX SAS 2-A

SMAW stick electrode, high-alloyed, chemical resistant

Description

Stabilised rutile coated stainless steel electrode. Preferably used for Ti or Nb stabilised 1.4541 / 1.4550 / 321 / 347 CrNi-steel grades.
BÖHLER FOX SAS 2-A is noted for its superior welding characteristics and metallurgy. It can be used on AC or DC. Other advantages include high current carrying capacity, minimum spatter formation, self releasing slag, smooth and clean weld profile, safety against formation of porosity due to moisture resistant coating and packaging into hermetically sealed tins. The fully alloyed core wire ensures the most reliable corrosion resistance.
Resistant to intergranular corrosion up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.03**	**0.8**	**0.8**	**19.5**	**10.0**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**470**	(≥ 390)
tensile strength R_m N/mm^2:		**620**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 55)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX SAS 2-A 347-17 E 19 9 Nb R

ø mm	**L mm**	**amps A**
2.0	300	40 - 60
2.5	250/350	50 - 90
3.2	350	80 - 120
4.0	350	110 - 160
5.0	450	140 - 200

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Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11,
1.4301 X5CrNi18-10,
1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (1105.), DB (30.014.06), ÜZ (30.014), ÖBB, TÜV-A (131), ABS (347-17), CL (0343), GL (4550), UDT, LTSS, VUZ, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SAS 2	GMAW solid wire:	SAS 2-IG (Si)
GTAW rod:	SAS 2-IG	Flux cored wire:	SAS 2-FD
SAW combination:	SAS 2-UP/BB 202		SAS 2 PW-FD

EN 1600:1997: E 19 12 3 L B 2 2
AWS A5.4-92: E 316L-15

BÖHLER FOX EAS 4 M

SMAW stick electrode, high-alloyed, chemical resistant

Description

Basic coated core wire alloyed stainless steel electrode. Preferably used for 1.4435 / 316L steel grades.
BÖHLER FOX EAS 4 M is designed to produce high quality weld deposits with reliable toughness values down to – 196 °C. 100 % X-ray safety together with very good root pass and positional welding characteristics. Good gap bridging ability, easy weld pool and slag control. Easy slag removal even in narrow preparations result in clean bead surfaces with minimum post weld cleaning. Ideal electrode for welding on site. Electrodes are packed in hermetically sealed tins and have a moisture resistant coating. Resistant to intergranular corrosion up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.4**	**1.2**	**18.8**	**11.5**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**460**	(≥ 350)
tensile strength R_m N/mm^2:		**600**	(≥ 540)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**90**	(≥ 80)
	- 120 °C:		(≥ 32)
	- 196 °C:		(≥ 27)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary: –	2.5	300	50 - 80
electrode identification:	3.2	350	80 - 110
FOX EAS 4 M 316L-15 E 19 12 3 L B	4.0	350	110 - 140

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Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

S31653; AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (0772.), ÖBB, TÜV-A (99), CL (0786), DNV (316), Statoil, UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M-A	GMAW solid wire:	EAS 4 M-IG (Si)
	FOX EAS 4 M-VD	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-TS	Flux cored wire:	EAS 4 M-FD
GTAW rod:	EAS 4 M-IG		EAS 4 PW-FD
		SAW combination:	EAS 4 M-UP/BB 202

EN 1600:1997: E 19 12 3 L R 3 2
AWS A5.4-92: E 316L-17

BÖHLER FOX EAS 4 M-A

SMAW stick electrode, high-alloyed, chemical resistant

Description

Rutile coated core wire alloyed stainless steel electrode. Preferably used for 1.4435 / 316L steel grades. BÖHLER FOX EAS 4 M-A is an acknowledged world leader, noted for its superior welding characteristics and metallurgy. It can be used on AC or DC. Other advantages include high current capacity, minimum spatter formation, self releasing slag, smooth and clean weld profile, safety against formation of porosity due to moisture resistant coating and packaging into hermetically sealed tins.
The fully alloyed core wire ensures the most reliable corrosion resistance. Resistant to intergranular corrosion up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.8**	**0.8**	**18.8**	**11.7**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 350)
tensile strength R_m N/mm²:		**600**	(≥ 540)
elongation A (L_0=5d_0) %:		**36**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 47)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX EAS 4 M-A 316L-17 E 19 12 3 L R

ø mm	**L mm**	**amps A**
1.5	250	25 - 40
2.0	300	40 - 60
2.5	250/350	50 - 90
3.2	350	80 - 120
4.0	350/450	110 - 160
5.0	450	140 - 200

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Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

S31653, AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (0773.), DB (30.014.14), ÜZ (30.014), ÖBB, TÜV-A (33), ABS (E 316L-17), CL (0094), DNV (316L), GL (4571), LR (316Lm), Statoil, UDT, VUZ, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	GMAW solid wire:	EAS 4 M-IG (Si)
	FOX EAS 4 M-VD	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-TS	Flux cored wire:	EAS 4 M-FD
GTAW rod:	EAS 4 M-IG		EAS 4 PW-FD
		SAW combination:	EAS 4 M-UP/BB 202

EN 1600:1997:	E 19 12 3 L R 1 5
AWS A5.4-92:	E 316L-17

BÖHLER FOX EAS 4 M-VD

SMAW stick electrode, high-alloyed, chemical resistant

Description

Rutile-basic coated stainless steel electrode. Especially designed with a fast freezing slag for vertical-down welding in sheet metal fabrication.
Highly economical, yielding fast travel speed resulting in low heat input and little distortion respectively associated straightening work. When using same electrode diameter and same wall thickness you can save 50% of welding time compared to vertical up position. No overheating of the base metal and therefore no risk of impaired corrosion resistance compared with the vertical-up welding mode. The product is ideally suited to save time and costs in the sheet metal fabrication.
Resistant to intergranular corrosion up to service temperatures of +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.7**	**0.7**	**19.0**	**12.0**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**470**	(≥ 350)
tensile strength R_m N/mm²:		**600**	(≥ 540)
elongation A (L_0=5d_0) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 47)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX EAS 4 M-VD 316L-17 E19 12 3 LR

ø mm	**L mm**	**amps A**
2.5	300	75 - 85
3.2	300	105 - 115

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Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

S31653, AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (9089.), CL (1299), DNV (316L), GL (4550), UDT, LTSS, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M
	FOX EAS 4 M-A
	FOX EAS 4 M-TS
GTAW rod:	EAS 4 M-IG
GMAW solid wire:	EAS 4 M-IG (Si)
Metal cored wire:	EAS 4 M-MC
Flux cored wire:	EAS 4 M-FD
	EAS 4 PW-FD
SAW combination:	EAS 4 M-UP/BB 202

EN 1600:1997: E 19 12 3 L R 1 2
AWS A5.4-92: E 316L-16 (mod.)

BÖHLER FOX EAS 4 M-TS

SMAW stick electrode, high-alloyed, chemical resistant

Description

Special type low carbon rutile-basic coated stainless steel electrode particulary designed for site welding of tin walled tubes and sheets. The very stable arc produces an excellent root penetration, bead configuration and gap bridging ability on DC electrode negative even when welding with a low amperage. BÖHLER FOX EAS 4 M-TS is a good economical alternative to GTAW welding on difficult accessible on-site welding applications.
High safety against formation of porosity by moisture resistant coating and packaging into hermetically sealed tin.
The product is resistant to intergranular corrosion up to service temperatures of +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.8**	**0.7**	**19.0**	**11.5**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**510**	(≥ 350)
tensile strength R_m N/mm²:		**630**	(≥ 540)
elongation A (L_0=5d_0) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 47)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX EAS 4 M-TS E 19 12 3 LR

ø mm	L mm	amps A
2.0	300	35 - 60
2.5	350	45 - 70
3.2	350	50 - 110

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DC minus for root pass

Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

S31653, AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (5625.), TÜV-A (615), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	GMAW solid wire:	EAS 4 M-IG (Si)
	FOX EAS 4 M-A	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-VD	Flux cored wire:	EAS 4 M-FD
GTAW rod:	EAS 4 M-IG		EAS 4 PW-FD
		SAW combination:	EAS 4 M-UP/BB 202

EN 1600:1997: E 19 12 3 Nb B 2 2
AWS A5.4-92: E 318-15

BÖHLER FOX SAS 4

SMAW stick electrode, high-alloyed, chemical resistant

Description

Stabilised core wire alloyed stainless steel electrode with basic coating mainly for Ti and Nb stabilised 1.4571 / 1.4580 / 316Ti steel grades.
BÖHLER FOX SAS 4 is designed to produce first class weld deposits with reliable CVN toughness values down to -90°C, 100% X-ray safety together with very good root pass and positional welding characteristics, good gap bridging ability, easy weld pool and slag control as well as easy slag removal even in narrow preparations resulting in clean bead surfaces and minimum post weld cleaning. An excellent electrode for welding on site and for heavy and rigid components.
The product is resistant to intergranular corrosion up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Nb
wt-%	**0.03**	**0.4**	**1.3**	**18.8**	**11.5**	**2.7**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**490**	(≥ 390)
tensile strength R_m N/mm²:		**660**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**31**	(≥ 28)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 100)
	- 90 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
–	2.5	300	50 - 80
electrode identification:	3.2	350	80 - 110
FOX SAS 4 318-15 E 19 12 3 Nb B	4.0	350	110 - 140

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Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4401 X5CrNiMo17-12-2, 1.4581 GX5CrNiMoNb19-11-2, 1.4437 GX6CrNiMo18-12, 1.4583 X10CrNiMoNb18-12, 1.4436 X3CrNiMo17-13-3

AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (0774.), DB (30.014.05), ÜZ (30.014), ÖBB, TÜV-A (132), ABS (Cr17/20, Ni10/13), GL (4571), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4-A
GTAW rod:	SAS 4-IG
GMAW solid wire:	SAS 4-IG (Si)
Flux cored wire:	SAS 4-FD
	SAS 4 PW-FD
SAW combination:	SAS 4-UP/BB 202

EN 1600:1997: E 19 12 3 Nb R 3 2
AWS A5.4-92: E 318-17

BÖHLER FOX SAS 4-A

SMAW stick electrode, high-alloyed, chemical resistant

Description

Stabilised rutile coated stainless steel electrode. Preferably used for Ti or Nb stabilised 1.4571 / 1.4580 / 316Ti CrNiMo steel grades.
BÖHLER FOX SAS 4-A is noted for its superior welding characteristics and metallurgy. It can be used on AC or DC. Other characteristics include high current carrying capacity, minimum spatter formation, self releasing slag, smooth and clean weld profile, safety against formation of porosity due to moisture resistant coating and packaging into hermetically sealed tins. The fully alloyed core wire ensures the most reliable corrosion resistance.
Resistant to intergranular corrosion up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Nb
wt-%	**0.03**	**0.8**	**0.8**	**19.0**	**11.5**	**2.7**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**490**	(≥ 390)
tensile strength R_m N/mm²:		**640**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 47)
	- 90 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX SAS 4-A 318-17 E 19 12 3 Nb R

ø mm	**L mm**	**amps A**
2.0	300	40 - 60
2.5	250/350	50 - 90
3.2	350	80 - 120
4.0	350	110 - 160
5.0	450	140 - 200

Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4401 X5CrNiMo17-12-2, 1.4581 GX5CrNiMoNb19-11-2, 1.4437 GX6CrNiMo18-12, 1.4583 X10CrNiMoNb18-12, 1.4436 X3CrNiMo17-13-3

AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (0777.), DB (30.014.07), ÜZ (30.014), ÖBB, TÜV-A (133), CL (0951), UDT, LTSS, VUZ, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4	GMAW solid wire:	SAS 4-IG (Si)
GTAW rod:	SAS 4-IG	Flux cored wire:	SAS 4-FD
			SAS 4 PW-FD
		SAW combination:	SAS 4-UP/BB 202

EN 1600:1997:	E Z 19 14 Si B 2 2
ISO 3581:	E 17.12 SiB

BÖHLER FOX EAS 2 Si

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Special basic coated core wire alloyed electrode for joint welding of the special steel X2CrNiSi1815, 1.4361 (BÖHLER A 610), which resists the attack of highly concentrated nitric acid as well as of nitric acid which additionally contains strong deoxidants. Also recommended for weld cladding of analogous type steels. Suitable for use at service temperatures up to +350 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**< 0.025**	**4.5**	**1.2**	**19.0**	**14.8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**500**	(≥ 390)
tensile strength R_m N/mm²:		**720**	(≥ 660)
elongation A (L_0=5d_0) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 47)
	- 50 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
300-350 °C, min. 2 h
electrode identification:
FOX EAS 2 Si E Z 19 14 Si B

ø mm	**L mm**	**amps A**
2.5	300	40 - 70
3.2	350	70 - 100

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Electrodes have to be welded with short arc. Amperage has to be adapted to wall thickness respectively welding position, to avoid overheated weld metal. For welding position PA/1G, 1F stringer beads are recommended.
Heat input should be restricted to a necessary minimum, additional cooling is recommend to improve corrosion results. Reduce heat input in position PF/3G to avoid negative influence of corrosion behaviour of root pass and heat affected zone, with limitation of weaving width of max. 2 x core wire diameter. Interpass temperature should not exceed 150°C. Grind out the end craters and grind previous passes. The TIG process, using EASN 2 Si-IG should be given preference for root welding. The weld metal does not require postweld heat treatment. In exceptional cases quench from + 1100 °C in water.

Base Materials

1.4361 X1CrNiSi18-15-4, UNS S30600

Approvals and Certificates

TÜV-D (1482.), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

GTAW rod: EASN 2 Si-IG

AWS A5.4-92: E317L-17

BÖHLER FOX E317 L

SMAW stick electrode
high-alloyed, high corrosion resistant

Description

Rutile coated core wire alloyed electrode suited for corrosion resistant, CrNiMo(N)-steels. It satisfies the high demands of offshore fabricators, shipyards building chemical tankers as well as the chemical / petrochemical, pulp and paper industries. Suitable for service temperatures from -60 to +300 °C. The weld metal exhibits resistance against pitting corrosion and intergranular corrosion resistance up to 300 °C (ASTM A 262 / Practice E)
Good operating characteristics on AC and DC, minimum spatter formation, self releasing slag with smooth and clean bead surface. BÖHLER FOX E 317 L is recommended for wall thicknesses up to 30 mm. Preheating and post weld heat treatment is not required by the weld deposit. The interpass temperature should be kept below 150 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	FN
wt-%	**0.03**	**0.8**	**0.8**	**19.0**	**13.0**	**3.6**	**+**	**4-12**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm^2:		**460**	(≥ 400)
tensile strength R_m N/mm^2:		**610**	(≥ 580)
elongation A (L_0=5d_0) %:		**35**	(≥ 30)
impact work ISO-V KV J	+20 °C:	**65**	(≥ 47)
	-20 °C:	**55**	
	-60 °C:	**47**	(≥ 32)

(*) u untreated, as-welded

Operating Data

re-drying if necessary:	**ø mm**	**L mm**	**amps A**
120-200°C, min. 2 h	2.5	300/350	55-85
electrode identification:	3.2	350	80-115
FOX E317 L 317L-17	4.0	350	110-155

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Base Materials

CrNiMo(N)-steels with increased Mo-content like grade AISI 316LN/317LN or corrosion resistant claddings on mild steels
1.4438 X2CrNiMo18-15-4, 1.4429 X2CrNiMoN17-13-3, 1.4434 X2CrNiMoN 18-12-4
AISI 316 LN, 317 L, 317LN

Approvals and Certificates

BV (317L)

Same Alloy/Similar Alloy Filler Metals

GMAW flux cored wire: E317L-FD
E 317L PW-FD
SAW combination: ASN 5 SY-UP/BB 202

EN 1600:1997:	E 18 16 5 N L B 2 2
AWS A5.4-92:	E 317LN-15 (mod.)

BÖHLER FOX ASN 5

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Basic (with rutile contents) coated core wire alloyed electrode for corrosion resistant CrNi steels with increased Mo-contents like 1.4439 / 317L. Suited for difficult corrosion conditions encountered e.g. in the chemical industry, flue gas de-sulphurisation plants, sea water desalinisation plants and particularly in the paper, pulp and textile industries. It is characterised by an increased Mo content (4.5 %) to compensate for segregation in high molybdenum alloyed weld metals to meet equivalent corrosion properties as the relevant base metals with 3-4 % Mo guarantee. The weld metal features excellent chemical resistance to stress corrosion cracking as well as high pitting resistance. Intergranular corrosion resistance at operating temperatures up to +300 °C. Excellent cryogenic toughness down to -269 °C. The electrode provides easy slag removal with smooth and clean bead surfaces as well as good positional weldability.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N	FN
wt-%	**≤ 0.04**	**0.5**	**2.5**	**18.5**	**17.0**	**4.3**	**0.15**	**36.3**	**≤ 0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 400)
tensile strength R_m N/mm²:		**660**	(≥ 590)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 90)
	- 269 °C:	**42**	(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:	**ø mm**	**L mm**	**amps A**
250 - 300 °C, min. 2 h	2.5	300	50 - 80
electrode identification:	3.2	350	80 - 110
FOX ASN 5 E 18 16 5 N L B	4.0	350	110 - 140

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Interpass temperature should not exceed + 150 °C. Maximum width of weaving should be limited to twice the core wire diameter of the electrode. The arc should be kept short.
Root pass welding is preferably carried out by the GTAW process, using ASN 5-IG welding wire.

Base Materials

1.4436 X3CrNiMo17-13-3, 1.4439 X2CrNiMoN17-13-5, 1.4429 X2CrNiMoN17-13-3, 1.4438 X2CrNiMo18-15-4, 1.4583 X10CrNiMoNb18-12

AISI 316Cb, 316LN, 317LN, 317L, UNS S31726

Approvals and Certificates

TÜV-D (00016.), TÜV-A (496), DNV (317), GL (4439), UDT, SEPROZ

Same Alloy / Similar Alloy Filler Metals

SMAW stick electrode:	FOX ASN 5-A	Flux cored wire:	E317L-FD*
GTAW rod:	ASN 5-IG		E317L PW-FD*
GMAW solid wire:	ASN 5-IG (Si)	SAW combination:	ASN 5-UP/BB 203

* for similar alloyed base metals only, not fully austenitic.

EN 1600:1997: E 18 16 5 N L R 3 2
AWS A5.4-92: E 317LN-17 (mod.)

BÖHLER FOX ASN 5-A

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Rutile coated core wire alloyed electrode suited for corrosion resistant, CrNi-steels with increased Mo content like 1.4439 / 317L. Field of application includes chemical industry, flue gas desulphurisation plants, sea water desalinisation, pulp and paper industry as well as textile and cellulose. The weld deposit exhibits excellent resistant to stress corrosion cracking, resistance against pitting corrosion. Intergranular corrosion resistance up to +300 °C service temperature.
It is characterised by an increased Mo content (4.5 %) to compensate for segregation in high molybdenum alloyed weld metals to meet equivalent corrosion properties as the relevant base metals with 3-4 % Mo guarantee. Good operating characteristics on AC and DC, minimum spatter formation, self releasing slag with smooth and clean bead surface.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N	FN
wt-%	**≤ 0.035**	**0.7**	**1.1**	**18.0**	**16.0**	**4.5**	**0.13**	**36.0**	**≤ 0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 400)
tensile strength R_m N/mm²:		**660**	(≥ 590)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 55)
	- 120 °C:	**47**	(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:	ø mm	L mm	amps A
250 - 300 °C, min. 2 h	2.5	300	65 - 85
electrode identification:	3.2	350	90 - 120
FOX ASN 5-A E 18 16 5 N L R	4.0	350	110 - 150

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Maximum width of weaving should be limited to twice the core wire diameter. BÖHLER FOX ASN 5-A is recommended for wall thicknesses up to 15 mm.
Preheating and post weld heat treatment is not required by the weld deposit. The interpass temperature should be kept below +150 °C. Solution annealing temperature +1080 - 1130 °C, quenching in water.

Base Materials

1.4436 X3CrNiMo17-13-3, 1.4439 X2CrNiMoN17-13-5, 1.4429 X2CrNiMoN17-13-3, 1.4438 X2CrNiMo18-15-4, 1.4583 X10CrNiMoNb18-12

AISI 316Cb, 316LN, 317LN, 317L, UNS S31726

Approvals and Certificates

TÜV-D (07118.), UDT

Same Alloy / Similar Alloy Filler Metals

SMAW stick electrode:	FOX ASN 5	Flux cored wire:	E317L-FD*
GTAW rod:	ASN 5-IG		E317L PW-FD*
GMAW solid wire:	ASN 5-IG (Si)	SAW combination:	ASN 5-UP/BB 203

* for similar alloyed base metals only, not fully austenitic.

EN 1600:1997: E Z 22 18 4 L B 2 2

BÖHLER FOX AM 400

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Basic coated core wire alloyed electrode for corrosion resistant non-magnetisable CrNiMo steels, preferably used for the steels W.no. 1.3952 and 1.3964 in the special shipbuilding sector. Good weldability in all positions except vertical-down. Fully austenitic weld metal, non-magnetic, excellent resistance to pitting, crevice corrosion and stress corrosion cracking, excellent subzero toughness, suited for service temperatures up to +350 °C (or up to +400 °C in media that do not induce intergranular corrosion). Further applications are sea water desalinisation plants, centrifuges, bleaching plants and the welding of cryogenic steels.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	**≤ 0.04**	**0.8**	**7.5**	**21.8**	**18.3**	**3.7**	**0.2**	**37.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**470**	(≥ 430)
tensile strength R_m N/mm²:		**700**	(≥ 640)
elongation A (L_0 = $5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**80**	(≥ 70)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX AM 400 E Z 22 18 4 L B

ø mm	**L mm**	**amps A**
2.5	250	50 - 80
3.2	350	80 - 110
4.0	350	110 - 140

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Preheating is not required and the interpass temperatures must not exceed +150 °C.

Base Materials

1.3948 X4CrNiMnMoN19-13-8, 1.3951 X2CrNiMoN22-15, 1.3952 X2CrNiMoN18-14-3, 1.3964 X2CrNiMnMoNNb21-16-5-3, 1.4439 X2CrNiMoN17-13-5

Approvals and Certificates

WIWEB, GL (3954), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

GTAW rod: AM 400-IG
GMAW solid wire: AM 400-IG

EN 1600: EZ 25 22 2 NL B 2 2

BÖHLER
FOX EASN 25 M

SMAW stick electrode
high-alloyed, chemical resistant

Description

BÖHLER FOX EASN 25 M is a core wire-alloyed basic coated Cr-Ni-Mo electrode. Characterised by a low C-content, a limited Mo-content (for better Huey-test-resistance), a well-defined N-alloying as well as a high Ni-content to assure a fully austenitic structure (ferrite contents < 0.5 %). The corrosion rates in the Huey-test are 0.08 g/m²^2.h (4 mils/year). The stick electrode is suited for urea plant components exposed to extremely severe corrosion at high pressures and temperatures. The weld deposit will exhibit superior resistance to boiling concentrated nitric acid (optimum condition: 60-80 % HNO3) when made to join components of the highest Huey test quality. It is also recommendable for weldments wetted by strong chloride solutions at high temperatures. The chromium and molybdenum percentages create good resistance to pitting from solutions containing chlorine ions. Further applications involve severe corrosive service in such industries as dyeing (leaching and dyeing baths), textiles, paper, leather, chemicals, pharmaceuticals, and rayon. During welding an interpass temperature of 150 °C and a weaving above two times core wire diameter should be avoided. The arc should be kept short. Grind out root pass end craters and use intermediate current settings.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N
wt-%	**≤0.035**	**0.4**	**5.5**	**25**	**22**	**2.2**	**0.14**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**405**	(> 380)
tensile strength R_m N/mm^2:		**615**	(580-690)
elongation A (L_0=5d_0) %:		**35**	(> 30)
impact work ISO-V KV J	+20 °C:	**110**	(> 90)
	-196 °C:		(> 50)

(*) u untreated, as-welded

Operating Data

re-drying:	**ø mm**	**L mm**	**amps A**
250-300°C, min. 2 h	2.5	300	55-75
electrode identification:	3.2	350	80-105
FOX EASN 25 M EZ 25 22 2 NL B	4.2	350	90-135

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Base Materials

X2CrNiMoN25-22-2 (1.4466) and in combination with X1CrNiMoN25-25-2 (1.4465), X2CrNiMo18-14-3 (1.4435)

Approvals and Certificates

TÜV-D, TUV-A, UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod: EASN 25M-IG

EN 1600:1997: E 20 25 5 Cu N L B 2 2
AWS A5.4-92: E 385-15 (mod.)

BÖHLER FOX CN 20/25 M

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Basic (with rutile contents) coated core wire alloyed electrode for corrosion resisting high-molybdenum CrNi steels like 1.4539 / N08904. Recommended for highly corrosive environments encountered e.g. in the chemical industry, in flue gas desulphurisation and sea water desalinisation plants, as well as in cooling and power plants using brackish or sea water. Particularly recommended for steels containing up to 5% molybdenum. The above average molybdenum content (6.5 %) is characteristic to BÖHLER FOX CN 20/25 M, thus compensating for segregation in high molybdenum alloyed weld metals.
The fully austenitic weld metal possess a marked resistance towards pitting and crevice corrosion in chloride containing media. Highly resistant against Sulphur-, Phosphorus-, Acetic- and Formic acid, as well as sea and brackish water. Caused from the low C-content of the weld metal, the risk of intergranular corrosion can be avoided. The high Ni-content in comparison to standard CrNi-weld metals leads to high resistance against stress corrosion cracking.
It is advisable to grind out the end craters of root passes. For root pass welding it is expedient to apply the GTAW process using BÖHLER CN 20/25 M-IG.

Typical Composition of All-weld Metal

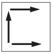
	C	Si	Mn	Cr	Ni	Mo	Cu	N	PRE_N
wt-%	≤ **0.04**	**0.4**	**4.0**	**20.0**	**25.0**	**6.5**	**1.4**	**0.14**	**≥ 45**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 350)
tensile strength R_m N/mm²:		**650**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 47)
	- 269 °C:	**42**	(≥ 32)

(*) *u untreated, as-welded*

Operating Data



re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX CN 20/25 M E 20 25 5 Cu N L B

ø mm	**L mm**	**amps A**
2.5	300	60 - 80
3.2	350	80 - 100
4.0	350	100 - 130

=+

Weaving width max. 2x core wire diameter. Arc should be kept short. End crater grinding is highly recommended. The electrode can be used in all position except vertical down. Preheating and post weld heat treatment are not required for the weld metal. The interpass temperature should not exceed +150°C.

Base Materials

same-alloyed high-Mo Cr-Ni-steels. 1.4539 X1NiCrMoCu25-20-5, 1.4439 X2CrNiMoN17-13-5, 1.4537 X1CrNiMoCuN25-25-5. UNS N08904, S31726

Approvals and Certificates

TÜV-D (4882.), TÜV-A (80), Statoil, UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode: FOX CN 20/25 M-A
GTAW rod: CN 20/25 M-IG
GMAW solid wire: CN 20/25 M-IG (Si)

EN 1600:1997: E 20 25 5 Cu N L R 3 2
AWS A5.4-92: E 385-17 (mod.)

BÖHLER FOX CN 20/25 M-A

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Rutile-basic coated core wire alloyed electrode with extremely high Mo-content. Very high pitting resistant equivalent ($PRE_N \geq 45$) – pitting potential (%Cr + 3.3 x %Mo + 30 x %N). Particularly recommended for steels containing up to 5 % molybdenum. The above average molybdenum content (6.2 %) is characteristic to BÖHLER FOX CN 20/25 M-A, thus compensating for segregation in high molybdenum alloyed weld metals. Special applicable in Sulphur- and Phosphorus production, pulp and paper industry, flue gas desulphurisation plants, further on for fertilizer production, petrochemical industry, fatty-, acetic- and formic acid production, sea water sludge fittings and pickling plants which are proceeded with sea or brackish water. The fully austenitic weld metal possess a marked resistance towards pitting and crevice corrosion in chloride containing media. Highly resistant against sulphur-, phosphorus-, acetic- and formic acid, as well as sea and brackish water. Caused from the low C-content of the weld metal, the risk of intergranular corrosion can be avoided. The high Ni-content in comparison to standard CrNi-weld metals leads to high resistance against stress corrosion cracking.
BÖHLER FOX CN 20/25 M-A possess excellent operating characteristic in all positions, except vertical down and easy handling. The weld metal shows good slag detachability as well as smooth, fine rippled beads with no residuals. This electrode should be preferably used up to wall thicknesses of 14 mm. It is designed for excellent operating characteristics on DC and AC. It is advisable to grind out the end craters of root passes.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Cu	N	PRE_N
wt-%	**0.03**	**0.7**	**2.0**	**20.5**	**25.0**	**6.2**	**1.6**	**0.17**	≥ **45**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**410**	(≥ 350)
tensile strength R_m N/mm²:		**640**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**34**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 47)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250-300 °C, min. 2 h
electrode identification:
FOX CN 20/25 M-A E 20 25 5 Cu N L R

ø mm	L mm	amps A
2.5	300	50 - 80
3.2	350	80 - 110
4.0	350	100 - 135

=+ ~

Base Materials

same-alloyed high-Mo Cr-Ni-steels
1.4539 X1NiCrMoCu25-20-5, 1.4439 X2CrNiMoN17-13-5, 1.4537 X1CrNiMoCuN25-25-5
UNS N08904, S31726

Approvals and Certificates

TÜV-D (6634.), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode: FOX CN 20/25 M
GTAW rod: CN 20/25 M-IG
GMAW solid wire: CN 20/25 M-IG (Si)

EN 1600:1997: E 22 9 3 N L B 2 2
AWS A5.4-92: E 2209-15

BÖHLER FOX CN 22/9 N-B

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Basic coated core wire alloyed electrode for welding of ferritic-austenitic duplex materials, e.g. 1.4462, UNS S31803.
Besides the high tensile strength, the special advantage of the weld metal of this electrode is its very good toughness behaviour down to -60 °C. Furthermore the high crack resistance of the weld metal and the particularly good resistance to stress corrosion cracking and pitting behaviour are significant features. FOX CN 22/9 N-B is specially designed for the joining of thick-walled sections (e.g. > 20 mm) and rigid constructions as well as for applications where extra low service temperature requirements exist.
The Pitting Resistance Equivalent (PRE_N) shows values of ≥ 35 in accordance with the formula (%Cr + 3.3 % Mo + 16 % N). The pitting resistance according to ASTM G48 / method A shows good results.
The electrode provides user friendly operating characteristics in all positions except vertical down with good slag removability and weld bead appearance. Additionally the filler metals offer high safety against the formation of porosity.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	**0.03**	**0.3**	**1.1**	**23.0**	**8.8**	**3.2**	**0.16**	**≥ 35**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**630**	(≥ 540)
tensile strength R_m N/mm²:		**830**	(≥ 690)
elongation A (L_0=5d_0) %:		**27**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**105**	(≥ 47)
	- 20 °C:	**80**	
	- 40 °C:	**65**	(≥ 32)
	- 60 °C:	**40**	

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary: **250 - 300 °C, min. 2 h**	2.5	350	50 - 75
electrode identification:	3.2	350	80 - 110
FOX CN 22/9 N-B 2209-15 E 22 9 3 N L B	4.0	350	100 - 145
	5.0	450	140 - 180

=+

For welding of root runs either GTAW with CN 22/9 N-IG or SMAW with FOX CN 22/9 N is applicable.

Base Materials

same-alloyed duplex steels, as well as similar-alloyed, ferritic-austenitic steels with higher tensile strength
1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4, 1.4462 X2CrNiMoN22-5-3 together with
1.4583 X10CrNiMoNb18-12, 1.4462 X2CrNiMoN22-5-3 mit P235GH / P265GH, S255N, P295GH, S355N, 16Mo3 UNS S31803, S32205

Approvals and Certificates

TÜV-D (7084.), CL (1475), UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N	Flux cored wire:	CN 22/9 N-FD
GTAW rod:	CN 22/9 N-IG		CN 22/9 PW-FD
GMAW solid wire:	CN 22/9 N-IG	SAW combination:	CN 22/9 N-UP/BB 202

EN 1600:1997: E 22 9 3 N L R 3 2
AWS A5.4-92: E 2209-17

BÖHLER FOX CN 22/9 N

SMAW stick electrode, high-alloyed, high corrosion resistant

Description

Rutile coated electrode designed for ferritic-austenitic duplex steels, e.g. 1. 4462, UNS 31803. Field of applications are in off-shore engineering and in the chemical industry. Besides offering high mechanical strength and toughness, the weld metal is also noted for excellent resistance to stress corrosion cracking and pitting resistance. BÖHLER FOX CN 22/9 N offers excellent positional weldability, and thus is perfectly suited for pipe welding. Besides the good wetting characteristics, slag removability, resistance to porosity and reliable CVN toughness down to -20 °C it is designed with a fully alloyed core wire providing best corrosion resistance and a very homogeneous micro structure with specified ferrite contents of 30 – 60 FN (WRC) and a Pitting Resistance Equivalent (PRE_N) of > 35. For wall thicknesses above 20 mm or impact requirements down to -60 °C we recommend our basic coated electrode BÖHLER FOX CN 22/9 N-B.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	**0.03**	**0.9**	**0.8**	**23.0**	**9.0**	**3.2**	**0.17**	**≥ 35**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**650**	(≥ 540)
tensile strength R_m N/mm²:		**820**	(≥ 690)
elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 22)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 47)
	- 10 °C:	**50**	
	- 20 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX CN 22/9 N 2209-17 E 22 9 3 N L R

ø mm	L mm	amps A
2.5	350	40 - 75
3.2	350	70 - 120
4.0	350	110 - 160
5.0	450	150 - 200

Preheating and interpass temperature max. +150 °C. In case of solution annealing is carried out max. +250 °C. Heat input in according to wall thickness.

Base Materials

same-alloyed duplex steels, as well as similar-alloyed, ferritic-austenitic steels with higher tensile strength

1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4,
1.4462 X2CrNiMoN22-5-3 mit 1.4583 X10CrNiMoNb18-12, 1.4462 X2CrNiMoN22-5-3 together with P235GH / P265GH, S255N, P295GH, S355N, 16Mo3

UNS S31803, S32205

Approvals and Certificates

TÜV-D (3636.), TÜV-A (260), ABS (E 22 09-17), CL (0797), DNV (Duplex), GL (4462), LR (X), RINA (2209), Statoil, UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N-B	Flux cored wire:	CN 22/9 N-FD
GTAW rod:	CN 22/9 N-IG		CN 22/9 PW-FD
GMAW solid wire:	CN 22/9 N-IG	SAW combination:	CN 22/9 N-UP/BB 202

EN 1600:1997: E 25 9 4 N L B 2 2
AWS A5.9-93: E2553-15(mod)

BÖHLER FOX CN 25/9 CuT

SMAW stick electrode
high alloyed, highly corrosion resistant

Description

Basic coated electrode, for welding of ferritic-austenitic superduplex steels. By virtue of specific alloy composition the deposit has, in addition to high tensile strength and toughness, also excellent resistance to stress corrosion cracking and pitting corrosion. The operating temperature range is -50 °C up to +250 °C. Well suited for the conditions in the offshore field.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	Cu	T	PRE_N
wt-%	**0.03**	**0.5**	**1.1**	**25.0**	**9.3**	**3.7**	**0.22**	**0.7**	**0.6**	**≥40**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**650**	(≥ 600)
tensile strength R_m N/mm²:		**850**	(≥ 750)
elongation A (L_0=5d_0) %:		**25**	(≥ 22)
impact work ISO-V KV J	+20 °C:	**75**	(≥ 70)
	-50 °C:	**50**	(≥ 34)

(*) *u untreated, as welded*

Operating Data

re-drying:	**ø mm**	**L mm**	**amps A**
250-300°C, min. 2 h	2.5	300/350	55-80
electrode identification:	3.2	350	80-105
FOX CN 25/9 Cu T E 25 9 4 N L B	4.0	350	90-140

=+

Welding of root pass with „thick layer“. Next two passes with thin layers and low heat input to avoid overheating and precipitations

Base Materials

25% Cr-Superduplex steels e.g.
1.4501 X2CrNiMoCuWN 25-7-4
UNS S 32750, UNS S32760,
ZERON 100, SAF 25/07, FALC 100

Approvals and Certificates

CL (applied)

Same Alloy Filler Metals

GTAW rod: CN 25/9 CuT-IG
GMAW solid wire: CN 25/9 CuT-IG

Notes

Notes

EN 12072:1999: W 13 4
AWS A5.9-93: ER410 NiMo (mod.)
W.Nr.: 1.4351 (mod.)

BÖHLER CN 13/4-IG

GTAW rod, high-alloyed, stainless

Description

GTAW rod of low-carbon type 13 % Cr 4 % Ni suited for soft-martensitic steels like 1.4313 / CA 6 NM. Designed with precisely tuned alloying composition creating a weld deposit featuring very good ductility, CVN toughness and crack resistance despite its high strength.
BÖHLER CN 13/4-IG as well as the coated electrode BÖHLER FOX CN 13/4 and the analogous GMAW wire are very popular in the construction of hydro turbines.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.02**	**0.7**	**0.7**	**12.3**	**4.7**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u		a	
yield strength R_e N/mm²:		**915**	(≥ 780)	**750**	(≥ 720)
tensile strength R_m N/mm²:		**1000**	(≥ 950)	**830**	(≥ 800)
elongation A (L_0=5d_0) %:		**15**	(≥ 10)	**21**	(≥ 18)
impact work ISO-V KV J	+ 20 °C:	**85**	(≥ 80)	**150**	(≥ 50)
	- 60 °C:				(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*
a annealed, 600 °C/8 h/furnace down to 300 °C/air – shielding gas Argon

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W 13 4**
back: **-**

ø mm
2.0
2.4

=–

Preheating and interpass temperatures in case of thick-walled sections 100 - 160 °C. Maximum heat input 15 kJ/cm. Tempering at 580 - 620 °C.

Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNi13-4, 1.4414 GX4CrNiMo13-4

ACI Gr. CA6NM

Approvals and Certificates

TÜV-D (4110.), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4 FOX CN 13/4 SUPRA	GMAW solid wire:	CN 13/4-IG
		Metal cored wire:	CN 13/4-MC CN 13/4-MC (F)
		SAW combination:	CN 13/4-UP/BB 203

EN 12072:1999: W 19 9 L
AWS A5.9-93: ER308L
W.Nr.: 1.4316

BÖHLER EAS 2-IG

GTAW rod, high-alloyed, chemical resistant

Description

GTAW rod of type W 19 9 L / ER308L suitable not only for standard welding jobs but also for cryogenic applications down to -269 °C.
Good welding and wetting characteristics of BÖHLER EAS 2-IG as well as corrosion resistance up to +350 °C is achieved.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni
wt-%	**0.02**	**0.5**	**1.7**	**20.0**	**10.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**450**	(≥ 400)
tensile strength R_m N/mm^2:		**620**	(≥ 570)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 100)
	- 269 °C:	**75**	(≥ 35)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W 19 9 L**
back: **ER 308 L**

ø mm
1.6
2.0
2.4
3.0

=–

Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10

AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (0145.), DB (43.014.08), ÜZ (43.014/1), ÖBB, TÜV-A (97), CL (0655), DNV (308L), GL (4550), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	Metal cored wire:	EAS 2-MC
	FOX EAS 2-A	GMAW flux cored wire:	EAS 2-FD
	FOX EAS 2-VD		EAS 2 PW-FD
GMAW solid wire:	EAS 2-IG (Si)	SAW combination:	EAS 2-UP/BB 202

EN 12072:1999: W 19 9 Nb
AWS A5.9-93: ER 347
W.Nr.: 1.4551

BÖHLER SAS 2-IG

GTAW rod, high-alloyed, chemical resistant

Description

GTAW rod of type W 19 9 Nb / ER 347 engineered to a very precise analysis to create a weld deposit of high purity, superior hot cracking an corrosion resistance.
CVN toughness down to -196 °C, resistant to intergranular corrosion up to +400 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.05**	**0.5**	**1.8**	**19.5**	**9.5**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**490**	(≥ 450)
tensile strength R_m N/mm^2:		**660**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 100)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W 19 9 Nb**
back: **ER 347**

ø mm
1.6
2.0
2.4
3.0

Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11, 1.4301 X5CrNi18-10, 1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (0142.), TÜV-A (77), CL (0261), GL (4550), UDT, LTSS, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX SAS 2
FOX SAS 2-A

GMAW solid wire: SAS 2-IG (Si)
GMAW flux cored wire: SAS 2-FD
SAS 2 PW-FD
SAW combination: SAS 2-UP/BB 202

EN 12072:1999: W 19 12 3 L
AWS A5.9-93: ER316L
W.Nr.: 1.4430

BÖHLER EAS 4 M-IG

GTAW rod, high-alloyed, chemical resistant

Description

GTAW rod of type W 19 12 3 L / ER316L engineered to a very precise analysis to create a weld deposit of high purity, superior hot cracking an corrosion resistance.
CVN toughness down to -196 °C, resistant to intergranular corrosion up to +400 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.02**	**0.5**	**1.7**	**18.5**	**12.3**	**2.6**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**470**	(≥ 450)
tensile strength R_m N/mm^2:		**650**	(≥ 580)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 100)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W 19 12 3 L**
back: **ER 316 L**

ø mm
1.6
2.0
2.4
3.0

Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

S31653, AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (0149.), DB (43.014.12), ÜZ (43.014/1), ÖBB, TÜV-A (101), CL (0446), DNV (316L), GL (4429), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-A	GMAW flux cored wire:	EAS 4 M-FD
	FOX EAS 4 M-VD		EAS 4 PW-FD
	FOX EAS 4 M-TS	SAW combination:	EAS 4 M-UP/BB 202
GMAW solid wire:	EAS 4 M-IG (Si)		

EN 12072:1999: W 19 12 3 Nb
AWS A5.9-93: ER318
W.Nr.: 1.4576

BÖHLER SAS 4-IG

GTAW rod, high-alloyed, chemical resistant

Description

GTAW rod of type W 19 12 3 Nb / ER318 engineered to a very precise analysis to create a weld deposit of high purity, superior hot cracking an corrosion resistance.
CVN toughness down to -120 °C, resistant to intergranular corrosion up to +400 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	Nb
wt-%	**0.04**	**0.4**	**1.7**	**19.5**	**11.5**	**2.7**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**520**	(≥ 400)
tensile strength R_m N/mm²:		**700**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 100)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W 19 12 3 Nb**
back: **ER 318**

ø mm
1.0*
1.2*
1.6
2.0
2.4
3.0

=–

* these diameters are delivered with a higher Si-content (ca. 0.8 %)

Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4401 X5CrNiMo17-12-2, 1.4581 GX5CrNiMoNb19-11-2, 1.4437 GX6CrNiMo18-12, 1.4583 X10CrNiMoNb18-12, 1.4436 X3CrNiMo17-13-3

AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (0236.), KTA 1408 1 (8046.00), DB (43.014.03), ÜZ (43.014/1), ÖBB, TÜV-A (134), CL (0441), GL (4571), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4	GMAW solid wire:	SAS 4-IG (Si)
	FOX SAS 4-A	GMAW flux cored wire:	SAS 4-FD
			SAS 4 PW-FD
		SAW combination:	SAS 4-UP /BB 202

EN 12072:1999: W Z 19 13 Si NL
W.-Nr.: 1.4361

BÖHLER EASN 2 Si-IG

GTAW rod, high-alloyed,
highly corrosion resistant

Description

GTAW rod designed for joint welding of the special stainless steel grade X2CrNiSi18-15, mat-no. 1.4361 (BÖHLER A 610), which is resistant to the attack of highly concentrated nitric acid and of nitric acid additionally containing strong deoxidants. Also suited for cladding applications on analogous materials.
Operating temperatures up to +350 °C.

Typical Composition of Welding Rod

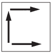
	C	Si	Mn	Cr	Ni	N
wt-%	≤ **0.015**	**4.6**	**0.7**	**19.5**	**13.4**	**0.12**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**520**	(≥ 440)
tensile strength R_m N/mm²:		**750**	(≥ 700)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 40)
	- 50 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data



shielding gases: **100 % Argon**
rod marking:
front: **W Z 19 13 Si NL**
back: **1.4361**

ø mm
1.6
2.0
2.4

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The deposit does not require post weld heat treatment. In exceptional cases quenching from a temperature of +1100 °C in water is recommended. Keep heat input as low as possible. Interpass temperature should not to exceed +150 °C. If possible, water cooling to improve heat dissipation is recommended.

Base Materials

1.4361 X1CrNiSi18-15-4, UNS S30600

Approvals and Certificates

TÜV-D (1483.), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX EAS 2 Si

EN 12072:1999: W Z 18 16 5 NL
AWS A5.9-93: ER317LN (mod.)
W.Nr.: 1.4453

BÖHLER ASN 5-IG

GTAW rod, high-alloyed, highly corrosion resistant

Description

GTAW rod for 3-4 % molybdenum alloyed CrNi-steels like 1.4438 / 317L.
The weld metal shows a stable austenitic microstructure with good pitting resistance (PRE_N >35) and crevice corrosion resistance as well as excellent CVN toughness behaviour down to -269 °C. Resistant to intergranular corrosion up to +400 °C.
BÖHLER ASN 5-IG has an increased Mo content (4.1 %) to compensate for segregation when welding high molybdenum alloyed steels, thus producing equivalent corrosion resistance to the relevant base metals offering a 3-4 % Mo guarantee.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N	FN
wt-%	≤ **0.02**	**0.2**	**5.0**	**19.0**	**16.5**	**4.1**	**0.16**	**38.0**	≤ **0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 400)
tensile strength R_m N/mm²:		**650**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 70)
	- 269 °C:	**75**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W Z 18 16 5 NL**
back: **1.4453**

ø mm
1.6
2.0
2.4

=−

Base Materials

1.4436 X3CrNiMo17-13-3, 1.4439 X2CrNiMoN17-13-5, 1.4429 X2CrNiMoN17-13-3, 1.4438 X2CrNiMo18-15-4, 1.4583 X10CrNiMoNb18-12

AISI 316Cb, 316LN, 317LN, 317L; UNS S31726

Approvals and Certificates

TÜV-D (00017.), TÜV-A (463), DNV (X), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX ASN 5 FOX ASN 5-A	GMAW flux cored wire:	E 317L-FD* E 317L PW-FD*
GMAW solid wire:	ASN 5-IG (Si)	SAW combination:	ASN 5-UP/BB 203

* for similar alloyed base metals only, not fully austenitic.

EN 12072:1999: W Z 22 17 8 4 NL
W.Nr.: 1.3954

BÖHLER AM 400-IG

**GTAW rod, high-alloyed,
highly corrosion resistant**

Description

This N-alloyed, fully austenitic and nonmagnetic special GTAW rod is distinguished by its especially high resistance to pitting, crevice corrosion and stress corrosion cracking. Excellent cryogenic toughness.
Suitable for service temperatures up to +350 °C, and up to +400 °C in media that do not induce intergranular corrosion. Used for sea water desalinisation plants, centrifuges, bleaching plants and in special shipbuilding.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	**0.02**	**0.7**	**7.5**	**22.2**	**18.1**	**3.6**	**0.22**	**36.9**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**480**	(≥ 450)
tensile strength R_m N/mm^2:		**700**	(≥ 680)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**170**	(≥ 70)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W Z 22 17 8 4 NL**
back: **1.3954**

ø mm
2.0

Preheating of the base metal is not required. The interpass temperature should not exceed +150 °C.

Base Materials

1.3948 X4CrNiMnMoN19-13-8, 1.3951 X2CrNiMoN22-15, 1.3952 X2CrNiMoN18-14-3, 1.3964 X2CrNiMnMoNNb21-16-5-3, 1.4439 X2CrNiMoN17-13-5

Approvals and Certificates

WIWEB, GL (3954), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX AM 400

GMAW solid wire: AM 400-IG

EN 12072:1999: W 25 22 2 NL

BÖHLER EASN 25 M-IG

GTAW rod
high-alloyed, chemical resistant

Description

GTAW rod for joining and surfacing applications on matching/similar steels. For weld cladding on high temperature steels and for fabrication joints on claddings. Characterised by a low C-content, a limited Mo-content (for better Huey-test-resistance), a well-defined N-alloying as well as a high Ni-content to assure a fully austenitic structure (ferrite contents < 0.5 %). The corrosion rates in the Huey-test are max. 0.25 g/m^2.h (10.89 mils/year). it is suited for urea plant components exposed to extremely severe corrosion at high pressures and temperatures. The weld deposit will exhibit superior resistance to boiling concentrated nitric acid (optimum condition: 60-80 % HNO3) when made to join components of the highest Huey test quality. It is also recommendable for weldments wetted by strong chloride solutions at high temperatures. The chromium and molybdenum percentages create good resistance to pitting from solutions containing chlorine ions. Further applications involve severe corrosive service in such industries as dyeing (leaching and dyeing baths), textiles, paper, leather, chemicals, pharmaceuticals, and rayon. Resistant to intercrystalline corrosion and wet corrosion up to +350 °C. During welding an interpass temperature of 150 °C should be avoided.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	N
wt-%	**0.025**	**0.2**	**6.0**	**25**	**22.5**	**2.2**	**0.13**

Mechanical Properties of All-weld Metal

(*)		U
yield strength R_e N/mm^2:		>400
tensile strength R_m N/mm^2:		>600
elongation A (L_0=5d_0) %:		>30
impact work ISO-V KV J	+20 °C	>80

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:
100% Argon
rod marking:
front: W 25 22 2 NL
back: 1.4465

ø mm
1.6
2.0
2.4

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Base Materials

X2CrNiMoN25-22-2 (1.4466) and in Combination with
X1CrNiMoN25-25-2 (1.4465), X2CrNiMo18-14-3 (1.4435)

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW stick electrode: FOX EASN 25M

EN 12072:1999: W Z 20 25 5 Cu NL
AWS A5.9-93: ER385 (mod.)
W.Nr.: 1.4519 (mod.)

BÖHLER CN 20/25 M-IG

GTAW rod, high-alloyed, highly corrosion resistant

Description

Special GTAW rod for corrosion resistant 4-5% Mo-alloyed CrNi-steels like 1.4539 / 904L. Very high pitting resistant equivalent (PREN ≥ 45) – pitting potential (%Cr + 3.3 x %Mo + 30 x %N). Due to the high Mo content (6.2 %) in comparison to W-No. 1.4539 respectively UNS N08904, the high segregation rate of high Mo-alloyed CrNi-weld metal can be compensated.
The fully austenitic weld metal possess a marked resistance towards pitting and crevice corrosion in chloride containing media. Highly resistant against sulphur-, phosphorus-, acetic- and formic acid, as well as sea- and brackish water. Caused from the low C-content of the weld metal, the risk of intergranular corrosion can be avoided. The high Ni-content in comparison to standard CrNi-weld metals leads to high resistance against stress corrosion cracking.
Special applicable in sulphur- and phosphorus production, pulp and paper industry, flue gas desulphurisation plants, further on for fertilizer production, petrochemical industry, fatty-, acetic- and formic acid production, sea water sludge fittings and pickling plants which are proceeded with sea or brackish water.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	Cu	N	PRE_N
wt-%	≤ **0.02**	**0.7**	**4.7**	**20.0**	**25.4**	**6.2**	**1.5**	**0.12**	≥ **45.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 350)
tensile strength R_m N/mm²:		**670**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**42**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**115**	(≥ 80)
	- 269 °C:	**72**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
rod marking:
front: **W Z 20 25 5 Cu NL**
back: **–**

ø mm
1.6
2.0
2.4

Preheating and post weld heat treatment is not required by the weld deposit. Interpass temperature should not exceed +150 °C.

Base Materials

same-alloyed high-Mo Cr-Ni-steels
1.4539 X1NiCrMoCu25-20-5, 1.4439 X2CrNiMoN17-13-5, 1.4537 X1CrNiMoCuN25-25-5
UNS N08904, S31726

Approvals and Certificates

TÜV-D (4881.), TÜV-A (390), Statoil, UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 20/25 M
FOX CN 20/25 M-A

GMAW solid wire: CN 20/25 M-IG (Si)

EN 12072:1999: W 22 9 3 NL
AWS A5.9-93: ER2209
W.Nr.: 1.4462 (mod.)

BÖHLER CN 22/9 N-IG

GTAW rod, high-alloyed, highly corrosion resistant

Description

GTAW rod of type W 22 9 3 NL / ER2209 designed for welding ferritic-austenitic duplex steels like 1.4462 / UNS 31803. The deposit possess, in addition to high tensile strength and toughness, also excellent resistance to stress corrosion cracking and pitting (Huey-test ASTM A 262-79 practice C). The operating temperature range is -60 °C up to +250 °C. To ensure particularly good weld metal properties care must be taken to archive controlled dilution and thorough back purging. In case of severe corrosion requirement, small amounts of N2 can be added to the shielding respectively purging gas.
BÖHLER CN 22/9 N-IG is characterised by a precisely alloyed composition which includes an extremely low oxygen content. It offers very high quality standards for ease of operation and good mechanical properties.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	≤ **0.015**	**0.4**	**1.7**	**22.5**	**8.8**	**3.2**	**0.15**	≥ **35**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**600**	(≥ 560)
tensile strength R_m N/mm²:		**800**	(≥ 720)
elongation A ($L_0 = 5d_0$) %:		**33**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 100)
	- 60 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
Ar + 1-2 % N_2
rod marking:
front: **W 22 9 3 NL**
back: **ER 2209**

ø mm
1.6
2.0
2.4
3.2

=–

Preheat and post weld heat treatment is generally not required. Interpass temperature should not exceed +150 °C.

Base Materials

same-alloyed duplex steels, as well as similar-alloyed, ferritic-austenitic steels with higher tensile strength
1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4,
1.4462 X2CrNiMoN22-5-3 with 1.4583 X10CrNiMoNb18-12,
1.4462 X2CrNiMoN22-5-3 with P235GH/ P265GH, S255N, P295GH, S355N, 16Mo3
UNS S31803, S32205

Approvals and Certificates

TÜV-D (4484.), TÜV-A (423), DNV (X{I1}), Statoil, UDT, CL (0776), GL (4462), ABS (ER 2209), LR (X), Statoil, UDT

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N-B	GMAW flux cored wire:	CN 22/9 N-FD
	FOX CN 22/9 N		CN 22/9 PW-FD
GMAW solid wire:	CN 22/9 N-IG	SAW combination:	CN 22/9 N-UP/BB 202

EN 12072:1999: W 25 9 4 NL
AWS A5.9-93: ER2553(mod)

BÖHLER CN 25/9 CuT-IG

GTAW-rod
high alloyed, highly corrosion resistant

Description

GTAW-rod highly suitable for welding ferritic-austenitic superduplex steels. By virtue of specific alloy composition the deposit has, in addition to high tensile strength and toughness, also excellent resistance to stress corrosion cracking and pitting corrosion. The operating temperature range is -50 °C up to 220 °C. Well suited for the conditions in the offshore field. For applications requiring low Hydrogen, we offer the product BÖHLER CN 25/9 CuT-IG-LH with Hydrogen Content guaranteed less than 3 ppm.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	N	Cu	T	PRE_N
wt-%	**0.02**	**0.3**	**0.8**	**25.5**	**9.5**	**3.7**	**0.22**	**0.6**	**0.6**	**≥40**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 700
tensile strength R_m N/mm²:		≥ 850
elongation A (L_0=5d_0) %:		≥ 25
impact work ISO-V A_V J	+20 °C:	≥ 120
	-40 °C:	≥ 100

(*) *u untreated, as welded – shielding gas Argon*

Operating Data

shielding gas:	**ø mm**
Argon + 2-3 % N_2	2.0
Argon	2.4

rod marking:
front: **W 25 9 4 NL**
back: Welding of root pass with „thick layer". Next two passes with thin layers and low heat input to avoid overheating and precipitations

Base Materials

25 % Cr-Superduplex steels e.g.
1.4501 X2CrNiMoCuWN 25-7-4
UNS S 32750, S 32760
ZERON 100, SAF 25/07, FALC 100

Approvals and Certificates

CL (applied)

Same Alloy Filler Metals

Stick electrode:	FOX CN 25/9 CuT
GMAW solid wire:	CN 25/9 CuT-IG

EN 12072:1999: G Z 13 Nb L
AWS A5.9-93: ER409Cb

BÖHLER KW 5 Nb-IG

GMAW solid wire
high-alloyed, stainless

Description

Special GMAW welding wire for catalytic converters as well as exhaust silencers, mufflers, manifolds, and manifold elbows of analogous or similar materials. Also used for repair welding and surfacing of sealing faces of gas, water, and steam turbines with service temperatures of up to +450 °C. Resists scaling up to +900 °C. Machinability depends largely on the degree of base metal dilution. Outstanding feeding, very good welding and flow characteristics.

Typical Composition of Solid Wire

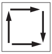
	C	Si	Mn	Cr	Nb
wt-%	**0.05**	**0.6**	**0.6**	**11.5**	**+**

Mechanical Properties of All-weld Metal

(*)	u	a
Brinell-hardness HB:	**150**	**130**

(*) *u untreated, as-welded – shielding gas Ar +8-10 % CO_2*
a annealed, 750 °C/2h – shielding gas Ar +8-10 % CO_2

Operating Data



Shielding gas:	**ø mm**
Argon +8-10 % CO_2	1.0

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Base Materials

analogous or similar alloyed steels
1.4512 X2CrTi12, 1.4006 X10Cr13, 1.4024 X15Cr13, 1.4021 X20Cr13
AISI 409, 410, 420

Approvals and Certificates

SEPROZ, UDT

Same Alloy Filler Metals

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EN 12072:1999: G Z 18 Nb L
AWS A5.9-93: ER430 (mod)

BÖHLER CAT 430 L Cb-IG

GMAW solid wire
high alloyed, stainless

Description

Special GMAW welding wire for catalytic converters as well as exhaust silencers, mufflers, manifolds, and manifold elbows of analogous or similar materials. Resists scaling up to +900 °C. Outstanding feeding characteristics. Very good welding and flow characteristics.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Nb
wt-%	**<0.02**	**0.5**	**0.5**	**18.0**	**>12xC**

Mechanical Properties of All-weld Metal

(*)	u	a
Brinell-hardness HB:	**150**	**130**

(*) *u untreated, as welded – shielding gas Ar +8-10 % CO_2*
a annealed, 760 °C/2h – shielding gas Ar +8-10 % CO_2

Operating Data

Shielding gas:	**ø mm**
Argon +5-10 % CO_2	1.0
Argon +1-3 % O_2	

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Base Materials

1.4511 X3CrNb17, 1.4016 X6Cr17,
AISI 430

Approvals and Certificates

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EN 12072:1999: G Z 18 Ti L
AWS A5.9-93: ER430(mod)

BÖHLER CAT 439 L Ti-IG

GMAW solid wire, high alloyed, stainless

Description

Special GMAW welding wire for catalytic converters as well as exhaust silencers, mufflers, manifolds, and manifold elbows of analogous or similar materials. Resists scaling up to 900 °C. Outstanding feeding characteristics. Very good welding and flow characteristics

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ti
wt-%	**0.03**	**0.8**	**0.8**	**18.0**	**>12xC**

Mechanical Properties of All-weld Metal

(*)	u	a
yield strength R_e N/mm^2:		
tensile strength R_m N/mm^2:		
elongation A (L_0=5d_0) %:		
impact work ISO-V KV J		
Brinell-hardness HB	**150**	**130**

(*) *u untreated, as welded – shielding gas Ar +8-10 % CO_2*
a annealed, 800 °C/1h – shielding gas Ar +8-10 % CO_2

Operating Data

Shielding gas:	**ø mm**
Argon +5-10 % CO_2	1.0
Argon +1-3 % O_2	

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Base Materials

1.4510, X3CrTi17, 1.4016 X6Cr17, 1.4502, X8CrTi18
AISI 439

Approvals and Certificates

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EN 12072:1999: G 13 4
AWS A5.9-93: ER410 NiMo (mod.)

BÖHLER CN 13/4-IG

GMAW solid wire
high-alloyed, stainless

Description

GMAW wire of low-carbon type 13% Cr 4% Ni suited for soft-martensitic steels like 1.4313 / CA 6 NM. Designed with precisely tuned alloying composition creating a weld deposit featuring very good ductility, CVN toughness and crack resistance despite its high strength.
BÖHLER CN 13/4-IG and the analogous GTAW rod as well as the coated stick electrode BÖHLER FOX CN 13/4 are very popular in the construction of hydro turbines.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo
wt-%	≤ **0.02**	**0.7**	**0.6**	**12.3**	**4.7**	**0.5**

Mechanical Properties of All-weld Metal

(*)	u		a	
yield strength R_e N/mm²:	**950**	(≥ 750)	**760**	(≥ 680)
tensile strength R_m N/mm²:	**1210**	(≥ 950)	**890**	(≥ 800)
elongation A ($L_0 = 5d_0$) %:	**12**	(≥ 10)	**17**	(≥ 15)
impact work ISO-V KV J + 20 °C:	**36**	(≥ 30)	**80**	(≥ 50)
- 20 °C:				(≥ 47)

(*) *u untreated, as-welded – shielding gas Argon + 8 - 10 % CO_2*
a annealed, 580 °C/8 h furnace down to 300 °C/air – shielding gas Argon + 8 - 10 % CO_2

Operating Data

shielding gases:	**ø mm**
Argon + 8 – 10 % CO_2	1.2

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Preheating and interpass temperatures in case of thick-walled sections 100 - 160 °C. Maximum heat input 15 kJ/cm. Tempering at 580 - 620 °C.

Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNi13-4, 1.4414 GX4CrNiMo13-4

ACI Gr. CA 6 NM

Approvals and Certificates

UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4	GTAW rod:	CN 13/4-IG
	FOX CN 13/4 SUPRA	Metal cored wire:	CN 13/4-MC
			CN 13/4-MC (F)
		SAW combination:	CN 13/4-UP/BB 203

EN 12072:1999:	G Z 13
AWS A5.9-93:	ER410 (mod.)
W.Nr.:	1.4009

BÖHLER KW 10-IG

GMAW solid wire
high-alloyed, stainless

Description

GMAW wire of type W Z 13 / ER 410 predominantly used for surfacings of sealing faces of valves for gas, water, and steam piping systems at service temperatures up to +450 °C. The machinability of the weld metal depends largely upon the kind of base metal and degree of dilution. Joint welding of similar 13 % chromium steels shows matching colour of the weld metal and very good ability to polishing. Good feeding, welding and wetting characteristics.
For joint welding preheating to +200 - 300 °C is recommended. Tempering at +700 - 750 °C to increase toughness.

Typical Composition of Solid Wire

	C	Si	Mn	Cr
wt-%	**0.06**	**0.7**	**0.6**	**13.6**

Mechanical Properties of All-weld Metal

(*)	u	a
yield strength R_e N/mm²:		(≥ 450)
tensile strength R_m N/ mm²:		(≥ 650)
elongation A ($L_o = 5d_o$) %:		(≥ 15)
impact work ISO-V KV J + 20 °C:		–
Brinell-hardness HB:	**320**	**200**

(*) *u untreated, as-welded – shielding gas Ar + 8 - 10 % CO_2*
a annealed, 720 °C/2 h - shielding gas Ar + 8 - 10 % CO_2

The hardness of the deposit is greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness. Gas mixtures containing CO_2 result in higher deposit hardness then CO_2-free gas mixtures.

Operating Data

shielding gases:	**ø mm**
Argon + 8 - 10 % CO_2	1.2
(**Argon + 3 % O_2 or max. 5 % CO_2**	1.6
(shielding gas depends on the application)	

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Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed
joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents ≤ 0.20% (repair welding); heat resistant Cr-steels of similar chemical composition. Be careful with dilution and welding technology.

1.4006 X12Cr13, 1.4021 X20Cr13

AISI 410, 420

Approvals and Certificates

SEPROZ, UDT

Same Alloy Filler Metals

SMAW stick electrode:	FOX KW 10
GTAW rod:	KW 10-IG

EN 12072:1999:	G 17
AWS A5.9-93:	ER430 (mod.)
W.Nr.:	1.4015

BÖHLER KWA-IG

GMAW solid wire
high-alloyed, stainless

Description

GMAW wire of type G 17 / ER430 suitable for surfacing of sealing faces of gas, water and steam valves and fittings. Service temperatures up to +450 °C. Scaling resistant up to +950 °C. Also in sulphur containing combustion gas at high temperature. BÖHLER KWA-IG wire is also suited for joint welding of stainless ferritic steels containing 12-17% chromium, and by the request of colour matching weld deposit/base metal. For thick-walled components it is recommendable to use BÖHLER A 7-IG wire for the filler passes in order to improve the ductility behaviour of the joint weld, KWA-IG wire for the cover pass especially in case of sulphur containing combustion gases. Excellent feeding, welding and wetting behaviour of the wire and weld metal are important economical features. For joint welding preheating up to +200 - 300 °C is recommended. Annealing at +730 - 800 °C improves the toughness of the weld deposit.

Typical Composition of Solid Wire

	C	Si	Mn	Cr
wt-%	**0.06**	**0.6**	**0.6**	**17.5**

Mechanical Properties of All-weld Metal

(*)	u	u - 1. Layer	u - 2. Layer	u - 3. Layer	a
yield strength R_e N/mm²:					(≥ 340)
tensile strength R_m N/mm²:					(≥ 540)
elongation A ($L_o = 5d_o$) %:					(≥ 20)
impact work ISO-V KV J + 20 °C					–
Brinell-hardness HB:	**180-230**	**350-450**	**280-350**	**230-260**	**150**

(*) *u untreated, as-welded – base material mild steel – shielding gas Ar + 8 - 10 % CO_2*
a annealed, 800 °C/1 h - shielding gas Ar + 8 - 10 % CO_2

The hardness of the deposit is greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness. Gas mixtures containing CO_2 result in higher deposit hardness then CO_2-free gas mixtures.

Operating Data

shielding gases:
Argon + 8 - 10 % CO_2
(**Argon + 3 % O_2 or max. 5 % CO_2**
(shielding gas depends on the application)

ø mm
1.2

=+

Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed.
joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents up to 0.20 % (repair welding). Be careful with dilution and welding technology.
1.4510 X3CrTi17
AISI 430 Ti; AISI 431

Approvals and Certificates

SEPROZ, UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SKWA	GMAW solid wire:	SKWA-IG
	FOX SKWAM		SKWAM-IG

EN 12072:1999:	G Z 17 Ti
AWS A5.9-93:	ER430 (mod.)
W.Nr.:	1.4502

BÖHLER SKWA-IG

GMAW solid wire
high-alloyed, stainless

Description

GMAW wire of type G Z 17 Ti / ER430 for build up on sealing faces of gas, water and steam valves and fittings made from unalloyed or low-alloyed steels. Service temperatures up to + 500 °C. The wire exhibits good feeding properties with excellent welding and wetting characteristics. Scaling resistant up to +900 °C. SKWA-IG wire is also suited for joint welding of stainless ferritic steels containing 13-18 % chromium steels, furthermore for applications where colour match of the base and weld metal is required.
Preheat to 250 - 450 °C for joint welding. Annealing at 650 - 750 °C improves the toughness of the weld deposit.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ti
wt-%	**0.07**	**0.8**	**0.6**	**17.5**	**+**

Mechanical Properties of All-weld Metal

(*)	u	u - 1. Layer	u - 2. Layer	u - 3. Layer	a
yield strength R_e N/mm²:					(≥ 300)
tensile strength R_m N/mm²:					(≥ 500)
elongation A ($L_o = 5d_o$) %:					(≥ 20)
impact work ISO-V KV J + 20 °C					–
Brinell-hardness HB:	**150-170**	**300-400**	**200-300**	**170-220**	**130**

(*) *u untreated, as-welded – base metal mild steel – shielding gas Ar + 8 - 10 % CO_2*
a annealed, 750 °C/2 h - shielding gas Ar + 8 - 10 % CO_2

The hardness of the deposit is greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness. Gas mixtures containing CO_2 result in higher deposit hardness then CO_2-free gas mixtures.

Operating Data

shielding gases:	**ø mm**
Argon + 8 - 10 % CO_2	1.0
(**Argon + 3 % O_2 or max. 5 % CO_2**	1.2
(shielding gas depends on the application)	1.6

=+

Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed.
joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents up to 0.20% (repair welding). Be careful with dilution and welding technology.

1.4510 X3CrTi17

AISI 430Ti, 431

Approvals and Certificates

DB (20.014.11), ÖBB, UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SKWA FOX SKWAM	GMAW solid wire:	KWA-IG SKWAM-IG

EN 12072:1999: G Z 17 Mo H
W.Nr.: 1.4115

BÖHLER SKWAM-IG

GMAW solid wire
high-alloyed, stainless

Description

GMAW solid wire of type 17 % Cr 1 % Mo for surfacing on sealing faces of gas, water and steam valves and fittings made from unalloyed or low-alloy steels, for service temperatures up to +450 °C. Excellent anti-friction properties. The weld deposit is still machinable. Scaling resistant up to +900 °C. SKWAM-IG wire is also suited for joint welding of stainless ferritic steels containing 13-18 % chromium, above all for applications where uniform colour of the base metal and weld seam is required. For thick-walled components it is recommendable to use BÖHLER A 7-IG wire for the filler passes in order to improve the ductility behaviour of the joint weld, SWAM-IG wire for the cover pass. Preheating to 250 - 450 °C for joint welding operations. Annealing at 650 - 750 °C improves the toughness of the weld deposit.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo
wt-%	**0.20**	**0.7**	**0.7**	**17.0**	**1.1**

Mechanical Properties of All-weld Metal

(*)	u	u - 1. Layer	u - 2. Layer	u - 3. Layer	a
yield strength R_e N/mm²:					(≥ 500)
tensile strength R_m N/mm²:					(≥ 700)
elongation A ($L_o = 5d_o$) %:					(≥ 15)
impact work ISO-V KV J + 20 °C					–
Brinell-hardness HB:	**appr. 350**	**400-500**	**380-450**	**330-400**	**200**

(*) *u untreated, as-welded – base metal mild steel – shielding gas Ar + 8 – 10 % CO_2*
a annealed, 720 °C/2 h – shielding gas Ar + 8 – 10 % CO_2

The hardness of the deposit is greatly influenced by the degree of dilution with the base metal (depending on the relevant welding conditions) and by its chemical composition. As a general rule it can be observed that the higher the degree of dilution and the C-content of the base metal, the higher the deposit hardness. Gas mixtures containing CO_2 result in higher deposit hardness then CO_2-free gas mixtures.

Operating Data

shielding gases:	**ø mm**
Argon + 8 - 10 % CO_2	1.2
(**Argon + 3 % O_2 or max. 5 % CO_2**	1.6
(shielding gas depends on the application)	

=+

Base Materials

surfacings: all weldable backing materials, unalloyed and low-alloyed.
joint welds: corrosion resistant Cr-steels as well as other similar-alloyed steels with C-contents up to 0.20 % (repair welding). Be careful with dilution and welding technology.

Approvals and Certificates

KTA 1408 1 (8044.00), DB (20.014.19), ÖBB, UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX SKWA	GMAW solid wire:	KWA-IG
	FOX SKWAM		SKWA-IG

EN 12072:1999:	G 19 9 L Si
AWS A5.9-93:	ER308 L Si
W.Nr.:	1.4316

BÖHLER EAS 2-IG (Si)

GMAW solid wire
high-alloyed, chemical resistant

Description

GMAW wire of type G 19 9 L Si / ER308LSi designed for first class welding, wetting and feeding characteristics and excellent weld metal CVN values down to -196 °C.
Resistance to intergranular corrosion up to +350 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni
wt-%	**0.02**	**0.8**	**1.7**	**20.0**	**10.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 350)
tensile strength R_m N/mm²:		**630**	(≥ 570)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 75)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 2.5% CO_2*

Operating Data

shielding gases:	**ø mm**
Argon + max. 2.5 % CO_2	0.8
	1.0
	1.2

=+

Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10

AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (3159.), DB (43.014.09), ÜZ (43.014/1), ÖBB, TÜV-A (98), CL (0579), DNV (308L), GL (4550S), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	Metal cored wire:	EAS 2-MC
	FOX EAS 2-A	GMAW flux cored wire:	EAS 2-FD
	FOX EAS 2-VD		EAS 2 PW-FD
GTAW rod:	EAS 2-IG	SAW combination:	EAS 2-UP /BB 202

EN 12072:1999:	G 19 9 NbSi
AWS A5.9-93:	ER347 Si
W.Nr.:	1.4551

BÖHLER SAS 2-IG (Si)

GMAW solid wire
high-alloyed, chemical resistant

Description

GMAW wire of type G 19 9 Nb Si / ER347Si designed for first class welding, wetting and feeding characteristics as well as reliable corrosion resistance up to +400 °C.
Low temperature service down to -196 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.03**	**0.9**	**1.3**	**19.4**	**9.7**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 400)
tensile strength R_m N/mm²:		**630**	(≥ 570)
elongation A ($L_0 = 5d_0$) %:		**33**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 65)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gases:
Argon + max. 2.5 % CO_2

ø mm
0.8
1.0
1.2

=+

Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11, 1.4301 X5CrNi18-10, 1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (0025.), TÜV-A (78), GL (4550S), UDT, LTSS, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 2	GTAW rod:	SAS 2-IG
	FOX SAS 2-A	GMAW flux cored wire:	SAS 2-FD
			SAS 2 PW-FD
		SAW combination:	SAS 2-UP/BB 202

EN 12072:1999: G 19 12 3 L Si
AWS A5.9-93: ER316 L Si
W.-Nr.: 1.4430

BÖHLER EAS 4 M-IG (Si)

GMAW solid wire, high-alloyed, chemical resistant

Description

GMAW wire of type G 19 12 3 L Si / ER316LSi designed for first class welding, wetting and feeding characteristics as well as reliable corrosion resistance up to +400 °C.
Low temperature service down to -196 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.02**	**0.8**	**1.7**	**18.4**	**12.4**	**2.8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**450**	(≥ 380)
tensile strength R_m N/mm²:		**630**	(≥ 560)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 70)
	- 196°C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gases:
Argon + max. 2.5 % CO_2

ø mm
0.8
1.0
1.2

=+

Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

UNS S31653; AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (3233.), DB (43.014.11), ÜZ (43.014/1), ÖBB, TÜV-A (100), CL (0408), DNV (316L), GL (4429S), Statoil, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-A	GMAW flux cored wire:	EAS 4 M-FD
	FOX EAS 4 M-VD		EAS 4 PW-FD
	FOX EAS 4 M-TS	SAW combination:	EAS 4 M-UP/BB 202
GTAW rod:	EAS 4 M-IG		

EN 12072:1999:	G 19 12 3 NbSi
AWS A5.9-93:	ER318 (mod.)
W.Nr.:	1.4576

BÖHLER SAS 4-IG (Si)

GMAW solid wire
high-alloyed, chemical resistant

Description

GMAW wire of type G 19 12 3 Nb Si / ER318Si designed for first class welding, wetting and feeding characteristics as well as reliable corrosion resistance up to +400 °C.
Low temperature service down to -120 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	Nb
wt-%	**0.035**	**0.8**	**1.4**	**19.0**	**11.5**	**2.8**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**490**	(≥ 390)
tensile strength R_m N/mm²:		**670**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**33**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 70)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gases:
Argon + max. 2.5 % CO_2

ø mm
0.8
1.0
1.2

=+

Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4401 X5CrNiMo17-12-2, 1.4581 GX5CrNiMoNb19-11-2, 1.4437 GX6CrNiMo18-12, 1.4583 X10CrNiMoNb18-12, 1.4436 X3CrNiMo17-13-3

AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (3492.), TÜV-A (135), DB (43.014.04), ÜZ (43.014/1), ÖBB, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4	GTAW rod:	SAS 4-IG
	FOX SAS 4-A	GMAW flux cored wire:	SAS 4-FD
			SAS 4 PW-FD
		SAW combination:	SAS 4-UP/BB 202

EN 12072:1999: G Z 18 16 5 NL
AWS A5.9-93: ER317 LN (mod.)
W.Nr.: 1.4453 (mod.)

BÖHLER ASN 5-IG (Si)

GMAW solid wire
high-alloyed, highly corrosion resistant

Description

GMAW wire for 3-4 % Mo alloyed CrNi-steels like 1.4438 / 317L.
The weld metal shows a stable austenitic microstructure with good pitting resistance (PRE_N > 35) and crevice corrosion resistance as well as excellent CVN toughness behaviour down to -196 °C. BÖHLER ASN 5-IG (Si) has an increased Mo content (4.3 %) to compensate for segregation when welding high molybdenum alloyed steels, thus producing equivalent corrosion resistance to the relevant base metals offering a 3-4 % Mo guarantee. Resistance to intergranular corrosion up to +400 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N	FN
wt-%	**0.03**	**0.7**	**7.0**	**19.0**	**17.5**	**4.3**	**0.16**	**37.1**	≤ **0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**430**	(≥ 400)
tensile strength R_m N/mm²:		**650**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 70)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 20 % He + 0.5 % CO_2*

Operating Data

shielding gases:
Argon + 20 - 30 % He + max. 2 % CO_2
Argon + 20 % He + 0.5 % CO_2

ø mm
1.0
1.2

=+

Base Materials

1.4436 X3CrNiMo17-13-3, 1.4439 X2CrNiMoN17-13-5, 1.4429 X2CrNiMoN17-13-3, 1.4438 X2CrNiMo18-15-4, 1.4583 X10CrNiMoNb18-12

AISI 316Cb, 316 LN, 317LN, 317L, UNS S31726

Approvals and Certificates

TÜV-D (04139.), DNV (X), GL (4439S), UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX ASN 5 FOX ASN 5-A	GMAW flux cored wire:	E317L-FD* E317L PW-FD*
GTAW rod:	ASN 5-IG	SAW combination:	ASN 5-UP /BB 203

* for similar alloyed base metals only, not fully austenitic.

EN 12072:1999: G Z 22 17 8 4 NL
W.Nr.: 1.3954

BÖHLER AM 400-IG

GMAW solid wire
high-alloyed, highly corrosion resistant

Description

This N-alloyed, fully austenitic and nonmagnetic material is distinguished by its especially high resistance to pitting, crevice corrosion and stress corrosion cracking. Excellent cryogenic toughness. Suited for temperatures up to +350 °C, and up to +400 °C in media that do not induce intergranular corrosion.
Field of application in sea water desalinisation plants, centrifuges, bleaching plants and in special shipbuilding.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	**0.02**	**0.7**	**7.5**	**22.2**	**18.1**	**3.6**	**0.22**	**37**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 430)
tensile strength R_m N/mm²:		**680**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 70)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 20 % He + 0.5 % CO_2*

Operating Data

shielding gases:	**ø mm**
Argon + 20 - 30 % He + max. 2 % CO_2	1.0
Argon + 20 % He + 0.5 % CO_2	1.2

=+

Preheating of the base metal is not required. The interpass temperature must be limited to a maximum of +150 °C. For GMAW welding, shielding gases such as Ar + 8 % O_2 + 2.5 % CO_2 or Ar + 3 % O_2, Ar + 8 % O_2 are especially suited.

Base Materials

1.3948 X4CrNiMnMoN19-13-8, 1.3951 X2CrNiMoN22-15, 1.3952 X2CrNiMoN18-14-3, 1.3964 X2CrNiMnMoNNb21-16-5-3, 1.4439 X2CrNiMoN17-13-5

Approvals and Certificates

WIWEB, GL (3954S), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX AM 400 GTAW rod: AM 400-IG

EN 12072:1999: G Z 20 25 5 Cu NL
AWS A5.9-93: ER385 (mod.)
W.Nr.: 1.4519 (mod.)

BÖHLER CN 20/25 M-IG (Si)

GMAW solid wire
high-alloyed, highly corrosion resistant

Description

GMAW wire for corrosion resistant 4-5 % Mo alloyed CrNi-steels like 1.4539 / 904L. Very high pitting resistant equivalent (PREN ≥ 45) – pitting potential (%Cr + 3.3 x %Mo + 30 x %N). Due to the high Mo content (6.2 %) in comparison to W.-No. 1.4539 respectively UNS N08904, the high segregation rate of high Mo-alloyed CrNi-weld metal can be compensated. The fully austenitic weld metal possess a marked resistance towards pitting and crevice corrosion in chloride containing media. Highly resistant against sulphur-, phosphorus-, acetic- and formic acid, as well as sea- and brackish water. Caused from the low C-content of the weld metal, the risk of intergranular corrosion can be avoided. The high Ni-content in comparison to standard CrNi-weld metals leads to high resistance against stress corrosion cracking.
Special applicable in sulphur- and phosphorus production, pulp and paper industry, flue gas desulphurisation plants, further on for fertilizer production, petrochemical industry, fatty-, acetic- and formic acid production, sea water sludge fittings and pickling plants which are proceeded with sea or brackish water.
The GMAW wire exhibits good feeding, welding and wetting characteristics.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	Cu	N	PRE_N
wt-%	**0.02**	**0.7**	**4.7**	**20.0**	**25.4**	**6.2**	**1.5**	**0.12**	≥ **45.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**410**	(≥ 350)
tensile strength R_m N/mm²:		**650**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**39**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 70)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 20 % He + 0.5 % CO_2*

Operating Data

shielding gases:	ø mm
Argon + 20 - 30 % He + max. 2 % CO_2	0.8
Argon + 20 % He + 0.5 % CO_2	1.0
	1.2

=+

Preheating and post weld heat treatment is not required by the deposit.
Interpass temperature should not exceed +150 °C.

Base Materials

same-alloyed CrNi-steels with high Mo-content

1.4539 X1NiCrMoCu25-20-5, 1.4439 X2CrNiMoN17-13-5, 1.4537 X1CrNiMoCuN25-25-5

UNS N08904, S31726

Approvals and Certificates

TÜV-D (4897.), TÜV-A (476), Statoil, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 20/25 M
FOX CN 20/25 M-A

GTAW rod: CN 20/25 M-IG

EN 12072:1999:	G 22 9 3 NL
AWS A5.9-93:	ER2209
W.Nr.:	1.4462 (mod.)

BÖHLER CN 22/9 N-IG

GMAW solid wire
high-alloyed, highly corrosion resistant

Description

GMAW wire particularly suitable for welding of ferritic-austenitic duplex steels. By virtue of specific alloy composition which includes an extremely low oxygen content the deposit has, in addition to high tensile strength and toughness, also excellent resistance to stress corrosion cracking and pitting (PRE_N >35). In order to ensure good deposit properties, care must be taken to achieve controlled dilution and thorough back purging. Ferrite content 30 – 60 FN (WRC). Suited for temperatures down to -40 °C and up to +250 °C. The wire exhibits good feeding, welding and wetting characteristics of the wire. The preferred gas for MIG welding is Argon + 20 % Helium + 2 % CO_2.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
wt-%	**0.015**	**0.4**	**1.7**	**22.5**	**8.8**	**3.2**	**0.15**	≥ **35**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**660**	(≥ 600)
tensile strength R_m N/mm²:		**830**	(≥ 720)
elongation A ($L_0 = 5d_0$) %:		**28**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**85**	(≥ 70)
	- 40 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 20 % He + 2 % CO_2*

Operating Data

shielding gases:	ø mm
Argon + 20 - 30 % He + max. 2 % CO_2	1.0
Argon + 20 - 30 % He + max. 1 % O_2	1.2

=+

Preheating and post weld heat treatment is not required be the weld deposit.
Interpass temperature should not exceed +150 °C.

Base Materials

same-alloyed duplex steels, as well as similar-alloyed, ferritic-austenitic steels with higher tensile strength

1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4,
1.4462 X2CrNiMoN22-5-3 together with 1.4583 X10CrNiMoNb18-12,
1.4462 X2CrNiMoN22-5-3 together with P235GH / P265GH, S255N, P295GH, S355N, 16Mo3

UNS S31803, S32205

Approvals and Certificates

TÜV-D (4483.), TÜV-A (424), CL (0311), DNV (X), GL (4462S), Statoil, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N-B	GMAW flux cored wire:	CN 22/9 N-FD
	FOX CN 22/9 N		CN 22/9 PW-FD
GTAW rod:	CN 22/9 N-IG	SAW combination:	CN 22/9 N-UP/BB 202

EN 12072:1999:	G 25 9 4 NL
AWS A5.9-93:	ER2553(mod)

BÖHLER CN 25/9 CuT-IG

GMAW solid wire
high alloyed, highly corrosion resistant

Description

GMAW wire highly suitable for welding ferritic-austenitic superduplex steels. By virtue of specific alloy composition the deposit has, in addition to high tensile strength and toughness, also excellent resistance to stress corrosion cracking and pitting corrosion. The operating temperature is -50 °C up to +250 °C. Well suited for the conditions in the offshore field.
For applications requiring low Hydrogen, we offer the product BÖHLER CN 25/9 CuT-IG-LH with Hydrogen Content guaranteed less than 3 ppm.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	N	Cu	T	PRE_N
wt-%	**0.02**	**0.3**	**0.8**	**25.3**	**9.5**	**3.7**	**0.22**	**0.6**	**0.6**	≥ **40**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 700
tensile strength R_m N/mm²:		≥ 850
elongation A (L_0=5d_0) %:		≥ 25
impact work ISO-V Av J	+20 °C:	≥ 120
	-50 °C:	≥ 100

(*) *untreated, as welded – shielding gas Argon + He + 0,5 % CO_2*

Operating Data

shielding gas:
Argon + 20-30 % He + 0.5-2 % CO_2
Argon + 20-30 % He + max. 1 % O_2

ø mm
1.0
1.2

=+

Base Materials

25 % Cr-Superduplex steels e.g.
1.4501 X2CrNiMoCuWN 25-7-4
UNS S 32750, S 32760
ZERON 100, SAF 25/07, FALC 100

Approvals and Certificates

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Same Alloy Filler Metals

Stick electrode:	FOX CN 25/9 CuT
GTAW rod:	CN 25/9 CuT-IG

EN 12073:1999: T 13 4 MM 2
AWS A5.9-93: EC410NiMo(mod.)

BÖHLER CN 13/4-MC

Metal cored wire,
high alloyed, stainless

Description

Metal cored wire for the fabrication and repair welding of hydro turbine components made of soft martensitic 13 % Cr 4 % Ni alloyed steels and cast steels.
BÖHLER CN 13/4-MC offers favourable spray arc or pulsarc characteristics, minimum spatter formation, flat and smooth bead profiles, excellent wetting behaviour and safe penetration.
It is easy to operate in all welding positions.
Additionally, precise alloy adjustment ensure very good impact test results of the heat treated weld metal. The hydrogen content is extra low (maximum 4 ml/100 g acc. to AWS A 4.3-93).
Significant gains in productivity can be realized by higher deposition rates and reduced post weld grinding when compared to GMAW using solid wires.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	≤ **0.025**	**0.7**	**0.9**	**12.0**	**4.6**	**0.6**

Mechanical Properties of All-weld Metal

(*)		u		a	
yield strength R_e N/mm²:		**800**	(≥ 750)	**760**	(≥ 680)
tensile strength R_m N/mm²:		**990**	(≥ 950)	**900**	(≥ 800)
elongation A ($L_0 = 5d_0$) %:		**12**	(≥ 10)	**16**	(≥ 15)
impact work ISO-V KV J	+20 °C:	**40**	(≥ 30)	**65**	(≥ 50)
	-20 °C:			**60**	(≥ 47)

(*) *u untreated, as-welded – shielding gas Ar + 2.5 % CO_2*
a annealed, 580 °C/8 h/furnace down to 300 °C/Air – shielding gas Ar + 2,5 % CO_2

Operating Data

Shielding gas:	**ø mm**	**amps A**	**voltage V**
Argon + 2.5 % CO_2	1.2	130 - 370	16 - 38
	1.6	250 - 550	22 - 40

Welding with conventional or pulsed power sources (slightly trailing torch position, angel appr. 80 °).
Recommended stick out 18 - 20 mm and length of arc 3 - 5 mm.
Recommended preheating and interpass temperatures in case of heavy wall thicknesses are 100 - 160 °C. Maximum heat input 15 kJ/cm.
Tempering at 580 - 620 °C.

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Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNiMo 13-4, ACI Grade CA 6 NM, 1.4414 GX4CrNiMo13-4

Approvals and Certificates

SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4	GMAW solid wire:	CN 13/4-IG
	FOX CN 13/4 SUPRA	Metal cored wire:	CN 13/4-MC (F)
GTAW rod:	CN 13/4-IG	SAW combination:	CN 13/4-UP/BB 203

EN 12073:2000: T 13 4 MM 2
AWS A5.9-93: EC410NiMo(mod.)

BÖHLER CN 13/4-MC (F)

Metal cored wire, high alloyed, stainless

Description

Metal cored wire for welding of hydro turbine components made of soft martensitic 13 % Cr 4 % Ni alloyed cast steels.
BÖHLER CN 13/4-MC (F) offers favourable spray arc or pulsarc characteristics, minimum spatter formation, flat and smooth bead profiles, excellent wetting behaviour and safe penetration. It is easy to operate in all welding positions.
The hydrogen content is low (maximum 5 ml/100 g acc. to AWS A 4.3-93).
Significant gains in productivity can be realized by higher deposition rates and reduced post weld grinding when compared to GMAW using solid wires.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	≤ **0.03**	**0.7**	**0.9**	**12.2**	**4.6**	**0.6**

Mechanical Properties of All-weld Metal

(*)		a	
yield strength R_e N/mm²:		**700**	(≥ 680)
tensile strength R_m N/mm²:		**880**	(≥ 800)
elongation A ($L_0 = 5d_0$) %:		**16**	(≥ 15)
Impact strength ISO-V KV J	+20 °C:	**55**	
	-20 °C:	**45**	

(*) a annealed/tempered, 580 °C/8 h/furnace to 300 °C/air – shielding gas Argon + 2,5 % CO_2

Operating Data

Shielding gas:
Argon + 2.5 % CO_2

ø mm	amps A	voltage V
1.2	130 - 370	16 - 38
1.6	250 - 550	22 - 40

Welding with conventional or pulsed power sources (preferably slightly trailing torch position, angel appr. 80 °). Recommended stick out 18-20 mm and length of arc 3-5 mm. Recommended preheating and interpass temperatures in case of heavy wall thicknesses are 100-160 °C. Maximum heat input 15 kJ/cm. Tempering at 580-620 °C. Positional weldability of metal cored wires is similar to solid wires.

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Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNiMo 13-4, ACI Grade CA6NM, 1.4414 GX4CrNiMo13-4

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4	GMAW solid wire:	CN 13/4-IG
	FOX CN 13/4 SUPRA	Metal cored wire:	CN 13/4-MC
GTAW rod:	CN 13/4-IG	SAW combination:	CN 13/4-UP/BB 203

EN 12073:2000: T 19 9 L MM 1
AWS A5.9-93: EC308L

BÖHLER EAS 2-MC

Metal cored wire, high-alloyed, chemical resistant

Description

Böhler EAS 2-MC is an austenitic CrNi-metal cored wire for GMAW applicable for same or similar alloyed, stabilized or non stabilized, corrosion resistant CrNi-steels. Suitable for service temperatures from -196 °C to +350 °C. This product achieves high productivity and is easy to operate. It provides excellent welding characteristics, smooth almost spatter free weld finish. The wider arc, in comparison to solid wire, will reduce the risk of lack of fusion and is less sensitive against misalignment of edges and different gap widths.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	≤ **0.03**	**0.6**	**1.4**	**19.8**	**10.2**

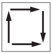
Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**380**	(≥ 350)
tensile strength R_m N/mm²:		**540**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**37**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**80**	(≥ 47)
	- 196 °C:	**40**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 2.5 % CO_2*

Operating Data

Shielding gas:	**ø mm**	**amps A**	**voltage V**
Argon + 2.5 % CO_2	1.2	60 - 280	13 - 30



Welding with conventional or pulsed power sources (preferably slightly leading torch position, angel appr. 80 °). Recommended stick out 15-20 mm and length of arc 3-5 mm.
Positional weldability of metal cored wires is similar to solid wires (puls arc welding is recommended).

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Base Materials

1.4306 X2CrNi19-11, AISI 304 L, 1.4301 X5CrNi18-10, AISI 304,1.4308 GX6CrNi18-9, 1.4311 X2CrNiN18-10, ASTM A320 Gr. B8C or D, AISI 304 LN, 1.4312 GX10CrNi18-8, ASTM A157 Gr. C9, AISI 302, 1.4541 X6CrNiTi18-10, AISI 321, 1.4546 X5CrNiNb18-10, AISI 321, 1.4550 X6CrNiNb18-10, AISI 347, 1.4552 GX5CrNiNb18-9

Approvals and Certificates

TÜV-D (09987.00)

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	GTAW-rod:	EAS 2-IG
	FOX EAS 2-A	GMAW solid wire:	EAS 2-IG (Si)
	FOX EAS 2-VD	GMAW flux cored wire:	EAS 2 PW-FD
	FOX		EAS 2-FD
		SAW combination:	EAS 2-UP/BB 202

EN 12073:2000: T 19 12 3 L MM1
AWS A5.9-93: EC316L

BÖHLER EAS 4 M-MC

Metal cored wire
high-alloyed, chemical resistant

Description

Böhler EAS 4 M-MC is an austenitic CrNiMo-metal cored wire for GMAW applicable for same or similar alloyed, stabilized or non stabilized, corrosion resistant CrNiMo-steels. Suitable for service temperatures from -196 °C to +400 °C. This product achieves high productivity and is easy to operate. It provides excellent welding characteristics, smooth almost spatter free weld finish. The wider arc, in comparison to solid wire, will reduce the risk of lack of fusion and is less sensitive against misalignment of edges and different gap widths.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	≤ **0.03**	**0.6**	**1.4**	**18.8**	**12.2**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**410**	(≥ 350)
tensile strength R_m N/mm²:		**560**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**34**	(≥ 30)
impact work ISO-V KV J	+20 °C:	**75**	(≥ 47)
	-196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 2.5 % CO_2*

Operating Data

Shielding gas:	**ø mm**	**amps A**	**voltage V**
Argon + 2.5 % CO_2	1.2	60 - 280	13 - 30

Welding with conventional or pulsed power sources (preferably slightly leading torch position, angel appr. 80 °).
Recommended stick out 15-20 mm and length of arc 3-5 mm.
Positional weldability of metal cored wires is similar to solid wires (puls arc welding is recommended).

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Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2
UNS S31653, AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (09988.00)

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	GTAW rod:	EAS 4 M-IG
	FOX EAS 4 M-A	GMAW flux cored wire:	EAS 4 M-FD
	FOX EAS 4 M-VD		EAS 4 PW-FD
	FOX EAS 4 M-TS	SAW combination:	EAS 4 M-UP/BB 202

EN 12073:1999: T 19 9 L R M 3
T 19 9 L R C 3
AWS A5.22-95: E308LT0-4
E308LT0-1
EN 12073:1999: T 19 9 L P M (C) 1 (for ø 0.9 mm)
AWS A5.22-95: E308LT1-4/-1 (for ø 0.9 mm)

BÖHLER EAS 2-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

Rutile strip alloyed flux cored welding wire of type T 19 9 L R / E308LT0 for GMAW of stainless steels like 1.4306 / 304L.
This product achieves high productivity and is easy to operate providing excellent operating characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. Suitable for service temperatures from -196 °C to +350 °C.
BÖHLER EAS 2-FD ø 0.9 mm is well suitable for welding of sheet metal from 1.5 mm and ø 1.2 mm can be used for wall thicknesses from 3 mm upwards.
Wire ø 0.9 mm is designed for positional welding, wire ø 1.2 mm and 1.6 mm are recommended mainly for down-hand and horizontal welding positions as well as in position PC/2G and slightly vertical down.

Typical Composition of All-weld Metal

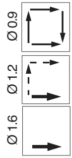
	C	Si	Mn	Cr	Ni
wt-%	**0.03**	**0.7**	**1.5**	**19.8**	**10.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**380**	(≥ 350)
tensile strength R_m N/mm²:		**560**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 35)
impact work ISO-V KV J	+20 °C:	**60**	(≥ 47)
	-196 °C:	**35**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data



re-drying: **possible, 150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
0.9	100 - 160	21 - 30
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10
AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (5348.), DB (43.014.14), ÜZ (43.014/2), ÖBB, TÜV-A (514), CL (1093), CWB (E308LT0-1(4)), GL (4550 (C1, M21)), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	GMAW solid wire:	EAS 2-IG (Si)
	FOX EAS 2-A	Metal cored wire:	EAS 2-MC
	FOX EAS 2-VD	GMAW flux cored wire:	EAS 2 PW-FD
GTAW rod:	EAS 2-IG	SAW combination:	EAS 2-UP/BB 202

EN 12073:1999:	T 19 9 L P M 1 T 19 9 L P C 1
AWS A5.22-95:	E308LT1-4 E308LT1-1

BÖHLER EAS 2 PW-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

Rutile strip alloyed flux cored welding wire with fast freezing slag providing excellent positional operating characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag. This flux cored welding wire offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable. Additional cost effective benefits are offered through use of less expensive shielding gases (Argon + 15 - 25 % CO_2 or 100 % CO_2), good wetting characteristics (less grinding), little temper discoloration & bead oxidation (less pickling expenses), easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work). Due to its characteristics mainly for positional welding and service temperatures between -196 °C to - +350 °C. For downhand & horizontal welding positions (1G, 1F, 2F) our flux cored wire BÖHLER EAS 2-FD should be preferred.

Typical Composition of All-weld Metal

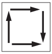
	C	Si	Mn	Cr	Ni
wt-%	**0.03**	**0.7**	**1.5**	**19.8**	**10.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**380**	(≥ 350)
tensile strength R_m N/mm²:		**560**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 35)
impact work ISO-V KV J	+20 °C:	**70**	(≥ 47)
	-196 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data



re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
1.2	100 - 220	20 - 31
1.6	175 - 260	21 -29

=+

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for positional welding; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10
AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (09117.), DB (43.014.23), ÜZ (43.014/02), ÖBB, CL (1255), CWB (E308LT1-1(4)), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2 FOX EAS 2-A FOX EAS 2-VD	GMAW solid wire:	EAS 2-IG (Si)
		Metal cored wire:	EAS 2-MC
		GMAW flux cored wire:	EAS 2-FD
GTAW rod:	EAS 2-IG	SAW combination:	EAS 2-UP/BB202

EN 12073:1999:	T 19 9 Nb R M 3 T 19 9 Nb R C 3
AWS A5.22-95:	E347T0-4 E347T0-1

BÖHLER SAS 2-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

Rutile strip alloyed flux cored welding wire of type T 19 9 Nb R / E347LT0 for GMAW of stainless steels like 1.4546 / 347.
BÖHLER SAS 2-FD is designed for single and multi-pass welding mainly in the flat and horizontal position, horizontal/vertical position as well as the slightly vertical-down position (1 o'clock).
This product achieves high productivity and is easy to operate providing excellent operating characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration.
Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. Suitable for service temperatures from -196 °C to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.03**	**0.7**	**1.4**	**19.0**	**10.4**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 380)
tensile strength R_m N/mm²:		**600**	(≥ 560)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+20 °C:	**75**	(≥ 47)
	-120 °C:	**45**	(≥ 32)
	-196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

Ø 1.2


Ø 1.6


re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2
welding with standard GMAW-facilities possible slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

ø mm	**amps A**	**voltage V**
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

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Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11, 1.4301 X5CrNi18-10, 1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (09740.), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 2 FOX SAS 2-A	GMAW solid wire:	SAS 2-IG (Si)
		GMAW flux cored wire:	SAS 2 PW-FD
GTAW rod:	SAS 2-IG	SAW combination:	SAS 2-UP/BB 202

EN 12073:1999:	T 19 9 Nb P M 1 T 19 9 Nb P C 1
AWS A5.22-95:	E347T1-4 E347T1-1

BÖHLER SAS 2 PW-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

Rutile strip alloyed flux cored welding wire with fast freezing slag providing excellent positional operating characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag.
This flux cored welding wire offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable. Additional cost effective benefits are offered through use of less expensive shielding gases, good wetting characteristics (less grinding), little temper discoloration & bead oxidation (less pickling expenses), easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work).
Due to its characteristics mainly for positional welding and service temperatures between -120 °C to +400 °C. For downhand and horizontal welding positions (1G, 1F, 2F) our flux cored wire BÖHLER SAS 2FD should be preferred.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.03**	**0.7**	**1.4**	**19.0**	**10.4**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 380)
tensile strength R_m N/mm²:		**600**	(≥ 560)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 47)
	- 120 °C:	**38**	(≥ 35)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	100 - 220	20 - 31

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welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for positional welding; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11, 1.4301 X5CrNi18-10, 1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (10059.), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 2 FOX SAS 2-A	GMAW solid wire:	SAS 2-IG (Si)
		GMAW flux cored wire:	SAS 2-FD
GTAW rod:	SAS 2-IG	SAW combination:	SAS 2-UP/BB 202

BÖHLER EAS 4 M-FD

GMAW flux cored wire, high-alloyed, chemical resistant

EN 12073:1999:	T 19 12 3 L R M 3	
	T 19 12 3 L R C 3	
AWS A5.22-95:	E316LT0-4	
	E316LT0-1	
EN 12073:1999:	T 19 12 3 L P M (C) 1	(for ø 0.9 mm)
AWS A5.22-95:	E316LT1-4/-1	(for ø 0.9 mm)

Description

Rutile flux cored welding wire of type T 19 12 3 L R / E316LT0 for GMAW of stainless steels like 1.4435 / 316L. This product achieves high productivity and is easy to operate providing excellent operating characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money.

Suitable for service temperatures of -120 °C to +400 °C. Resists intergranular corrosion up to +400 °C. BÖHLER EAS 4 M-FD ø 0.9 mm is well suitable for welding of sheet metal from 1.5 to 3 mm (out of position > 5 mm) and ø 1.2 mm can be used for wall thicknesses from 3 mm and up. Wire ø 0.9 mm is designed for positional welding, wire ø 1.2 mm and 1.6 mm are recommended mainly for downhand and horizontal welding positions, horizontal/vertical position as well as the slightly vertical-down position (1 o'clock).

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.7**	**1.5**	**19.0**	**12.0**	**2.7**

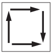
Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**400**	(≥ 350)
tensile strength R_m N/mm²:		**560**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 47)
	- 120 °C:	**35**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

Ø 0.9



Ø 1.2

Ø 1.6

re-drying: **possible, 150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
0.9	100 - 160	21 - 30
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2
UNS S31653; AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (5349.), DB (43.014.15), ÜZ (43.014/2), ÖBB, TÜV-A (515), CL (1131), CWB (E316LT0-1(4)), LR (DX, BF, 316LS), GL (4571 (C1, M21)), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	GMAW solid wire:	EAS 4 M-IG (Si)
	FOX EAS 4 M-A	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-VD	GMAW flux cored wire:	EAS 4 PW-FD
	FOX EAS 4 M-TS	SAW combination:	EAS 4 M-UP/BB 202
GTAW rod:	EAS 4 M-IG		

EN 12073:1999:	T 19 12 3 L P M 1 T 19 12 3 L P C 1
AWS A5.22-95:	E316LT1-4 E316LT1-1

BÖHLER EAS 4 PW-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

BÖHLER EAS 4 PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional operating characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag.
This flux cored welding wire offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable. Additional cost effective benefits are offered through use of less expensive shielding gases (Argon + 15-25 % CO_2 or 100 % CO_2), good wetting characteristics (less grinding), little temper discoloration & bead oxidation (less pickling expenses), easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work). Due to its characteristics mainly for positional welding and service temperatures between -120 °C to +400 °C. Resists intergranular corrosion up to +400 °C. For downhand & horizontal welding positions (1G, 1F, 2F) our flux cored wire BÖHLER EAS 4 M-FD should be preferred.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.03**	**0.7**	**1.5**	**19.0**	**12.0**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**400**	(≥ 350)
tensile strength R_m N/mm²:		**560**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**65**	(≥ 47)
	- 120 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	100 - 220	20 - 31
1.6	175 - 260	21 - 29

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for positional welding; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3,
1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2,
1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2
UNS S31653; AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (09118.), DB (43.014.24), ÜZ (43.014/02), ÖBB, CL (1461), LR (DXVu.O, BF, 316LS),
CWB (E316LT1-1(4)), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	GMAW solid wire:	EAS 4 M-IG (Si)
	FOX EAS 4 M-A	Metal cored wire:	EAS 4 M-MC
	FOX EAS 4 M-VD	GMAW flux cored wire:	EAS 4 M-FD
	FOX EAS 4 M-TS	SAW combination:	EAS 4 M-UP/BB 202
GTAW rod:	EAS 4 M-IG		

EN 12073:1999: T 19 12 3 Nb R M 3
T 19 12 3 Nb R C 3

BÖHLER SAS 4-FD

GMAW flux cored wire,
high-alloyed, chemical resistant

Description

Rutile, strip alloyed, flux cored welding wire for GMAW of austenitic CrNiMo (Ti/Cb) alloyed steels preferably used in the horizontal and downhand position as well as the slightly vertical down position (1 o'clock). This product provides high productivity and is easy to operate achieving excellent welding characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cieaning and pickling provide considerable savings in time and money. Suitable for service temperatures down to -120 °C. Resists to intergranular corrosion up to +400 °C. For positional welding (PF, PG, PE) our flux cored wire BÖHLER SAS 4 PW-FD should be preferred.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Nb
wt-%	**0.03**	**0.6**	**1.3**	**18.8**	**12.2**	**2.6**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**430**	(≥ 390)
tensile strength R_m N/mm²:		**570**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**65**	(≥ 47)
	- 120 °C:	**35**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

Ø 1.2


Ø 1.6


re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

=+

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4437 GX6CrNiMo18-12, 1.4409 GX2CrNiMo 19-11-2, 1.4581 GX5CrNiMoNb 19-11-2, UNS S31653, AISI 316, 316L, 316Ti, 316Cb

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4	GMAW solid wire:	SAS 4 -IG (Si)
	FOX SAS 4 -A	GMAW flux cored wire:	SAS 4 PW-FD
GTAW rod:	SAS 4 -IG	SAW combination:	SAS 4 -UP/BB 202

EN 12073:1999: T 19 12 3 Nb P M 1
T 19 12 3 Nb P C 1

BÖHLER SAS 4 PW-FD

GMAW flux cored wire,
high-alloyed, chemical resistant

Description

Rutile, strip alloyed, flux cored welding wire with fast freezing slag providing excellent positional welding characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag.
BÖHLER SAS 4 PW-FD offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable. Additional cost effective benefits are offered through use of less expensive shielding gases, good wetting characteristics (less grinding), little temper discoloration and bead oxidation (less pickling expenses), easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work). Due to its characteristics mainly for positional welding and service temperatures between -120 °C to +400 °C. For downhand and horizontal welding positions (PA, PB, PC) our flux cored wire SAS 4-FD should be preferred.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Nb
wt-%	**0.03**	**0.6**	**1.3**	**18.8**	**12.2**	**2.6**	**+**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**430**	(≥ 390)
tensile strength R_m N/mm²:		**570**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**65**	(≥ 47)
	- 120 °C:	**40**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying:
possible, 150 °C / 24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	100 - 220	20 - 31

=+

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for positional welding; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4437 GX6CrNiMo18-12, 1.4409 GX2CrNiMo 19-11-2, 1.4581 GX5CrNiMoNb 19-11-2, UNS S31653, AISI 316, 316L, 316Ti, 316Cb

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4	GMAW solid wire:	SAS 4 -IG (Si)
	FOX SAS 4 -A	GMAW flux cored wire:	SAS 4-FD
GTAW rod:	SAS 4 -IG	SAW combination:	SAS 4 -UP/BB 202

EN 12073:1999: TZ 19 13 4 L R M 3
TZ 19 13 4 L R C 3
AWS A5.22-95: E317LT0-4
E317LT0-1

BÖHLER E 317 L-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

This product achieves high productivity and is easy to operate providing excellent welding characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning and pickling provide considerably savings in time and money. It is designed for welding of corrosion resistant CrNiMo-steels in the flat and horizontal position, horizontal/vertical position as well as the slightly vertical-down position (1 o'clock). It satisfies the high demands of offshore fabricators, shipyards building chemical tankers as well as the chemical / petrochemical, pulp and paper industries. Suitable for service temperatures from -60 to +300 °C. The weld metal exhibits resistance against pitting corrosion and intergranular corrosion resistance (ASTM A 262 / Practise E) up to +300 °C. For corrosion resistant single claddings the wire should be used under mixture gas (Argon + 15 - 25 % CO_2)

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	FN
wt-%	≤ **0.035**	**0.7**	**1.3**	**18.5**	**13.3**	**3.4**	**3-8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 350)
tensile strength R_m N/mm²:		**570**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**50**	(≥ 47)
	- 60 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 18 % CO_2*

Operating Data

re-drying: **possible, 150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
1.2	125 - 280	20 - 34

=+

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15 - 18 l/min

Base Materials

CrNiMo-steels with higher Mo-content like grade AISI 317L or corrosion resistant claddings on mild steels

1.4435 X2CrNiMo18-14-3, 1.4429 X2CrNiMoN17-13-3, 1.4438 X 2 CrNiMo 18-15-4

AISI 316L, 316 LN, 317LN, 317L

Approvals and Certificates

UDT

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 317 L	GMAW solid wire:	ASN 5-IG (Si)
	FOX ASN 5	GMAW flux cored wire:	E 317 L PW-FD
	FOX ASN 5-A	SAW combination:	ASN 5-SY5UP/BB 203
GTAW rod:	ASN 5-IG		

EN 12073:1999:	TZ 19 13 4 L P M 1
	TZ 19 13 4 L P C 1
AWS A5.22-95:	E317LT1-4
	E317LT1-1

BÖHLER E 317 L PW-FD

GMAW flux cored wire, high-alloyed, chemical resistant

Description

E 317L PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional operating characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag.
It is designed for welding of corrosion resistant CrNiMo-steels and satisfies the high demands of offshore fabricators, shipyards building chemical tankers as well as the chemical/petrochemical, pulp and paper industries.
Suitable for service temperatures from -60 °C to +300 °C.
The weld metal exhibits resistance against pitting corrosion and intergranular corrosion resistance (ASTM A 262 / Practise E) up to 300 °C. For corrosion resistant single claddings the wire should be used under mixture gas (Argon + 15-25% CO_2)

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	FN
wt-%	≤ **0.035**	**0.7**	**1.3**	**18.5**	**13.3**	**3.4**	**5-10**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**380**	(≥ 350)
tensile strength R_m N/mm²:		**560**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**39**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**58**	(≥ 47)
	- 60 °C:	**50**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 18 % CO_2*

Operating Data

re-drying: **possible, 150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	100 - 220	20 - 31

=+

Preheating and post weld heat treatment is not required by the weld deposit. The interpass temperature should be kept below 150 °C. Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80°), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15-18 l/min.

Base Materials

CrNiMo-steels with increased Mo-content, or corrosion resistant claddings on mild steels.

1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4429 X2CrNiMoN17-11-2,

AISI 316L, 316 LN, 317 L, 317LN

Approvals and Certificates

BV (317 L), LR (DXVuO, BF, 317L)

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 317 L	GMAW solid wire:	ASN 5-IG (Si)
	FOX ASN 5	GMAW flux cored wire:	E 317 L-FD
	FOX ASN 5-A	SAW combination:	ASN 5SY-UP/BB 203
GTAW rod:	ASN 5-IG		

EN 12073:1999: T 22 9 3 NL R M 3
T 22 9 3 NL R C 3
AWS A5.22-95: E2209T0-4
E2209T0-1

BÖHLER CN 22/9 N-FD

GMAW flux cored wire, high-alloyed, highly corrosion resistant

Description

BÖHLER CN 22/9 N-FD is a rutile DUPLEX-steel flux-cored wire for GMAW of 1.4462 / S31803 steel grades. Besides its high productivity and all the other general benefits of flux cored wire welding it offers good wetting characteristics, easy slag release, very little temper discoloration & bead oxidation, smooth and clean weld finish. These specific advantages help to save additional costs especially when GMAW the Duplex steels.
The structure of the all-weld metal is austenitic-ferritic (FN 35-50). The pitting corrosion resistance factor PREN is higher than 35. The weld deposit is corrosion resistant acc. to ASTM A262-93a, practice E, C, B and ASTM G48/method A (24h) up to 22 °C (as welded, pickled), 30 °C (solution treated, pickled).
The broad field of welding parameters for BÖHLER CN 22/9 N-FD permits universal application in a very wide range of wall thicknesses using the spray-arc transfer together with fast travel speeds which help to control the maximum heat inputs easily.
BÖHLER CN 22/9 N-FD provides outstanding welding results in the flat and horizontal position, horizontal/vertical position as well as the slightly vertical-down position (1 o'clock). Service temperatures between -40 °C and +250 °C are usable.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N	FN
wt-%	**0.03**	**0.8**	**0.9**	**22.7**	**9.0**	**3.2**	**0.13**	≥ **35**	**30-50**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**600**	(≥ 450)
tensile strength R_m N/mm²:		**800**	(≥ 690)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 47)
	- 40 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying: **possible, 150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	125 - 280	22 - 36

=+

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80°), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15-18 l/min.

Base Materials

same and similar alloyed duplex steels, as well as dissimilar joints or weld claddings
1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4,
1.4462 X2CrNiMoN22-5-3 with 1.4583 X10CrNiMoNb18-12,
1.4462 X2CrNiMoN22-5-3 with P235GH / P265GH, S255N, P295GH, S460N, 16Mo3
UNS S31803, S32205

Approvals and Certificates

TÜV-D (7133.), ABS (E 2209 T0-4), CL (1113), CWB (E2209T0-4), DNV (Duplex (M21)), GL (4462S (M21,C1)), LR (X (M21)), RINA (2209S), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N-B	GMAW solid wire:	CN 22/9 N-IG
	FOX CN 22/9 N	GMAW flux cored wire:	CN 22/9 PW-FD
GTAW rod:	CN 22/9 N-IG	SAW combination:	CN 22/9 N-UP/BB 202

EN 12073:1999: T 22 9 3 NL P M 1
T 22 9 3 NL P C 1
AWS A5.22-95: E2209T1-4
E2209T1-1

BÖHLER CN 22/9 PW-FD

GMAW flux cored wire, high-alloyed, highly corrosion resistant

Description

BÖHLER CN 22/9 PW-FD is a rutile Duplex steel all-positional flux cored wire for GMAW the steel grades 1.4462 / S31803. It is suited for joint welding of similar alloyed austenitic-ferritic duplex steels as well as for dissimilar joints and weld cladding. The weld metal is resistant against intergranular corrosion (wet corrosion up to +250 °C). It features a good resistance against pitting (CPT ASTM G48/method A (24 h) up to 25 °C) and stress corrosion cracking in chloride-containing fluids i.e. sea water.
BÖHLER CN 22/9 PW-FD is an ideal completion of our high class range of Duplex Filler Metals. It is designed to satisfy the high demands of offshore fabricators, shipyards building chemical tankers as well as the chemical/petrochemical, pulp and paper industries. Service temperatures between -40 °C and +250 °C are usable. Good wetting characteristics (less grinding), easy slag release, very little temper discoloration & bead oxidation (less pickling expenses), and smooth and clean weld finish help to save additional costs especially when multi-pass welding Duplex stainless steels.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N	FN
wt-%	≤ **0.03**	**0.8**	**0.9**	**22.7**	**9.0**	**3.2**	**0.13**	≥ **35**	**30-50**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**600**	(≥ 480)
tensile strength R_m N/mm²:		**800**	(≥ 690)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**80**	(≥ 47)
	- 20 °C:	**65**	
	- 40 °C:	**55**	
	- 46 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying: **possible, 150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	100 - 220	20 - 31

=+

welding with standard GMAW-facilities possible slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for all welding positions; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V; the gas flow should be 15 - 18 l/min

Base Materials

same and similar alloyed duplex steels, as well as dissimilar joints or weld claddings
1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4, 1.4462 X2CrNiMoN22-5-3 with 1.4583 X10CrNiMoNb18-12, 1.4462 X2CrNiMoN22-5-3 with P235GH / P265GH, S255N, P295GH, S460N, 16Mo3, UNS S31803, S32205

Approvals and Certificates

TÜV-D (7666.), ABS (E 22 09 T1-4(1)), CL (1268), CWB (E2209T1-1(4)), DNV (X(M21;C1)), GL (4462S (M21)), LR (X(M21,C1)), RINA (2209 S), UDT

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N-B	GMAW solid wire:	CN 22/9 N-IG
	FOX CN 22/9 N	GMAW flux cored wire:	CN 22/9 N-FD
GTAW rod:	CN 22/9 N-IG	SAW combination:	CN 22/9 N-UP/BB 202

SAW solid wire:
EN 12072:1999: S 13 4
AWS A5.9-93: ER410NiMo(mod.)
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER CN 13/4-UP // BB 203

SAW wire/flux-combination, high-alloyed, stainless

Description

Sub-arc wire/flux combination for welding similar soft-martensitic steels like 1.4313 / CA 6 NM. BÖHLER CN 13/4-UP // BB 203 yields a weld deposit featuring very good ductility and CVN toughness as well as high crack resistance.
BÖHLER BB 203 is a fluoride-basic, agglomerated flux providing good operating characteristics, smooth beads and a low hydrogen weld metal (HD ≤ 5 ml/100 g).
For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
SAW solid wire %	≤ **0.020**	**0.7**	**0.6**	**12.2**	**4.8**	**0.5**
all-weld metal %	**0.025**	**0.6**	**0.6**	**12.1**	**4.7**	**0.5**

Mechanical Properties of All-weld Metal

(*)		a
yield strength R_e N/mm²:		≥ 600
tensile strength R_m N/mm²:		≥ 800
elongation A ($L_0 = 5d_0$) %:		≥ 15
impact work ISO-V KV J	+ 20 °C:	≥ 50

(*) *a annealed, 600 °C/2 h*

Operating Data

re-drying of sub-arc flux:
300 - 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Preheat and interpass temperatures in case of thick-walled sections +100 - 160 °C.
Maximum heat input 15 kJ/cm. Tempering at +580 - 620 °C.

Base Materials

1.4317 GX4CrNi13-4, 1.4313 X3CrNiMo13-4, 1.4351 X3CrNi13-4, 1.4414 GX4CrNiMo13-4

ACI Gr. CA 6 NM

Approvals and Certificates

UDT, SEPROZ
SAW solid wire: SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 13/4	GMAW solid wire:	CN 13/4-IG
	FOX CN 13/4 SUPRA	Metal cored wire:	CN 13/4-MC
GTAW rod:	CN 13/4-IG		CN 13/4-MC (F)

SAW solid wire:
EN 12072:1999 S 17 Mo H
W.No.: 1.4115

Sub-arc flux:
EN 760: SA FB 2 DC

BÖHLER SKWAM-UP // BB 203

SAW wire/flux-combination high-alloyed, stainless

Description

SAW wire/flux combination of type 17 % Cr 1 % Mo for surfacing on sealing faces of gas, water and steam valves and fittings made from unalloyed or low-alloy steels, for service temperatures up to +450 °C. Excellent anti-friction properties. The weld deposit is still machinable. Scaling resistant up to +900 °C. BÖHLER BB 203 produces well contoured and smooth welding beads. It offers an especially low flux consumption. Beside a good slag detachability the flux features good fillet weld capabilities. For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo
SAW wire wt-%	**0.16**	**0.6**	**0.7**	**17.0**	**1.1**
all-weld metal %	**0.15**	**0.6**	**0.7**	**16.5**	**1.1**

Mechanical Properties of All-weld Metal

(*)	u
Brinell-hardness HB:	**320-420**

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300-350 °C / **2-10 h**
max. amperage of sub-arc flux:
800 A

ø mm
3.2

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Base Materials

surfacings:
all weldable backing materials, unalloyed, low-alloyed and stainless steel.

Approvals and Certificates

TÜV-D (90949.50 for service temperatures up to +350 °C)

Same Alloy Filler Metals

SMAW stick electrode:	FOX SKWAM
GMAW solid wire:	SKWAM-IG

SAW solid wire:
EN 12072:1999: S 19 9 L
AWS A5.9-93: ER308L
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER EAS 2-UP // BB 202

SAW wire/flux-combination, high-alloyed, chemical resistant

Description

SAW-wire/flux combination for multi-pass welding of stainless steel grades like 1.4306 / 304L. Smooth beads, easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users.
Suited for service temperatures from -196 °C to +350 °C.
BÖHLER BB 202 is a fluoride-basic agglomerated flux providing a low flux consumption and a low hydrogen weld metal. For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni
SAW solid wire %	**0.02**	**0.45**	**1.7**	**20.1**	**10.8**
all-weld metal %	**0.02**	**0.60**	**1.3**	**19.8**	**10.8**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 350
tensile strength R_m N/mm²:		≥ 550
elongation A ($L_0 = 5d_0$) %:		≥ 35
impact work ISO-V KV J	+ 20 °C:	≥ 80
	- 50 °C:	≥ 60
	- 100 °C:	≥ 50
	- 196 °C:	≥ 35

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Base Materials

1.4306 X2CrNi19-11, 1.4301 X5CrNi18-10, 1.4311 X2CrNiN18-10, 1.4312 GX10CrNi18-8, 1.4541 X6CrNiTi18-10, 1.4546 X5CrNiNb18-10, 1.4550 X6CrNiNb18-10

AISI 304, 304L, 304LN, 302, 321, 347; ASTM A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (7509.), UDT, TÜV-D (9170. together with BB 203),
SAW solid wire: TÜV-D (2604.), KTA 1408 1 (942025.01), DB (52014.11), ÜZ (52014/2), TÜV-A (392), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 2	GMAW solid wire:	EAS 2-IG (Si)
	FOX EAS 2-A	Metal cored wire:	EAS 2-MC
	FOX EAS 2-VD	GMAW flux cored wire:	EAS 2-FD
GTAW rod:	EAS 2-IG		EAS 2 PW-FD

SAW solid wire:
EN 12072:1999: S 19 9 Nb
AWS A5.9-93: ER347
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER SAS 2-UP // BB 202

SAW wire/flux-combination, high-alloyed, chemical resistant

Description

SAW wire/flux-combination for multi-pass welding of stainless steel grades like 1.4541 / 347. Smooth beads, easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users.
Suited for service temperatures from -196 °C to +400 °C. BÖHLER BB 202 is a fluoride-basic agglomerated flux providing a low flux consumption and a low hydrogen weld metal.
For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
SAW solid wire %	≤ **0.050**	**0.50**	**1.7**	**19.5**	**9.5**	**0.60**
all-weld metal %	≤ **0.045**	**0.65**	**1.3**	**19.3**	**9.5**	**0.50**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 420
tensile strength R_m N/mm²:		≥ 600
elongation A ($L_0 = 5d_0$) %:		≥ 30
impact work ISO-V KV J	+ 20 °C:	≥ 90
	- 50 °C:	≥ 70
	- 100 °C:	≥ 50
	- 196 °C:	≥ 35

(*) u untreated, as-welded

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Base Materials

1.4550 X6CrNiNb18-10, 1.4541 X6CrNiTi18-10, 1.4552 GX5CrNiNb19-11,
1.4301 X5CrNi18-10,
1.4312 GX10CrNi18-8, 1.4546 X5CrNiNb18-10, 1.4311 X2CrNiN18-10, 1.4306 X2CrNi19-11

AISI 347, 321, 302, 304, 304L, 304LN; ASTM A296 Gr. CF 8 C; A157 Gr. C9; A320 Gr. B8C or D

Approvals and Certificates

TÜV-D (7510.), TÜV-A (428), UDT, TÜV-D (9172. together with BB 203),
SAW solid wire: TÜV-D (2604.), KTA 1408 1 (942025.01), DB (52.014.02), ÜZ (52.014/2), ÖBB, TÜV-A (392), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 2	GMAW solid wire:	SAS 2-IG (Si)
	FOX SAS 2-A	GMAW flux cored wire:	SAS 2-FD
GTAW rod:	SAS 2-IG		SAS 2 PW-FD

SAW solid wire:	
EN 12072:1999:	S 19 12 3 L
AWS A5.9-93:	ER316L
sub-arc flux:	
EN 760:1996:	SA FB 2 DC

BÖHLER EAS 4 M-UP // BB 202

SAW wire/flux-combination, high-alloyed, chemical resistant

Description

SAW wire/flux-combination for multi-pass welding of stainless steel grades like 1.4435 / 316L. Smooth beads, easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users.
Suited for service temperatures from -120 °C to +400 °C.
BÖHLER BB 202 is a fluoride-basic agglomerated flux providing a low flux consumption and a low hydrogen weld metal. For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
SAW solid wire %	**0.02**	**0.45**	**1.7**	**18.5**	**12.2**	**2.8**
all-weld metal %	**0.02**	**0.60**	**1.3**	**18.3**	**12.2**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 350
tensile strength R_m N/mm2:		≥ 560
elongation A ($L_0 = 5d_0$) %:		≥ 35
impact work ISO-V KV J	+ 20 °C:	≥ 80
	- 50 °C:	≥ 60
	- 100 °C:	≥ 50
	-120 °C:	≥ 32

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Base Materials

1.4401 X5CrNiMo17-12-2, 1.4404 X2CrNiMo17-12-2, 1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3, 1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4583 X10CrNiMoNb18-12, 1.4409 GX2CrNiMo 19-11-2

UNS S31653; AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (7508.), UDT, TÜV-D (9175 together with BB 203),
SAW solid wire: TÜV-D (2604.), KTA 1408 1 (942025.01), DB (52.014.13), ÜZ (52.014/2), ÖBB, TÜV-A (392), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX EAS 4 M	GMAW solid wire:	EAS 4 M-IG (Si)
	FOX EAS 4 M-A	Welding cored wire:	EAS 4 M-MC
	FOX EAS 4 M-VD	GMAW flux cored wire:	EAS 4 M-FD
	FOX EAS 4 M-TS		EAS 4 PW-FD
GTAW rod:	EAS 4 M-IG		

SAW solid wire:
EN 12072:1999: S 19 12 3 Nb
AWS A5.9-93: ER318
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER SAS 4-UP // BB 202

SAW wire/flux-combination, high-alloyed, chemical resistant

Description

SAW wire/flux-combination for multi-pass welding of stainless steel grades like 1.4571 / 316Ti. Smooth beads, easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users.
Suited for service temperatures from -120 °C to +400 °C. BÖHLER BB 202 is a fluoride-basic agglomerated flux providing a low flux consumption and a low hydrogen weld metal.
For information regarding the sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Nb
SAW solid wire %	**0.030**	**0.50**	**1.7**	**19.6**	**11.4**	**2.7**	**0.55**
all-weld metal %	**0.025**	**0.65**	**1.3**	**18.8**	**11.4**	**2.7**	**0.45**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 430
tensile strength R_m N/mm2:		≥ 600
elongation A ($L_0 = 5d_0$) %:		≥ 30
impact work ISO-V KV J	+ 20 °C:	≥ 80
	- 50 °C:	≥ 70
	- 120 °C:	≥ 32

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Base Materials

1.4571 X6CrNiMoTi17-12-2, 1.4580 X6CrNiMoNb17-12-2, 1.4401 X5CrNiMo17-12-2, 1.4581 GX5CrNiMoNb19-11-2, 1.4437 GX6CrNiMo18-12, 1.4583 X10CrNiMoNb18-12, 1.4436 X3CrNiMo17-13-3

AISI 316L, 316Ti, 316Cb

Approvals and Certificates

TÜV-D (7511.), TÜV-A (429), UDT, TÜV-D (9171. with BB 203),
SAW solid wire: TÜV-D (2604.), KTA 1408 1 (942025.01), DB (52.014.12), ÜZ (52.014/2), ÖBB, TÜV-A (392), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX SAS 4	GMAW solid wire:	SAS 4-IG (Si)
	FOX SAS 4-A	GMAW flux cored wire:	SAS 4-FD
GTAW rod:	SAS 4-IG		SAS 4 PW-FD

SAW solid wire:
AWS A5.9-93: ER317L

Sub-arc flux:
EN 760: SA FB 2 DC

BÖHLER ASN 5 SY-UP // BB 202

SAW wire/flux-combination
high-alloyed, highly corrosion resistant

Description

Sub-arc wire/flux combination for CrNiMo steels. It satisfies the high demands of offshore fabricators, shipyards building chemical tankers as well as the chemical/petrochemical, pulp and paper industries. Suitable for service temperatures from -60 °C to +300 °C. The weld metal exhibits resistance against pitting corrosion and intergranular corrosion resistance (ASTM A 262 / Practice E) up to 300 °C. BÖHLER BB 203 SY is a fluoride-basic agglomerated flux providing a low flux consumption. Preheating and post weld heat treatment is not required by the weld deposit. The interpass temperature should be kept below 150 °C.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	FN
SAW wire wt-%	**≤0.03**	**0.50**	**1.6**	**19.0**	**13.5**	**3.6**	
all-weld metal %	**<0.03**	**0.60**	**1.2**	**18.5**	**13.4**	**3.5**	**4-12**

Mechanical Properties of All-weld Metal

		u	
yield strength R_e N/mm²:		**410**	(≥ 350)
tensile strength R_m N/mm²:		**590**	(≥ 550)
elongation A (L_0=5d_0) %:		**29**	(≥ 25)
impact work ISO-V KV J	+20 °C:	**58**	(≥ 47)
	-60 °C:	**50**	(≥ 32)

u untreated, as welded

Operating Data

re-drying of sub-arc flux:
300-350 °C / **min. 2, max. 10 h**
max. amperage of sub-arc flux:
800 A

ø mm
3.0
4.0

=±

Base Materials

CrNiMo-steels with increased Mo-content like grade, resp. for corrosion resistant claddings on mild steels
1.4435 X2CrNiMo18-14-3, 1.4436 X3CrNiMo17-13-3,
1.4429 X2CrNiMoN17-11-2, AISI 316L, 316 LN, 317 L, 317LN

Approvals and Certificates

BV (317 L), LR (D, BF 317L)

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX E 317 L
GMAW flux cored wire:	E 317 L PW-FD
	E317 L-FD

SAW solid wire:
EN 12072:1999: S 18 16 5 NL
AWS A5.9-93: ER317LN (mod.)
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER ASN 5-UP // BB 203

SAW wire/flux-combination, high-alloyed, highly corrosion resistant

Description

Sub-arc wire/flux combination for CrNiMo steels containing 3-4 % Mo e.g. 1.4438 / 317L. The weld metal shows a stable austenitic microstructure with good pitting resistance (PREN > 33) and crevice corrosion resistance as well as an excellent toughness behaviour down to -196 °C. BÖHLER BB 203 is a fluoride-basic agglomerated flux providing good operating characteristics, smooth beads and a low-hydrogen weld metal. For information regarding the sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
SAW solid wire %	**0.02**	**0.2**	**5.0**	**19.0**	**16.5**	**4.0**	**0.15**	**34.6**
all-weld metal %	**0.02**	**0.2**	**4.5**	**18.5**	**16.3**	**4.0**	**0.14**	**33.9**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		≥ 420
tensile strength R_m N/mm2:		≥ 630
elongation A ($L_0 = 5d_0$) %:		≥ 35
impact work ISO-V KV J	+ 20 °C:	≥ 120
	- 50 °C:	≥ 100
	- 100 °C:	≥ 80
	- 196 °C:	≥ 40

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Base Materials

1.4436 X3CrNiMo17-13-3, 1.4439 X2CrNiMoN17-13-5, 1.4429 X2CrNiMoN17-13-3, 1.4438 X2CrNiMo18-15-4, 1.4583 X10CrNiMoNb18-12

AISI 316Cb, 316L, 317LN, 317L; UNS S31726

Approvals and Certificates

UDT

Same Alloy / Similar Alloys Filler Metals

SMAW stick electrode:	FOX ASN 5	GMAW solid wire:	ASN 5-IG (Si)
	FOX ASN 5-A	GMAW flux cored wire:	E 317L-FD*
GTAW rod:	ASN 5-IG		E 317L PW-FD*

* for similar alloyed base metals only, not fully austenitic.

SAW solid wire:
EN 12072:1999: S 22 9 3 NL
AWS A5.9-93: ER2209
sub-arc flux:
EN 760:1996: SA FB 2 DC

BÖHLER CN 22/9 N-UP // BB 202

SAW wire/flux-combination, high-alloyed, highly corrosion resistant

Description

Sub-arc wire/flux combination for welding the Duplex stainless steels 1.4462 / S31803. Smooth beads, easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users.
Suitable for service temperatures from -40 °C to +250 °C. The pitting index PREN is > 35. BÖHLER BB 202 is a fluoride-basic agglomerated flux. For CVN requirements lower than -40 °C we recommend our flux BÖHLER BB 203. For information regarding the sub-arc welding fluxes BÖHLER BB 202 and BB 203 see our detailed data sheets.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N	PRE_N
SAW solid wire %	≤ **0.02**	**0.40**	**1.7**	**23.0**	**9.0**	**3.2**	**0.15**	**36.0**
all-weld metal %	**0.015**	**0.55**	**1.30**	**22.5**	**8.9**	**3.1**	**0.14**	**35.0**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 550
tensile strength R_m N/mm²:		≥ 750
elongation A ($L_0 = 5d_0$) %:		≥ 27
impact work ISO-V KV J	+ 20 °C:	≥ 100
	- 40 °C:	≥ 32

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage: **800 A**

ø mm
3.0

=±

Base Materials

same-alloyed duplex stainless steels, as well as similar-alloyed, ferritic-austenitic steels with higher tensile strength

1.4462 X2CrNiMoN22-5-3, 1.4362 X2CrNiN23-4,
1.4462 X2CrNiMoN22-5-3 with 1.4583 X10CrNiMoNb18-12
or other stainless steel grades

UNS S31803, S32205

Approvals and Certificates

TÜV-D (7507.), TÜV-A (339), ABS (ER 2209), CL (1049), DNV (X), GL (4462 TM), LR (X), UDT, (TÜV-D with BB203 9173.)

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 22/9 N-B	GMAW solid wire:	CN 22/9 N-IG
	FOX CN 22/9 N	GMAW flux cored wire:	CN 22/9 PW-FD
GTAW rod:	CN 22/9 N-IG		CN 22/9 N-FD

Notes

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Notes

2.7 Filler metals for Dissimilar Joints and Special Applications

Objectives

The materials used for welding engineering appear vast, confusing and complicated if one takes into consideration all the dissimilar weld joints that are possible between the most varied types of steel. It is practically impossible to record every individual combination of materials. Since this is the case, the queries received by our welding technicians help line very often refer to the practical problems surrounding welding of dissimilar joints.
The choice of filler metal must be emphasised as a crucial criterion. This choice must be made so that where possible the weld metal generated is not too hard, brittle and susceptible to cracks allowing for dilution with the different parent metals.
As a consequence of this, later sections of this manual set out general ground rules containing tips, recommendations and precautionary measures in the form of broad guidelines which are to be considered when choosing filler metals and creating a welding technology. However, ground rules such as these may only be deemed as of value if they can be implemented in practice with sufficient expertise and basic knowledge of metallurgy.
This section describes filler metals that may be used for many different dissimilar welds or in the welding of problem steels.

Contents

Overview – Standard Classifications

Böhler	EN		AWS	
SMAW stick electrodes				
FOX A 7	EN 1600:	E 18 8 Mn B 2 2	AWS A5.4-92:	E307-15(mod.)
FOX A 7-A	EN 1600:	E Z 18 9 MnMo R 3 2	AWS A5.4-92:	E307-16(mod.)
FOX CN 19/9 M	EN 1600:	E 20 10 3 R 3 2	AWS A5.4-92:	E308Mo-17(mod.)
FOX CN 23/12-A	EN 1600:	E 23 12 L R 3 2	AWS A5.4-92:	E309L-17
FOX CN 23/12 Mo-A	EN 1600:	E 23 12 2 L R 3 2	AWS A5.4-92:	E309MoL-17(mod.)
FOX CN 24/13	EN 1600:	E 23 12 B 2 2	AWS A5.4-92:	E309L-15
FOX CN 24/13 Nb	EN 1600:	E 23 12 Nb B 2 2	AWS A5.4-92:	E309Cb-15
FOX CN 29/9	EN 1600:	E 29 9 R 1 2	AWS A5.4-92:	E312-16(mod.)
FOX CN 29/9-A	EN 1600:	E 29 9 R 3 2	AWS A5.4-92:	E312-17(mod.)
FOX RDA				
GTAW rods				
A 7 CN-IG	EN 12072:	W 18 8 Mn	AWS A5.9-93:	ER307(mod.)
CN 19/9 M-IG	EN 12072:	W 20 10 3	AWS A5.9-93:	ER308Mo(mod.)
CN 23/12-IG	EN 12072:	W 23 12 L	AWS A5.9-93:	ER309L
GMAW solid wires				
A 7-IG	EN 12072:	G 18 8 Mn	AWS A5.9-93:	ER307(mod.)
CN 19/9 M-IG	EN 12072:	G 20 10 3	AWS A5.9-93:	ER308Mo(mod.)
CN 23/12-IG	EN 12072:	G 23 12 L	AWS A5.9-93:	ER309L
GMAW flux-cored wires				
A 7-MC	EN 12073:	T 18 8 Mn MM1	AWS A5.9-93:	EC307(mod.)
CN 23/12-MC	EN 12073:	T 23 12 L MM1	AWS A5.9-93:	E309L
A 7-FD	EN 12073:	T 18 8 Mn R M 3	AWS A5.22-95:	E307T0-G
		T 18 8 Mn R C 3		
A 7 PW-FD	EN 12073:	T 18 8 Mn P M 2	AWS A5.22-95:	E307T1-G
		T 18 8 Mn P C 2		
CN 23/12-FD	EN 12073:	T 23 12 L R M 3	AWS A5.22-95:	E309LT0-4
		T 23 12 L R C 3		E309LT0-1
CN 23/12 PW-FD	EN 12073:	T 23 12 L P M 1	AWS A5.22-95:	E309LT1-4
		T 23 12 L P C 1		E309LT1-1
CN 23/12 Mo-FD	EN 12073:	T 23 12 2 L R M 3	AWS A5.22-95:	E309LMoT0-4
		T 23 12 2 L R C 3		E309LMoT0-1
CN 23/12 Mo PW-FD	EN 12073:	T 23 12 2 L P M 1	AWS A5.22-95:	E309LMoT1-4
		T 23 12 2 L P C 1		E309LMoT1-1
SAW wire/flux-combinations				
A 7CN-UP	EN 12072:	S 18 8 Mn	AWS A5.9-93:	ER307(mod.)
A 7CN-UP/BB 203	EN 12072/760:	S 18 8 Mn / SA FB 2	AWS:	ER307(mod.)
CN 23/12-UP	EN 12072:	S 23 12 L	AWS A5.9-93:	ER309L
CN 23/12-UP/BB 202	EN 12072/760:	S 23 12 L / SA FB 2	AWS:	ER309L

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb
SMAW stick electrodes							
FOX A 7	0.10	0.7	6.5	18.8	8.8	–	
FOX A 7-A	0.10	1.2	4.2	19.5	8.5	0.7	
FOX CN 19/9 M	0.04	0.8	1.0	20.2	10.3	3.2	
FOX CN 23/12-A	0.02	0.7	0.7	23.0	12.5	–	
FOX CN 23/12 Mo-A	0.02	0.7	0.8	23.0	12.5	2.7	
FOX CN 24/13	0.03	0.3	1.3	24.0	13.0		
FOX CN 24/13 Nb	0.03	0.4	1.0	24.5	12.5	–	0.85
FOX CN 29/9	0.11	1.0	0.7	29.0	10.2		
FOX CN 29/9-A	0.11	0.9	0.7	28.5	9.5		
FOX RDA	–	–	–	–	–	–	
GTAW rods							
A 7 CN-IG	0.08	0.8	7.0	19.0	9.0		
CN 19/9 M-IG	0.06	0.7	1.3	20.0	10.0	3.3	
CN 23/12-IG	≤ 0.02	0.5	1.7	24.0	13.2		
GMAW solid wires							
A 7-IG	0.08	0.9	7.0	19.2	9.0		
CN 19/9 M-IG	0.06	0.7	1.3	20.0	10.0	3.3	
CN 23/12-IG	0.02	0.5	1.7	24.0	13.2		
GMAW flux-cored wires							
A 7-MC	0.1	0.6	6.3	18.8	9.2		
CN 23/12-MC	≤0.03	0.6	1.4	22.7	12.2		
A 7-FD	0.1	0.7	6.5	18.5	8.8		
A 7 PW-FD	0.1	0.8	7.0	19.0	9.0		
CN 23/12-FD	≤0.03	0.7	1.4	22.8	12.5		
CN 23/12 PW-FD	≤0.03	0.7	1.4	22.8	12.5		
CN 23/12 Mo-FD	≤0.03	0.6	1.4	22.7	12.3	2.7	
CN 23/12 Mo PW-FD	≤0.03	0.7	1.4	22.7	12.3	2.7	
SAW wire/flux-combinations							
A 7CN-UP	0.08	0.8	7.0	19.2	9.0		
A 7CN-UP/BB 203	0.08	0.9	6.8	18.5	8.8		
CN 23/12-UP	≤0.02	0.5	1.7	24.0	13.2		
CN 23/12-UP/BB 202	0.015	0.65	1.3	23.4	13.1		

EN 1600:1997: E 18 8 Mn B 2 2
AWS A5.4-92: E307-15(mod.)

BÖHLER FOX A 7

SMAW stick electrode, high-alloyed, special applications

Description

Basic coated special stainless steel electrode for joint welding of dissimilar joints, problem steels and for repair and maintenance. Very popular electrode for numerous applications. The weld metal offers exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -110 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier. The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.1**	**0.7**	**6.5**	**18.8**	**8.8**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 390)
tensile strength R_m N/mm²:		**660**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**90**	(≥ 80)
	- 110 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX A 7 E 18 8 Mn B

ø mm	L mm	amps A
2.5	300	55 - 75
3.2	350	80 - 100
4.0	350	100 - 130
5.0	450	140 - 170
6.0	450	160 - 200

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

TÜV-D (06786.), DNV (E 18 8 MnB), GL (4370), UDT, LTSS, VUZ, PRS (4370), SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7-A	Metal cored wire:	A 7-MC
GTAW rod:	A 7CN-IG	GMAW flux cored wire:	A 7-FD, A 7 PW-FD
GMAW solid wire:	A 7-IG	SAW combination:	A 7CN-UP/BB 203

EN 1600:1997: E Z 18 9 MnMo R 3 2
AWS A5.4-92: E307-16(mod.)

BÖHLER FOX A 7-A

SMAW stick electrode, high-alloyed, special applications

Description

Rutile-basic coated special stainless steel electrode for joint welding of dissimilar joints, problem steels and for repair and maintenance. Very popular electrode for numerous applications. The weld metal offers exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -100 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier. The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance. BÖHLER FOX A 7-A is suitable for both AC and DC.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.10**	**1.2**	**4.2**	**19.5**	**8.5**	**0.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**520**	(≥ 390)
tensile strength R_m N/mm²:		**720**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 47)
	- 100 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX A 7-A E Z 18 9 MnMo R

ø mm	L mm	amps A
2.5	350	60 - 80
3.2	350	80 - 110
4.0	350	110 - 140
5.0	450	140 - 170

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Preheating and interpass temperature as required by the base metal.

Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

TÜV-D (09101.), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7	Metal cored wire:	A 7-MC
GTAW rod:	A 7CN-IG	GMAW flux cored wire:	A 7-FD, A 7 PW-FD
GMAW solid wire:	A 7-IG	SAW combination:	A 7CN-UP/BB203

EN 1600:1997: E 20 10 3 R 3 2
AWS A5.4-92 E308Mo-17(mod.)

BÖHLER FOX CN 19/9 M

SMAW stick electrode, high-alloyed, special applications

Description

Rutile coated electrode of type E 20 10 3 / 308Mo. This electrode is designed for dissimilar joints and weld cladding.
BÖHLER FOX CN 19/9 M offers a lower chromium and ferrite content than a 309MoL weld deposit with the result that carbon diffusion and Cr-carbide formation is reduced after post weld heat treatment and lower ferrite contents can be achieved in the second layer of 316L claddings.
Suitable for service temperatures from -80 °C to +300 °C. Safety against formation of porosity due to the moisture resistant coating.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	N
wt-%	**0.04**	**0.8**	**1.0**	**20.2**	**10.3**	**3.2**	**0.09**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**520**	(≥ 450)
tensile strength R_m N/mm²:		**700**	(≥ 650)
elongation A ($L_0 = 5d_0$) %:		**30**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 55)
	- 80 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX CN 19 9 M E 20 10 3 R

ø mm	**L mm**	**amps A**
2.5	250	50 - 85
3.2	350	75 - 115
4.0	350	110 - 160
5.0	450	160 - 200

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Preheating and interpass temperature as required by the base metal.

Base Materials

high-strength, mild steels and low-alloyed constructional steels, QT-steels and armour plates among themselves or among each other; non-alloy as well as alloyed boiler or constructional steels with high-alloy stainless Cr- and Cr-Ni-steels; austenitic manganese steels similar and dissimilar.

Approvals and Certificates

TÜV-D (1086.), DB (30.014.03), ÜZ (30.014), ÖBB, ABS (Cr18/20, Ni8/10Mo), GL (4431), LR (V4-P12), UDT

Same Alloy Filler Metals

GTAW rod:	CN 19/9 M-IG	GMAW solid wire:	CN 19/9 M-IG

EN 1600:1997: E 23 12 L R 3 2
AWS A5.4-92: E309L-17

BÖHLER FOX CN 23/12-A

SMAW stick electrode, high-alloyed, special applications

Description

Rutile coated stainless steel electrode of type E 23 12 L / 309L providing increased delta ferrite contents (FN ~17) in the weld deposit for safe and crack resistant dissimilar joint welds and claddings. BÖHLER FOX CN 23/12-A is noted for its superior welding characteristics and metallurgy. It can be used on AC and DC. Other advantages include high current carrying capacity, minimum spatter formation, self releasing slag, smooth and clean weld profile, safety against formation of porosity due to the moisture resistant coating and its packaging into hermetically sealed tins. Operating temperature from -60 °C to +300 °C and for weld claddings up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.02**	**0.7**	**0.7**	**23.0**	**12.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 400)
tensile strength R_m N/mm²:		**570**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 47)
	- 60 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX CN 23/12-A 309L-17 E 23 12 L R

ø mm	L mm	amps A
2.5	350	60 - 80
3.2	350	80 - 110
4.0	350	110 - 140
5.0	450	140 - 180

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Preheating and interpass temperature as required by the base metal.

Base Materials

dissimilar joint welds: of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings: for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7

Approvals and Certificates

TÜV-D (1771.), DB (30.014.08), ÜZ (30014), ÖBB, TÜV-A (130), ABS (E 309L-17), BV (UP), CL (1477), DNV (NV 309 L), GL (4332), LR (DXV u. 0, CMnSS), UDT, VUZ, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12 Mo-A	GMAW flux cored wire:	CN 23/12-FD
GTAW rod:	CN 23/12-IG		CN 23/12 PW-FD
GMAW solid wire:	CN 23/12-IG		CN 23/12 Mo-FD
Metal cored wire:	CN 23/12-MC		CN 23/12 Mo PW-FD
		SAW combination:	CN 23/12-UP/BB 202

EN 1600:1997: E 23 12 2 L R 3 2
AWS A5.4-92: E309MoL-17(mod.)

BÖHLER FOX CN 23/12 Mo-A

SMAW stick electrode, high-alloyed, special applications

Description

Rutile coated stainless steel electrode of type E 23 12 2 L / 309MoL providing increased delta ferrite contents (FN ~20) in the weld deposit for safe and crack resistant dissimilar joint welds as well as claddings or root passes of clad steel. BÖHLER FOX CN 23/12 Mo-A is noted for its superior welding characteristics and metallurgy. It can be used on AC and DC. Other advantages include high current carrying capacity, minimum spatter formation, self releasing slag, smooth and clean weld profile, safety against formation of porosity due to the moisture resistant coating and its packaging into hermetically sealed tins.
Operating temperature from -10 °C to +300 °C and for weld claddings (1st layer) up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.02**	**0.7**	**0.8**	**23.0**	**12.5**	**2.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**580**	(≥ 490)
tensile strength R_m N/mm²:		**720**	(≥ 630)
elongation A ($L_0 = 5d_0$) %:		**27**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**55**	(≥ 47)
	- 20 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX CN 23/12 Mo-A E 23 12 2 L R

ø mm	**L mm**	**amps A**
2.0	300	45 - 60
2.5	350	60 - 80
3.2	350	80 - 120
4.0	350	100 - 160
5.0	450	140 - 220

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Preheating and interpass temperature as required by the base metal.

Base Materials

dissimilar joint welds:
mild steels and low-alloyed constructional and QT-steels among themselves or among each other; unalloyed as well as low-alloyed boiler or constructional steels with stainless Cr-, CrNi- and CrNiMo-steels; ferritic-austenitic joint welds in boiler and pressure vessel parts.
weld claddings: for the first layer of corrosion resistant claddings on P235GH, P265GH, S255N, P295GH, S355N - S500N; for the first layer of corrosion resistant weld claddings on high temperature quenched and tempered fine-grained steels acc. AD-Merkblatt HPO, class 3.

Approvals and Certificates

TÜV-D (1362.), TÜV-A (34), ABS (E 309 Mo), CL (1191), RINA (309Mo), DNV (309MoL), LR (DXV u. 0, CMnSS), BV (309 Mo), UDT, LTSS, VUZ, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A	GMAW flux cored wire:	CN 23/12-FD
GTAW rod:	CN 23/12-IG		CN 23/12 PW-FD
GMAW solid wire:	CN 23/12-IG		CN 23/12 Mo-FD
Metal cored wire:	CN 23/12-MC		CN 23/12 Mo PW-FD
		SAW combination:	CN 23/12-UP/BB 202

EN 1600:1997: E 23 12 L B 2 2
AWS A5.4-92: E309L-15

BÖHLER
FOX CN 24/13

SMAW stick electrode for special applications

Description

Special basic coated electrode with controlled alloying elements to meet the metallurgical requirements of buffer layers. Stringer bead technique is recommended. Normally used in combination with different corrosion resistant claddings, depending on the base material also with an additional PWHT. For service temperatures up to +400 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.03**	**0.3**	**1.3**	**24.0**	**13.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**430**	(≥ 320)
tensile strength R_m N/mm²:		**570**	(≥ 520)
elongation A ($L_0=5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+20 °C:	**70**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

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re-drying: if necessary:
300-350 °C, min. 2 h
electrode identification:
FOX CN 24/13 309 L-15 E 23 12 L B

ø mm	**L mm**	**amps A**
3.2	350	95-115
4.0	350	120-145

Preheating and interpass temperature acc. the base materials.

Base Materials

For buffer layers on weldable unalloyed, high tensile, high temperature or alloyed base metals.

Approvals and Certificates

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EN 1600:1997:	E 23 12 Nb B 2 2
AWS A5.4-92:	E309Cb-15

BÖHLER FOX CN 24/13 Nb

SMAW stick electrode for special applications

Description

Special basic coated electrode with controlled alloying elements to meet the metallurgical requirements of buffer layers. Excellent welding properties, stable arc, well detaching slag without residuals. Stringer bead technique is recommended. Normally used in combination with different corrosion resistant claddings, depending on the base material also with an additional PWHT. For service temperatures up to +400 °C.

Typical Chemical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.03**	**0.4**	**1.0**	**24.5**	**12.5**	**0.85**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**505**	(≥ 350)
tensile strength R_m N/mm^2:		**690**	(≥ 550)
elongation A (L_0=5d_0) %:		**25**	(≥ 22)
impact work ISO-V KV J	+20 °C:	**95**	(≥ 47)
	-10 °C:	**85**	

(*) *u untreated, as-welded*

Operating Data

re-drying: if necessary
300-350 °C, min. 2 h
electrode identification:
FOX CN 24/13 Nb 309 Cb-15 E 23/12 Nb B

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ø mm	L mm	amps A
3.2	350	95-115
4.0	350	120-145

Preheating and interpass temperature acc. the base materials.

Base Materials

For buffer layers on weldable unalloyed, high tensile, high temperature or alloyed base metals.

Approvals and Certificates

TÜV-D (00141.)

EN 1600:1997: E 29 9 R 1 2
AWS A5.4-92: E312-16(mod.)

BÖHLER FOX CN 29/9

SMAW stick electrode, high-alloyed, special applications

Description

Rutile-basic coated stainless steel electrode of type 29 % Cr 9 % Ni / E312.
BÖHLER FOX CN 29/9 is a repair & maintenance electrode that offers outstanding operating characteristics and weld metals of high strength combined with high crack resistance when welding problem steels or dissimilar joints.
The weld metal also work hardens making it suitable for wear resisting build-ups on clutches, gear wheels, shafts, etc. Also suitable for repair welding of tools.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.11**	**1.0**	**0.7**	**29.0**	**10.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**620**	(≥ 490)
tensile strength R_m N/mm^2:		**770**	(≥ 690)
elongation A ($L_0 = 5d_0$) %:		**25**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**30**	(≥ 24)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:	**ø mm**	**L mm**	**amps A**
250 - 300 °C, min. 2 h	2.5	300	60 - 80
electrode identification:	3.2	350	80 - 110
FOX CN 29/9 E 29 9 R	4.0	350	110 - 140

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Preheating and interpass temperature as required by the base metal.

Base Materials

for problem steels with high strength, joining of dissimilar materials, tool steels, heat treatable or quenched and tempered steels, spring steels, high carbon steels etc.

Approvals and Certificates

DB (30.014.11), ÜZ (30.014), ÖBB, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 29/9-A

EN 1600:1997: E 29 9 R 3 2
AWS A5.4-92: E312-17(mod.)

BÖHLER FOX CN 29/9-A

SMAW stick electrode, high-alloyed, special applications

Description

Rutile coated stainless steel electrode of type 29 % Cr 9 % Ni / E312.
BÖHLER FOX CN 29/9-A is a repair & maintenance electrode that offers outstanding operating characteristics on both DC and AC and weld metals of high strength combined with high crack resistance when welding problem steels or dissimilar joints.
The weld metal also work hardens making it suitable for wear resisting build-ups on clutches, gear wheels, shafts, etc. Also suitable for repair welding of tools.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.11**	**0.9**	**0.7**	**28.5**	**9.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**650**	(≥ 490)
tensile strength R_m N/mm^2:		**810**	(≥ 670)
elongation A ($L_0 = 5d_0$) %:		**24**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**30**	(≥ 24)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX CN 29/9-A E 29 9 R

ø mm	**L mm**	**amps A**
2.5	300	60 - 80
3.2	350	80 - 110
4.0	350	110 - 140
5.0	450	140 - 180

Preheating and interpass temperature as required by the base metal.

Base Materials

for problem steels with high strength, joining of dissimilar materials, tool steels, heat treatable or quenched and tempered steels, spring steels, high carbon steels etc.

Approvals and Certificates

DB (30.014.16, 20.014.07), ÜZ (30.014), ÖBB, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 29/9

BÖHLER FOX RDA

SMAW stick electrode, high-alloyed, special applications

Description

Special coated stainless steel electrode for welding of rule die steel.

This electrode provides easy striking and re-striking, excellent welding characteristics as well as very ductile and crack resistant joints welds on rule die steel.

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX RDA

ø mm	**L mm**	**amps A**
1.5	250	40 - 60
2.0	250	50 - 80

Base Materials

Rule die steels

Approvals and Certificates

UDT

EN 12072:1999: W 18 8 Mn
AWS A5.9-93: ER307(mod.)
W.Nr.: 1.4370

BÖHLER A 7 CN-IG

GTAW rod, high-alloyed, special applications

Description

GTAW rod of type W 18 8 Mn / ER307 for numerous applications.
The weld metal offers exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -110 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier.
The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance.
Very good welding and wetting characteristics.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni
wt-%	**0.08**	**0.8**	**7.0**	**19.0**	**9.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 450)
tensile strength R_m N/mm²:		**660**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 100)
	- 110 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**
rod marking:
front: **W 18 8 Mn**
back: **1.4370**

ø mm
1.6
2.0
2.4
3.0

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Preheating and interpass temperature as required by the base metal.

Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

TÜV-D (00023.), DNV (X), GL (4370), UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX A 7
FOX A 7-A
GMAW solid wire: A 7-IG

Metal cored wire: A 7-MC
GMAW flux cored wire: A 7-FD, A 7 PW-FD
SAW combination: A 7CN-UP/BB 203

EN 12072:1999:	W 20 10 3
AWS A5.9-93:	ER308Mo(mod.)
W.Nr.:	1.4431

BÖHLER CN 19/9 M-IG

GTAW rod, high-alloyed, special applications

Description

GTAW rod of type W 20 10 3 / 308Mo. This rod is designed for dissimilar joints and weld cladding. BÖHLER CN 19/9 M-IG offers a lower chromium and ferrite content than a 309L weld deposit with the result that carbon diffusion and Cr-carbide formation is reduced after post weld heat treatment and lower ferrite contents can be achieved in the second layer of 316L claddings. Suitable for service temperatures from -80 °C to +300 °C.
Very good welding and wetting characteristics.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.06**	**0.7**	**1.3**	**20.0**	**10.0**	**3.3**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**550**	(≥ 470)
tensile strength R_m N/mm²:		**750**	(≥ 670)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 80)
	- 80 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

		ø mm
shielding gas:	**100 % Argon**	
rod marking:		1.6
front:	**W 20 10 3**	2.0
back:	**1.4431**	2.4

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Preheating and interpass temperature as required by the base metal.

Base Materials

high-strength, mild steels and low-alloyed constructional steels, QT-steels and armour plates among themselves or among each other; non-alloy as well as alloyed boiler or constructional steels with high-alloy stainless Cr- and Cr-Ni-steels; austenitic manganese steels similar and dissimilar.

Approvals and Certificates

TÜV-D (0427.), DNV (308Mo)

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 19/9 M

GMAW solid wire: CN 19/9 M-IG

EN 12072:1999: W 23 12 L
AWS A5.9-93: ER309 L
W.Nr.: 1.4332

BÖHLER CN 23/12-IG

GTAW rod, high-alloyed, special applications

Description

GTAW rod of type W 23 12 L / ER309L. This is a standard alloy for welding dissimilar joints with an average ferrite content 16 FN.
BÖHLER CN 23/12-IG is designed for very good welding and wetting characteristics as well as good safety after dilution when welding dissimilar joints. Suitable for service temperatures between -120 °C and +300 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni
wt-%	**0.02**	**0.5**	**1.7**	**24.0**	**13.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**440**	(≥ 430)
tensile strength R_m N/mm^2:		**590**	(≥ 580)
elongation A ($L_0 = 5d_0$) %:		**34**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**150**	(≥ 80)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**
rod marking:
front: **W 23 12 L**
back: **ER 309 L**

ø mm
1.6
2.0
2.4

=−

Preheating and interpass temperature as required by the base metal.

Base Materials

dissimilar joint welds:
of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings:
for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7

Approvals and Certificates

TÜV-D (4699.), TÜV-A (307), CL (0321), GL (4332), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A
	FOX CN 23/12 Mo-A
GMAW solid wire:	CN 23/12-IG
Metal cored wire:	CN 23/12-MC
GMAW flux cored wire:	CN 23/12-FD
	CN 23/12 PW-FD
	CN 23/12 Mo-FD
	CN 23/12 Mo PW-FD
SAW combination:	CN 23/12-UP/BB 202

EN 12072:1999: G 18 8 Mn
AWS A5.9-93: ER307 (mod.)
W.Nr.: 1.4370

BÖHLER A 7-IG

GMAW solid wire, high-alloyed, special applications

Description

GMAW wire of type G 18 8 Mn / ER307 for numerous applications.
The weld metal offers exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -110 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier.
The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance. Very good feeding, welding and wetting characteristics.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni
wt-%	**0.08**	**0.9**	**7.0**	**19.2**	**9.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**430**	(≥ 370)
tensile strength R_m N/mm²:		**640**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**36**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 100)
	- 110 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + max. 2.5 % CO_2*

Operating Data

shielding gas:
Argon + max. 2.5 % CO_2

ø mm
0.8
1.0
1.2
1.6

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

TÜV-D (06632.), DB (43.014.13), ÜZ (43.014/1), ÖBB, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7	Metal cored wire:	A 7-MC
	FOX A 7-A	GMAW flux cored wire:	A 7-FD, A 7 PW-FD
GTAW rod:	A 7CN-IG	SAW combination:	A 7CN-UP/BB 203

EN 12072:1999:	G 20 10 3
AWS A5.9-93:	ER308Mo(mod.)
W.Nr.:	1.4431

BÖHLER CN 19/9 M-IG

GMAW solid wire, high-alloyed, special applications

Description

GMAW wire of type G 20 10 3 / (308Mo). This wire is designed for dissimilar joints and weld cladding.
BÖHLER CN 19/9 M-IG offers a lower chromium and ferrite content than a 309L weld deposit with the result that carbon diffusion and Cr-carbide formation is reduced after post weld heat treatment and lower ferrite contents can be achieved in the second layer of 316L claddings.
Suitable for service temperatures from -60 °C to +300 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo
wt-%	**0.06**	**0.7**	**1.3**	**20.0**	**10.0**	**3.3**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**520**	(≥ 450)
tensile strength R_m N/mm²:		**720**	(≥ 650)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**140**	(≥ 70)
	- 60 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + max. 2.5 % CO_2*

Operating Data

shielding gases:	**ø mm**
Argon + max. 2.5 % CO_2	1.0
Argon + max. 1.0 % O_2	1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

high-strength, mild steels and low-alloyed constructional steels, QT-steels and armour plates among themselves or among each other; non-alloy as well as alloyed boiler or constructional steels with high-alloy stainless Cr- and Cr-Ni-steels; austenitic manganese steels similar and dissimilar.

Approvals and Certificates

TÜV-D (1087.), DB (43.014.10), ÜZ (43.014/1), ÖBB, DNV (308Mo)

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 19/9 M GTAW rod: CN 19/9 M-IG

EN 12072:1999: G 23 12 L
AWS A5.9-93: ER309 L
W.Nr.: 1.4332

BÖHLER CN 23/12-IG

GMAW solid wire, high-alloyed, special applications

Description

GMAW wire of type G 23 12 L / ER309L. This is a standard alloy for welding dissimilar joints with an average ferrite content 16 FN.
BÖHLER CN 23/12-IG is designed for very good welding, wetting and feeding characteristics as well as good safety after dilution when welding dissimilar joints.
Suitable for service temperatures between -80 °C and +300 °C.

Typical Composition of Solid Wire

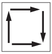
	C	Si	Mn	Cr	Ni
wt-%	**0.02**	**0.5**	**1.7**	**24.0**	**13.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 400)
tensile strength R_m N/mm²:		**570**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**130**	(≥ 55)
	- 80 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + max. 2.5 % CO_2*

Operating Data



shielding gases:
Argon + max. 2.5 % CO_2
Argon + max. 1.0 % O_2

ø mm
0.8
1.0
1.2

=+

Preheat and interpass temperature as required by the base metal.

Base Materials

dissimilar joint welds:
of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings:
for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7.

Approvals and Certificates

TÜV-D (4698.), DB (43.014.18), ÜZ (43014), ÖBB, TÜV-A (308), CL (0351), DNV (309L), GL (4332S), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A	GMAW flux cored wire:	CN 23/12-FD
	FOX CN 23/12 Mo-A		CN 23/12 PW-FD
GTAW rod:	CN 23/12-IG		CN 23/12 Mo-FD
Metal cored wire:	CN 23/12-MC		CN 23/12 Mo PW-FD
		SAW combination:	CN 23/12-UP/BB 202

EN 12073:2000: T 18 8 Mn MM1
AWS A5.9-93: EC307(mod.)

BÖHLER A 7-MC

Metal cored wire,
high-alloyed, special applications

Description

Metal cored wire of type T 18 8 Mn/ EC307 for numerous applications.
The weld metal offers exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -110 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier. The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance, excellent welding characteristics, smooth almost spatter free weld finish. The wider arc, in comparison to solid wire, will reduce the risk of lack of fusion and is less sensitive against misalignment of edges and different gap widths.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.1**	**0.6**	**6.3**	**18.8**	**9.2**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**400**	(≥ 350)
tensile strength R_m N/mm²:		**600**	(≥ 500)
elongation A ($L_0 = 5d_0$) %:		**42**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 32)
	- 110 °C:	**30**	

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gas:	**ø mm**	**amps A**	**voltage V**
Argon + 2.5 % CO_2	1.2	60-280	13-30

Preheating and interpass temperature as required by the base metal. Welding with conventional or pulsed power sources (preferably slightly leading torch position, angel appr. 80 °). Recommended stick out 15-20 mm and length of arc 3-5 mm. Positional weldability of metal cored wires is similar to solid wires (puls arc welding is recommended).

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Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13-17 % chromium and heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7 FOX A 7-A	GMAW flux cored wire:	A 7-FD A 7 PW-FD
GTAW rod:	A 7CN-IG	SAW combination:	A 7CN-UP/BB 203
GMAW solid wire:	A 7-IG		

EN 12073: 2000: T 23 12 L MM1
AWS A5.9-93: EC309L

BÖHLER CN 23/12-MC

Metal cored wire,
high-alloyed, special applications

Description

Metal cored wire of type T 23 12 L / ER309L for welding dissimilar joints between high alloyed Cr- and CrNi(Mo)-steels and mild- or low alloyed steels.
BÖHLER CN 23/12-MC is designed for very good welding, wetting and feeding characteristics as well as good safety after dilution when welding dissimilar joints.
Suitable for service temperatures between -120 °C and +300 °C.
The wider arc, in comparison to solid wire, will reduce the risk of lack of fusion and is less sensitive against misalignment of edges and different gap widths.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**≤ 0.03**	**0.6**	**1.4**	**22.7**	**12.2**

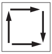
Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**400**	(≥ 350)
tensile strength R_m N/mm²:		**450**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 47)
	- 120 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gas:	ø mm	amps A	voltage V
Argon + 2.5 % CO_2	1.2	60 - 280	13 - 30



Preheat and interpass temperature as required by the base metal.
Welding with conventional or pulsed power sources (preferably slightly leading torch position, angel appr. 80 °). Recommended stick out 15-20 mm and length of arc 3-5 mm. Positional weldability of metal cored wires is similar to solid wires (puls arc welding is recommended).

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Base Materials

dissimilar joint welds:
of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings:
for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7

Approvals and Certificates

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Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A	GMAW flux cored wire:	CN 23/12-FD
	FOX CN 23/12 Mo-A		CN 23/12 PW-FD
GTAW rod:	CN 23/12-IG		CN 23/12 Mo-FD
GMAW solid wire:	CN 23/12-IG		CN 23/12 Mo PW-FD
		SAW combination:	CN 23/12-UP/BB 202

EN 12073:1999: T 18 8 Mn R M 3
T 18 8 Mn R C 3
AWS A5.22-95: E307T0-G

BÖHLER A 7-FD

GMAW flux cored wire, high-alloyed, special applications

Description

Rutile flux cored welding wire preferable for flat & horizontal welding positions. BÖHLER A7-FD achieves high productivity and is easy to operate providing excellent welding characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. Increased travel speeds as well as little demand for cleaning provide considerable savings in time and money.
The weld deposit offers high ductility and elongation together with excellent crack resistance even when subjected to thermal shock. It will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels. There is no fear of embrittlement when operating down to service temperatures of -100 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier.

Typical Composition of All-weld Metal

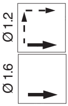
	C	Si	Mn	Cr	Ni
wt-%	**0.1**	**0.8**	**6.8**	**19.0**	**9.0**

Mechanical Properties of All-weld Metal

(*)		u		
yield strength R_e N/mm²:		**420**	(≥ 400)	hardness
tensile strength R_m N/mm²:		**630**	(≥ 600)	appro. 200 HB
elongation A (L_0 = 5d_0) %:		**39**	(≥ 35)	stress hardened
impact work ISO-V KV J	+ 20 °C:	**60**		up to 400 HV
	- 100 °C:		(≥ 32)	

(*) *u untreated, as-welded – shielding gas Argon + 18 % CO_2*

Operating Data



re-drying if necessary: **150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15-18 l/min. Preheating and interpass temperature as required by the base metal.

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Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7-A	Metal cored wire:	A 7-MC
	FOX A 7	GMAW flux cored wire:	A 7 PW-FD
GTAW rod:	A 7CN-IG	SAW combination:	A 7CN-UP/BB 203
GMAW solid wire:	A 7-IG		

EN 12073:1999: T 18 8 Mn P M 2
T 18 8 Mn P C 2
AWS A5.22-95: E 307 T 1-G

BÖHLER A 7 PW-FD

GMAW flux cored wire, high-alloyed, special applications

Description

Rutile flux cored welding wire with fast freezing slag providing positional welding characteristics and fast travel speedsl BÖHLER A7 PW-FD achieves high productivity and is easy to operate providing excellent welding characteristics, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish and safe penetration. The weld deposit offers high ductility and elongation together with excellent crack resistance even when subjected to thermal shock. It will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels. Beside the major savings in time and cost BÖHLER offers a high production quality level together with lowest probabilities for welding errors. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. Description of all-weld-metal: strain hardening, good resistance against cavitation, crack resistance, resistance against thermal shock, scaling resistance goes up to +850 °C. There is no fear of embrittlement when operating down to service temperatures of -100 °C or above +500 °C. When working at service temperatures above +650 °C please contact the supplier.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.1**	**0.8**	**6.8**	**19.0**	**9.0**

Mechanical Properties of All-weld Metal

(*)		u		
yield strength R_e N/mm²:		**420**	(≥ 400)	hardness
tensile strength R_m N/mm²:		**630**	(≥ 600)	appro. 200 HB
elongation A ($L_0 = 5d_0$) %:		**39**	(≥ 35)	stress hardened
impact work ISO-V KV J	+ 20 °C:	**60**		up to 400 HV
	- 100 °C:		(≥ 32)	

(*) *u untreated, as-welded – shielding gas Argon + 18 % CO_2*

Operating Data

re-drying if necessary: **150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	120 - 190	21 - 29

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel approx. 80 °C), slight weaving is recommended for all welding positions, when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V.
The gas flow should be 15-18 l/min.Preheating and interpass temperature as required by the base metal.

Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels up to +850 °C, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7-A	Metal cored wire:	A 7-MC
	FOX A 7	GMAW flux cored wire:	A 7-FD
GTAW rod:	A 7CN-IG	SAW combination:	A 7CN-UP/BB 203
GMAW solid wire:	A 7-IG		

EN 12073:1999:	T 23 12 L R M 3 T 23 12 L R C 3	
AWS A5.22-95:	E309LT0-4 E309LT0-1	
EN 12073:1999:	T 23 12 L P M (C) 1	(for ø 0.9 mm)
AWS A5.22-95:	E309LT1-4/-1	(for ø 0.9 mm)

BÖHLER CN 23/12-FD

GMAW flux cored wire, high-alloyed, special applications

Description

Rutile flux-cored welding wire for GMAW of dissimilar joints of Cr- and CrNi(Mo)-steels and non- or low-alloy steels, as well as weld cladding of un- or low alloyed base metals preferably in flat or horizontal position. This product achieves high productivity and is easy to operate achieving excellent welding characteristics, self releasing slag, almost no spatter formation and temper discolouration, smooth weld finish and safe penetration. Beside the major savings in time and cost BÖHLER offers a high production quality level together with lowest probabilities for welding errors. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. Suitable for service temperatures of -60 °C to +300 °C.
BÖHLER CN 23/12-FD ø 0.9 mm is well suitable for welding of sheet metal (thickness greater than 1.5 mm, for out-of-position welding greater than 5 mm). The slag concept gives the opportunity to weld this diameter in all welding positions. Wires with ø 1.2 mm can be used for wall thicknesses from 3 mm and up.
Wire ø 0.9 mm is designed for positional welding, wire ø 1.2 mm and 1.6 mm are recommended mainly for downhand and horizontal welding positions.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**≤ 0.03**	**0.7**	**1.4**	**22.8**	**12.5**

Mechanical Properties of All-weld Metal

		u *untreated, as-welded – shielding gas Ar+18%CO_2*		
yield strength Re N/mm²:		**400** (≥ 350)		
tensile strength Rm N/mm²:		**540** (≥ 520)		
elongation A (L0 = 5d0) %:		**35** (≥ 30)		
impact work ISO-V KV J	+ 20 °C:	**60** (≥ 47)	- 60 °C:	**45** (≥ 32)

Operating Data

Ø 0.9
Ø 1.2
Ø 1.6

re-drying if necessary:
150 °C/24 h
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2
welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15-18 l/min.
Preheat and interpass temperatures as required by the base metal.

ø mm	amps A	voltage V
0.9	100 - 160	21 - 30
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

=+

Base Materials

dissimilar joint welds: of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings: for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7

Approvals and Certificates

TÜV-D (5349.), DB (43.014.16), ÜZ (43.014/2), ÖBB, TÜV-A (516), CL (1401), CWB (E309LT0-1(4)), GL (4571 (C1, M21)), UDT, SEPROZ, LR (DX, CMn/SS)

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A FOX CN 23/12 Mo-A	Metal cored wire:	CN 23/12-MC
GTAW rod:	CN 23/12-IG	GMAW flux cored wire:	CN 23/12 PW-FD CN 23/12 Mo-FD CN 23/12 Mo PW-FD
GMAW solid wire:	CN 23/12-IG	SAW combination:	CN 23/12-UP/BB 202

EN 12073:1999:	T 23 12 L P M 1
	T 23 12 L P C 1
AWS A5.22-95:	E 309 LT1-4
	E 309 LT1-1

BÖHLER CN 23/12 PW-FD

GMAW flux cored wire, high-alloyed, special applications

Description

BÖHLER CN 23/12 PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional welding characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag.
This flux cored welding wire offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable. Additional cost effective benefits are offered through use of less expensive shielding gases, good wetting characteristics (less grinding), little temper discoloration & bead oxidation, easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work).
Due to its characteristics mainly for positional welding and service temperatures between -60 °C to +300 °C. For downhand & horizontal welding positions (1G,1F, 2F) our flux cored wire BÖHLER CN 23/12-FD should be preferred.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	≤ **0.03**	**0.7**	**1.4**	**22.8**	**12.5**

Mechanical Properties of All-weld Metal

(*)	u	
yield strength R_e N/mm²:	**400**	(≥ 350)
tensile strength R_m N/mm²:	**540**	(≥ 520)
elongation A ($L_0 = 5d_0$) %:	**35**	(≥ 30)
impact work ISO-V KV J + 20 °C:	**65**	(≥ 47)
- 60 °C:	**50**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data

re-drying if necessary:
possible, 150 °C / 24 h
shielding gases: **Argon + 15 - 25 % CO_2**
100 % CO_2

ø mm	**amps A**	**voltage V**
1.2	100 - 220	20 - 31
1.6	175 - 260	21 - 29

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welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for all welding positions; when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15-18 l/min. Preheat and interpass temperatures as required by the base metal.

Base Materials

dissimilar joint welds: of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings: for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7

Approvals and Certificates

TÜV-D (09115.), DB (43.014.22), ÜZ (43.014/02), ABS (E309 LT 1-1(4)), CL (0264), LR (DXV u. O, CMn/SS), CWB (E309LT0-1(4)), UDT, SEPROZ, ÖBB

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A
	FOX CN 23/12 Mo-A
GTAW rod:	CN 23/12-IG
GMAW solid wire:	CN 23/12-IG
Metal cored wire:	CN 23/12-MC
GMAW flux cored wire:	CN 23/12-FD
	CN 23/12 Mo-FD
	CN 23/12 Mo PW-FD
SAW combination:	CN 23/12-UP/BB 202

EN 12073:1999: T 23 12 2 L R M 3
T 23 12 2 L R C 3
AWS A5.22-95: E 309LMoT0-4 (1)
EN 12073:1999: T 23 12 2 L P M (C) 1 (for ø 0.9 mm)
AWS A5.22-95: E 309 LMoT1-4/-1 (for ø 0.9 mm)

BÖHLER CN 23/12 Mo-FD

GMAW flux cored wire, high-alloyed, special applications

Description

Rutile flux-cored welding wire of type T 23 12 2 L / E309LMoT0 for GMAW of dissimilar joints of Cr- and CrNi(Mo)-steels and non- or low-alloy steels, as well as weld cladding of un- or low alloyed base metals preferably in flat or horizontal position. The wire offers a high safety against hot cracking even in the case of high dilution. For Mo-alloyed claddings the product is necessary for the 1. layer. This product achieves high productivity and is easy to operate achieving excellent welding characteristics, self releasing slag, almost no spatter formation and temper discolouration, smooth weld finish and safe penetration. Beside the major savings in time and cost BÖHLER offers a high production quality level together with lowest probabilities for welding errors. Increased travel speeds as well as little demand for cleaning and pickling provide considerable savings in time and money. Suitable for service temperatures of –60 °C to +300 °C. BÖHLER CN 23/12 Mo-FD ø 0.9 mm is well suitable for welding of sheet metal (thickness greater than 1.5 to 3 mm, for out-of-position welding greater than 5 mm). The slag concept gives the opportunity to weld this diameter in all welding positions. Wires with ø 1.2 mm can be used for wall thicknesses from 3 mm and up. Wire ø 0,9 mm is designed for positional welding, wire ø 1.2 mm and 1.6 mm are recommended mainly for downhand and horizontal welding positions, horizontal/vertical position as well as slightly vertical down position (1 o'clock).

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo
wt-%	**≤ 0.03**	**0.6**	**1.4**	**22.7**	**12.3**	**2.7**

Mechanical Properties of All-weld Metal

		u *untreated, as-welded – shielding gas Ar + 18 % CO_2*		
yield strength Re N/mm²:		**500** (≥ 450)		
tensile strength Rm N/mm²:		**700** (≥ 550)		
elongation A ($L_0 = 5d_0$) %:		**30** (≥ 25)		
impact work ISO-V KV J	+ 20 °C:	**55** (≥ 47)	- 60 °C:	**37** (≥ 32)

Operating Data

Ø 0.9 Ø 1.2 Ø 1.6

re-drying if necessary: **150 °C/24 h**
shielding gases:
Argon + 15 - 25 % CO_2
100 % CO_2

ø mm	amps A	voltage V
0.9	100 - 160	21 - 30
1.2	125 - 280	20 - 34
1.6	200 - 350	25 - 35

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), when using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15-18 l/min. Preheat and interpass temperatures as required by the base metal.

Base Materials

dissimilar joint welds: mild steels and low-alloyed constructional and QT-steels among themselves or among each other; unalloyed as well as low-alloyed boiler or constructional steels with stainless Cr-, CrNi- and CrNiMo-steels; ferritic-austenitic joint welds in boiler and pressure vessel parts.
weld claddings: for the first layer of corrosion resistant claddings on P235GH, P265GH, S255N, P295GH, S355N - S500N; for the first layer of corrosion resistant weld claddings on high temperature quenched and tempered fine-grained steels acc. AD-Merkblatt HPO, class 3.

Approvals and Certificates

TÜV-D (5351.), DB (43.014.17), ÜZ (43.014/2), ÖBB, TÜV-A (517), ABS (E 308 MoLT0-4), CL (1304), DNV (309MoL (M21)), GL (4459 (C1, M21)), LR (X (M21)), RINA (309MO S), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A	Metal cored wire:	CN 23/12-MC
	FOX CN 23/12 Mo-A	GMAW flux cored wire:	CN 23/12-FD
GTAW rod:	CN 23/12-IG		CN 23/12 PW-FD
GMAW solid wire:	CN 23/12-IG		CN 23/12 Mo PW-FD
		SAW combination:	CN 23/12-UP/BB 202

EN 12073:1999:	T 23 12 2 L P M 1
	T 23 12 2 L P C 1
AWS A5.22-95:	E 309LMoT1-4
	E 309LMoT1-1

BÖHLER CN 23/12 Mo PW-FD

GMAW flux cored wire, high-alloyed, special applications

Description

BÖHLER CN 23/12 Mo PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional welding characteristics and fast travel speeds. It is easy to use and operates with a powerful penetrating spray arc transfer, minimum spatter formation and self releasing slag.
This flux cored welding wire offers many economical and quality advantages over solid wire pulse arc welding. High deposition rates and productivity gains are easily achievable. Additional cost effective benefits are offered through use of less expensive shielding gases (Argon + 15-25 % CO_2 or 100 % CO_2), good wetting characteristics (less grinding), little temper discoloration & bead oxidation, easy operation and safe penetration (reduces the risk of weld defects and associated repair work costs), and smooth and clean weld finish (less post weld work).
Due to its characteristics mainly for positional welding and service temperatures between -60 °C to +300 °C. For downhand & horizontal welding positions (1G, 1F, 2F) our flux cored wire BÖHLER CN 23/12 Mo-FD should be preferred.

Typical Composition of All-weld Metal

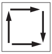
	C	Si	Mn	Cr	Ni	Mo
wt- %	**≤ 0.03**	**0.7**	**1.4**	**22.7**	**12.3**	**2.7**

Mechanical Properties of All-weld Metal

(*)	u	
yield strength R_e N/mm²:	**530**	(≥ 450)
tensile strength R_m N/mm²:	**720**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:	**32**	(≥ 25)
impact work ISO-V KV J + 20 °C:	**65**	(≥ 47)
- 60 °C:	**50**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Ar + 18 % CO_2*

Operating Data



re-drying if necessary:	**ø mm**	**amps A**	**voltage V**
possible, 150 °C / 24 h	1.2	100 - 220	20 - 31

shielding gases: **Argon + 15 - 25 % CO_2**
100 % CO_2

=+

Welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), slight weaving is recommended for positional welding. When using 100 % CO_2 as shielding gas it is necessary to increase the voltage by 2 V. The gas flow should be 15-18 l/min. Preheat and interpass temperatures as required by the base metal.

Base Materials

dissimilar joint welds: mild steels and low-alloyed constructional and QT-steels among themselves or among each other; unalloyed as well as low-alloyed boiler or constructional steels with stainless Cr-, CrNi- and CrNiMo-steels; ferritic-austenitic joint welds in boiler and pressure vessel parts.
weld claddings: for the first layer of corrosion resistant claddings on P235GH, P265GH, S255N, P295GH, S355N - S500N; for the first layer of corrosion resistant weld claddings on high temperature quenched and tempered fine-grained steels acc. AD-Merkblatt HPO, class 3.

Approvals and Certificates

TÜV-D (09116.), BV (309Mo), UDT, SEPROZ

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A	Metal cored wire:	CN 23/12-MC
	FOX CN 23/12 Mo-A	GMAW flux cored wire:	CN 23/12 Mo-FD
GTAW rod:	CN 23/12-IG		CN 23/12-FD
GMAW solid wire:	CN 23/12-IG		CN 23/12 PW-FD
		SAW combination:	CN 23/12-UP/BB 202

SAW solid wire:
EN 12072:1999: S 18 8 Mn
AWS A5.9-93: ER307 (mod.)
sub-arc flux:
EN 760: SA FB 2 DC

BÖHLER A 7 CN-UP // BB 203

SAW wire/flux-combination, high-alloyed, special applications

Description

SAW wire/flux combination of type S 18 8 Mn / (ER307) for numerous applications.
BÖHLER A 7-UP // BB 203 yields a weld deposit offering exceptionally high ductility and elongation together with outstanding crack resistance. There is no fear of embrittlement when operating down to service temperatures of -100 °C or above +500 °C. The scaling resistance goes up to +850 °C. When working at service temperatures above +650 °C please contact the supplier. The weld metal can be post weld heat treated without any problems. The deposit will work harden and offers good resistance against cavitation. Ductility is good even after high dilution when welding problem steels or when subjected to thermal shock or scaling. An excellent alloy providing cost effective performance. BÖHLER BB 203 is a fluoride-basic, agglomerated flux providing good operating characteristics, smooth beads and a low hydrogen weld metal. For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni
SAW wire wt-%	**0.08**	**0.8**	**7.0**	**19.2**	**9.0**
SAW wire wt-%	**0.08**	**0.9**	**6.8**	**18.5**	**8.8**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 390
tensile strength R_m N/mm²:		≥ 620
elongation A ($L_0 = 5d_0$) %:		≥ 36
impact work ISO-V KV J	+ 20 °C:	≥ 95
	- 50 °C:	≥ 60
	- 100 °C:	≥ 40

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C, 2 h – 10 h
max. amperage of sub-arc flux: **800 A**
Preheat and interpass temperatures as required by the base metal.

ø mm
3.0

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Base Materials

For fabrication, repair and maintenance!
Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13 - 17 % chromium heat resistant steels, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.

Approvals and Certificates

UDT
SAW solid wire: TÜV-D (02604.), UDT

Same Alloy Filler Metals

SMAW stick electrode:	FOX A 7	GMAW solid wire:	A 7-IG
	FOX A 7-A	Metal cored wire:	A 7-MC
GTAW rod:	A 7CN-IG	GMAW flux cored wire:	A 7-FD, A 7 PW-FD

SAW solid wire:
EN 12072:1999: S 23 12 L
AWS A5.9.93: ER309L
sub-arc flux:
EN 760: SA FB 2 DC

BÖHLER
CN 23/12-UP // BB 202

SAW wire/flux-combination, high-alloyed, special applications

Description

SAW wire/flux combination of type S 23 12 L / ER309L. This is a standard alloy for welding dissimilar joints, steels with poor weldability and weld claddings.
SAW wire/flux-combination for multi-pass welding, smooth beads, low hydrogen contents (HD > 5 ml/100 g), easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users. The average ferrite content is 16 FN. Suitable up to service temperatures of +300 °C.
BÖHLER BB 202 is a fluoride-basic, agglomerated flux providing good operating characteristics. For information regarding this sub-arc welding flux see our detailed data sheet.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni
SAW wire wt-%	**≤ 0.02**	**0.50**	**1.7**	**24.0**	**13.2**
all-weld metal %	**0.015**	**0.65**	**1.3**	**23.4**	**13.1**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 320
tensile strength R_m N/mm²:		≥ 520
elongation A ($L_0 = 5d_0$) %:		≥ 30
impact work ISO-V KV J	+ 20 °C:	≥ 70

(*) *u untreated, as-welded*

Operating Data

re-drying of sub-arc flux:
300 – 350 °C / 2 h – 10 h
max. amperage: **800 A**
Preheat and interpass temperatures as required by the base metal.

ø mm
3.0

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Base Materials

dissimilar joint welds:
of and between high-strength, mild steels and low-alloyed QT-steels, stainless, ferritic Cr- and austenitic Cr-Ni- steels, manganese steels
claddings:
for the first layer of corrosion resistant weld claddings on ferritic-perlitic steels in boiler and pressure vessel parts up to fine-grained steel S500N, as well as of high temperature steels like 22NiMoCr4-7 acc. SEW-Werkstoffblatt 365, 366, 20MnMoNi5-5 and G18NiMoCr3-7

Approvals and Certificates

DNV (309L), UDT
SAW solid wire: TÜV-D (2604.)

Same Alloy/Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 23/12-A	Metal cored wire:	CN 23/12-MC
	FOX CN 23/12 Mo-A	GMAW flux cored wire:	CN 23/12-FD
GTAW rod:	CN 23/12-IG		CN 23/12 PW-FD
GMAW solid wire:	CN 23/12-IG		CN 23/12 Mo-FD
			CN 23/12 Mo PW-FD

Notes

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Notes

2.8 Filler metals for Heat Resistant Steels

Objectives

This section contains data sheets for filler metals that are suitable for welding heat-resistant steels.
Heat-resistant steels are used at temperatures over 550 °C. In addition to scale-resistance and adequate high-temperature strength there is also a requirement for the lowest possible changes in volume during repeated heating up and cooling down so that the oxide layers do not crack open. Over and above this they should also have adequate resistance to various annealing and furnace atmospheres.
The Cr, Si and Al alloying elements give rise to the scale resistance due to the formation of dense and adhesive oxide layers. The Cr-Al alloy steels are ferritic and less suitable for welding but are extremely resistant in sulphur-containing gases. The Cr-Ni-Si alloy steels exhibit an austenitic microstructure, have excellent resistance in carburising furnace atmospheres containing nitrogen but form a low melting point eutectic with nickel in sulphurous gases at approx. 700 °C.
With these steels it is important to be aware of the embrittlement ranges 400...500 °C (with Cr contents above 15 %) and above 950 °C (grain growth) in ferritic steels and the sphase embrittlement between 650 and 800 °C with Cr contents above 20 %.

Content

Overview – Standard Classifications

Böhler	EN	AWS
SMAW stick electrodes		
FOX FA	EN 1600: E 25 4 B 2 2	–
FOX FF	EN 1600: E 22 12 B 2 2	AWS A5.4-92: E309-15(mod.)
FOX FF-A	EN 1600: E 22 12 R 3 2	AWS A5.4-92: E309-17(mod.)
FOX FFB	EN 1600: E 25 20 B 2 2	AWS A5.4-92: E310-15(mod.)
FOX FFB-A	EN 1600: E 25 20 R 3 2	AWS A5.4-92: E310-16
FOX CN 21/33 Mn	EN 1600: E Z 21 33 B 4 2	–
FOX CN 25/35 Nb	EN 1600: E Z 25 35 Nb B 6 2	–
FOX CN 35/45 Nb	EN 1600: E Z 35 45 Nb B 6 2	–
GTAW rods		
FA-IG	EN 12072: W 25 4	–
FF-IG	EN 12072: W 22 12	AWS A5.9-93: ER309(mod.)
FFB-IG	EN 12072: W 25 20 Mn	AWS A5.9-93: ER310(mod.)
CN 21/33 Mn-IG	EN 12072: W Z21 33 Nb	–
CN 25/35 Nb-IG	EN 12072: W Z25 35 Nb	–
CN 35/45 Nb-IG	EN 12072: W Z35 45 Nb H	–
GMAW solid wires		
FA-IG	EN 12072: G 25 4	–
FF-IG	EN 12072: G 22 12 H	AWS A5.9-93: ER309(mod.)
FFB-IG	EN 12072: G 25 20 Mn	AWS A5.9-93: ER310(mod.)
CN 21/33 Mn-IG	EN 12072: G Z21 33 Nb	–
CN 25/35 Nb-IG	EN 12072: G Z25 35 Nb	–
CN 35/45 Nb-IG	EN 12072: G Z35 45 Nb H	–

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Nb	Fe	Ti
SMAW stick electrodes								
FOX FA	0.1	0.5	1.2	25.0	5.4			
FOX FF	0.1	1.0	1.1	22.0	12.0			
FOX FF-A	0.1	0.8	1.0	22.5	12.5			
FOX FFB	0.11	0.6	3.5	26.0	20.5			
FOX FFB-A	0.12	0.5	2.2	26.0	20.5			
FOX CN 21/33 Mn	0.14	0.3	4.5	21.0	33.0	1.3	bal.	
FOX CN 25/35 Nb	0.4	1.0	1.5	25.0	35.0	1.2	bal.	0.1
FOX CN 35/45 Nb	0.45	1.0	0.8	35.0	45.5	0.9	bal.	
GTAW rods								
FA-IG	0.08	0.8	1.2	25.7	4.5			
FF-IG	0.11	1.2	1.2	22.0	11.0			
FFB-IG	0.12	0.9	3.2	25.0	20.5			
CN 21/33 Mn-IG	0.2	0.2	2.3	22.0	33.0	1.7		
CN 25/35 Nb-IG	0.42	1.2	1.8	26.0	35.0	1.3	bal.	
CN 35/45 Nb-IG	0.42	1.5	1.0	35.0	45.5	0.8		
GMAW solid wires								
FA-IG	0.08	0.8	1.2	25.7	4.5			
FF-IG	0.08	1.1	1.6	23.0	12.5			
FFB-IG	0.12	0.9	3.2	25.0	20.5			
CN 21/33 Mn-IG	0.2	0.2	2.3	22.0	33.0	1.7		
CN 25/35 Nb-IG	0.42	1.2	1.8	26.0	35.0	1.3	bal.	
CN 35/45 Nb-IG	0.42	1.5	1.0	35.0	45.5	0.8		

EN 1600:1997: E 25 4 B 2 2

BÖHLER FOX FA

SMAW stick electrode, high-alloyed, heat resistant

Description

Basic coated alloyed-core wire electrode for welding heat resistant steels. For furnaces requiring elevated resistance to reducing and oxidizing sulphurous gases as well as for final passes of weld joints in heat resistant, ferritic CrSiAl steels.
Scaling resistant up to +1100 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.10**	**0.5**	**1.2**	**25.0**	**5.4**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**520**	(≥ 490)
tensile strength R_m N/mm^2:		**680**	(≥ 640)
elongation A ($L_0 = 5d_0$) %:		**22**	(≥ 15)
impact work ISO-V KV J	+ 20 °C:	**45**	(≥ 30)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:	**ø mm**	**L mm**	**amps A**
–	2.5	300	50 - 75
electrode identification:	3.2	350	80 - 105
FOX FA E 25 4 B	4.0	350	100 - 130

=+

Preheating and interpass temperatures 200 - 400 °C, depending on the relevant base metal and material thickness.

Base Materials

ferritic-austenitic
1.4821 X 20 CrNiSi 25 4, 1.4823 G-X 40 CrNiSi 27 4
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25, 1.4710 X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 327, ASTM A297HC

Approvals and Certificates

UDT, SEPROZ

Same Alloy Filler Metals

GTAW rod:	FA-IG	GMAW solid wire:	FA-IG

EN 1600:1997: E 22 12 B 2 2
AWS A5.4-92: E309-15(mod.)

BÖHLER FOX FF

SMAW stick electrode, high-alloyed, heat resistant

Description

Basic coated alloyed-core wire electrode for welding analogous, heat resistant rolled, forged and cast steels as well as heat resistant ferritic CrSiAl steels. For weld joints exposed to reducing, sulphurous gases, the final layer has to be deposited by means of FOX FA, e.g. in annealing plants, hardening plants, steam boiler construction, the crude oil industry and the ceramics industry. Scaling resistant up to +1000 °C.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.1**	**1.0**	**1.1**	**22**	**12**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**440**	(≥ 400)
tensile strength R_m N/mm²:		**600**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**80**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
–	2.5	300	50 - 75
electrode identification:	3.2	350	80 - 100
FOX FF E 22 12 B	4.0	350	110 - 140

=+

Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4828 X 15 CrNiSi 20 12, 1.4826 G-X 40 CrNiSi 22 9, 1.4833 X7 CrNi23 14
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305, ASTM A297HF

Approvals and Certificates

TÜV-D (9090.), TÜV-A (21), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX FF-A
GTAW rod: FF-IG
GMAW solid wire: FF-IG

EN 1600:1997: E 22 12 R 3 2
AWS A5.4-92: E309-17

BÖHLER FOX FF-A

SMAW stick electrode, high-alloyed, heat resistant

Description

Rutile coated alloyed-core wire electrode for welding analogous, heat resistant rolled, forged and cast steels as well as heat resistant ferritic CrSiAl steels, e.g. in annealing plants, hardening plants, steam boiler construction, the crude oil industry and the ceramics industry. For weld joints in CrSiAl steels exposed to sulphurous gases, the final layer has deposited by means of FOX FA. Scaling resistant up to +1000 °C. Smooth beads and easy slag removal.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.1**	**0.8**	**1.0**	**22.5**	**12.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**460**	(≥ 350)
tensile strength R_m N/mm²:		**610**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**37**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**60**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX FF-A E 22 12 R

ø mm	**L mm**	**amps A**
2.5	350	50 - 80
3.2	350	80 - 110
4.0	350	110 - 140

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Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4828 X 15 CrNiSi 20 12, 1.4826 G-X 40 CrNiSi 22 9, 1.4833 X7 CrNi23 14
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305, ASTM A297HF

Approvals and Certificates

TÜV-D (9091.), ABS (309-17), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX FF
GTAW rod: FF-IG
GMAW solid wire: FF-IG

EN 1600:1997: E 25 20 B 2 2
AWS A5.4-92: E310-15(mod.)

BÖHLER FOX FFB

SMAW stick electrode, high-alloyed, heat resistant

Description

Basic coated alloyed-core wire electrode for analogous, heat resisting rolled, forged and cast steels e.g. in annealing plants, hardening plants, steam boiler construction, the crude oil industry and the ceramics industry. Joint welds in heat resisting CrSiAl steels exposed to sulphurous gases should be given a final layer deposited by means of FOX FA.
Scaling resistant up to +1200 °C. Cryogenic resistance down to -196 °C. The service temperature range between +650 and +900 °C should be avoided owing to the risk of embrittlement.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.11**	**0.6**	**3.5**	**26.0**	**20.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 350)
tensile strength R_m N/mm²:		**600**	(≥ 560)
elongation A ($L_0 = 5d_0$) %:		**36**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**100**	(≥ 47)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
–
electrode identification:
FOX FFB E 25 20 B

ø mm	**L mm**	**amps A**
2.5	300	50 - 75
3.2	350	80 - 110
4.0	350	110 - 140
5.0	450	140 - 180

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Preheating and interpass temperatures for ferritic steels +200 - 300 °C.

Base Materials

austenitic
1.4841 X 15 CrNiSi 25 20, 1.4845 X 12 CrNi 25 21, 1.4828 X 15 CrNiSi 20 12,
1.4840 G-X 15 CrNi 25 20, 1.4846 G-X 40 CrNi 25 21, 1.4826 G-X 40 CrNiSi 22 9
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25,
1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305, 310, 314; ASTM A297 HF; A297 HJ

Approvals and Certificates

TÜV-D (0143.), Statoil, UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX FFB-A	GMAW solid wire:	FFB-IG
GTAW rod:	FFB-IG		

EN 1600:1997: E 25 20 R 3 2
AWS A5.4-92: E310-16

BÖHLER FOX FFB-A

SMAW stick electrode, high-alloyed, heat resistant

Description

Rutile coated alloyed-core wire electrode for analogous, heat resisting rolled steels e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. In weld joints exposed to sulphurous gases the final layer has to be deposited by means of FOX FA. Smooth beads and easy slag removal.
Scaling resistance up to +1200 °C.
The temperature range between +650 and +900 °C should be avoided owing to the risk of embrittlement. Thick-walled weldments to be carried out by means of the basic electrode FOX FFB.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni
wt-%	**0.12**	**0.5**	**2.2**	**26.0**	**20.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**430**	(≥ 350)
tensile strength R_m N/mm²:		**620**	(≥ 550)
elongation A ($L_0 = 5d_0$) %:		**35**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**75**	(≥ 47)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2 h
electrode identification:
FOX FFB-A 310-16 E 25 20 R

ø mm	L mm	amps A
2.0	300	40 - 60
2.5	300	50 - 80
3.2	350	80 - 110
4.0	350	110 - 140

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Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4841 X 15 CrNiSi 25 20, 1.4845 X 12 CrNi 25 21, 1.4828 X 15 CrNiSi 20 12, 1.4840 G-X 15 CrNi 25 20, 1.4846 G-X 40 CrNi 25 21, 1.4826 G-X 40 CrNiSi 22 9
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25, 1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305, 310, 314; ASTM A297 HF; A297 HJ

Approvals and Certificates

Statoil, UDT, VUZ, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX FFB	GMAW solid wire:	FFB-IG
GTAW rod:	FFB-IG		

EN 1600:1999: EZ 21 33 B 4 2

BÖHLER FOX CN 21/33 Mn

SMAW stick electrode
high-alloyed, heat resistant

Description

Basic coated electrode for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition. Suitable for operating temperatures up to 1050 °C in carburized low-sulphur gas. Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb	Fe
wt-%	**0.14**	**0.3**	**4.5**	**21**	**33**	**1.3**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm²:	≥ 410
tensile strength R_m N/mm²:	≥ 600
elongation A (L_0=5d_0) %:	≥ 25
impact work ISO-V KV J	≥ 70

(*) *u untreated, as-welded*

Operating Data

re-drying:	**ø mm**	**L mm**	**amps A**
250-300°C, min. 2 h	2.5	300	50-75
electrode identification:	3.2	350	70-110
FOX CN 21/33 Mn	4.0	400	90-140

=+

Base Materials

1.4876 X10 NiCrAlTi 32 20
1.4859 GX10 NiCrNb 32 2o
1.4958 X 5 NiCrAlTi 3120
1.4959 X 8NiCrAlTi 32 21
Alloy 800 H, UNS N08800, N08810, N08811

Approvals and Certificates

TÜV-D (10514.), TÜV-A, CL

Same-alloy Filler Metals

GTAW rod:	CN 21/33 Mn-IG
GMAW solid wire:	CN 21/33 Mn-IG

EN 1600:1999: EZ 25 35 Nb B 6 2

BÖHLER FOX CN 25/35 Nb

SMAW stick electrode
high-alloyed, heat resistant

Description

Basic coated electrode for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition Resistant to scaling up to 1150 °C.
Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb	Ti	Fe
wt-%	**0.4**	**1.0**	**1.5**	**25**	**35**	**1.2**	**0.1**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 480
tensile strength R_m N/mm^2:	≥ 700
elongation A (L_0=5d_0) %:	≥ 8

(*) *u untreated, as-welded*

Operating Data

re-drying:	**ø mm**	**L mm**	**amps A**
250-300 °C, min. 2 h	2.5	300	50-75
electrode identification:	3.2	350	70-120
FOX CN 25/35 Nb	4.0	400	100-140

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Base Materials

1.4852 GX40NiCrSiNb35-25
1.4857 GX40NiCrSi35-25

Approvals and Certificates

TÜV-D (applied), TÜV-A, CL

Similar-alloy Filler Metals

GTAW rod:	CN 25/35 Nb-IG
GMAW solid wire:	CN 25/35 Nb-IG

DIN EN1600:1997: EZ 35 45 Nb B 6 2

BÖHLER FOX CN 35/45 Nb

SMAW stick electrode
high-alloyed, heat resistant

Description

Basic coated electrode for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition Resistant to scaling up to 1180 °C.
Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb	Fe
wt-%	**0.45**	**1**	**0.8**	**35.0**	**45.5**	**0.9**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm²:	≥ 450
tensile strength R_m N/mm²:	≥ 600
elongation A (L_0=5d_0) %:	≥ 8

(*) *u untreated, as welded*

Operating Data

re-drying if necessary:
120 - 200 °C, min. 2-3 hrs
electrode identification:
FOX CN 35/45 Nb

ø mm	**L mm**	**amps A**
2.5	300	70-90
3.2	350	90-110
4.0	350	100-140

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Base Materials

GX45NiCrNbSiTi45-35

Approvals and Certificates

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Same Alloy Filler Metals

GTAW rod:	CN 35/45 Nb-IG
GMAW solid wire:	CN 35/45 Nb-IG

EN 12072:1999:	W 25 4
W.Nr.:	1.4820

BÖHLER FA-IG

GTAW rod, high-alloyed, heat resistant

Description

TIG welding rod for gas-shielded welding of heat resisting, analogous or similar steels. Ferritic-austenitic deposit. The low Ni-content renders this filler metal especially recommendable for applications involving the attack of sulphurous oxidizing or reducing combustion gases.
Scaling resistance up to +1100 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni
wt-%	**0.08**	**0.8**	**1.2**	**25.7**	**4.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**540**	(≥ 500)
tensile strength R_m N/mm^2:		**710**	(≥ 650)
elongation A ($L_0 = 5d_0$) %:		**22**	(≥ 20)
impact work ISO-V KV J	+ 20 °C:	**70**	(≥ 40)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**
rod marking:
front: **W 25 4**
back: **1.4820**

ø mm
2.4

=−

Preheating and interpass temperature as required by the base metal.

Base Materials

ferritic-austenitic
1.4821 X 20 CrNiSi 25 4, 1.4823 G-X 40 CrNiSi 27 4
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25,
1.4710 X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 327; ASTM A297HC

Approvals and Certificates

UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX FA

GMAW solid wire: FA-IG

EN 12072:1999:	W 22 12 H
AWS A5.9-93:	ER309(mod.)
W.Nr.:	1.4829

BÖHLER FF-IG

GTAW rod, high-alloyed, heat resistant

Description

TIG welding rod for analogous, heat resisting rolled, forged and cast steels as well as for heat resisting, ferritic CrSiAl steels, e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. Austenitic deposited with a ferrite content of approx. 8 %. Preferably used for applications involving the attack of oxidizing gases. The final layer of joint welds in CrSiAl steels exposed to sulphurous gases must be deposited by means of FOX FA or FA-IG. Scaling resistance up to +1000 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni
wt-%	**0.11**	**1.2**	**1.2**	**22.0**	**11.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**500**	(≥ 420)
tensile strength R_m N/mm²:		**630**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**32**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**115**	(≥ 85)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas: **100 % Argon**
rod marking:
front: **W 22 12 H**
back: **1.4829**

ø mm
1.6
2.0
2.4

Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4828 X 15 CrNiSi 20 12, 1.4826 G-X 40 CrNiSi 22 9, 1.4833 X7 CrNi 2314
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305; ASTM A297HF

Approvals and Certificates

TÜV-A (20), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode: FOX FF
FOX FF-A

GMAW solid wire: FF-IG

EN 12072:1999:	W 25 20 Mn
AWS A5.9-93:	ER310(mod.)
W.Nr.:	1.4842

BÖHLER FFB-IG

GTAW rod, high-alloyed, heat resistant

Description

TIG welding rod for analogous, heat resisting, rolled, forged and cast steels, e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. Fully austenitic deposit. Preferably employed for applications involving the attack of oxidizing, nitrogen-containing or low-oxygen gases. The final layer of joint welds in heat resisting CrSiAl steels exposed to sulphurous gases must be deposited by means of FOX FA or FA-IG.
Scaling resistance up to +1200 °C. Cryogenic toughness down to -196 °C.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni
wt-%	**0.12**	**0.9**	**3.2**	**25.0**	**20.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**420**	(≥ 380)
tensile strength R_m N/mm^2:		**630**	(≥ 580)
elongation A ($L_0 = 5d_0$) %:		**33**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**85**	(≥ 80)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

		ø mm
shielding gas:	**100 % Argon**	1.6
rod marking:		2.0
front:	**W 25 20 Mn**	2.4
back:	**1.4842**	

Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4841 X 15 CrNiSi 25 20, 1.4845 X 12 CrNi 25 21, 1.4828 X 15 CrNiSi 20 12,
1.4840 G-X 15 CrNi 25 20, 1.4846 G-X 40 CrNi 25 21, 1.4826 G-X 40 CrNiSi 22 9
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25,
1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305, 310, 314; ASTM A297 HF; A297 HJ

Approvals and Certificates

UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX FFB FOX FFB-A	GMAW solid wire:	FFB-IG

EN 12072: 1999: W Z21 33 Nb
W.No.: 1.4850(mod.)

BÖHLER CN 21/33 Mn-IG

GTAW rod, high-alloyed, heat resistant

Description

GTAW rod for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition. Suitable for operating temperatures up to +1050 °C in carburized low-sulphur gas. Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.2**	**0.2**	**2.3**	**22.0**	**33.0**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		≥ 450
tensile strength R_m N/mm²:		≥ 620
elongation A (L_0=5d_0) %:		≥ 17
impact work ISO-V KV J	+20 °C:	≥ 50

(*) u *untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas:
100 % Argon
rod marking:
front: **21/33**
back: **1.4850**

ø mm
2.0
2.4
3.2

Base Materials

1.4876 X10 NiCrAlTi 32 20
1.4859 GX10 NiCrNb 32 20
1.4958 X 5 NiCrAlTi 3120
1.4959 X 8 NiCrAlTi 32 21
Alloy 800 H, UNS N08800, N08810, N08811

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW stick electrode: FOX CN 21/33 Mn
GMAW solid wire: CN 21/33 Mn-IG

EN 12072:1999:	W Z25 35 Nb
W.No.:	1.4853

BÖHLER CN 25/35 Nb-IG

GTAW rod, high-alloyed, heat resistant

Description

GTAW rod for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition Resistant to scaling up to 1150 °C. Typical alloy for welding of pyrolysis furnace tubes.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Nb	Fe
wt-%	**0.42**	**1.2**	**1.8**	**26**	**35**	**1.3**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 400
tensile strength R_m N/mm^2:	≥ 600
elongation A (L_0=5d_0) %:	≥ 8

(*) *u untreated, as-welded*

Operating Data

shielding gas:	**ø mm**
100 % Argon	
rod marking:	2.4
front: **25/35Nb**	2.4
back: **1.4853**	3.2

Base Materials

GX40 NiCrSiNb 35-25 (1.4852)
G-X40 NiCrSi 35-25 (1.4857)

Approvals and Certificates

TÜV-D (applied), TÜV-A, CL

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 25/35 Nb
GMAW solid wire:	CN 25/35 Nb-IG

DIN EN12072:1999: W Z35 45 Nb H

BÖHLER CN 35/45 Nb-IG

GTAW rod, high-alloyed, heat resistant

Description

GTAW rod for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition Resistant to scaling up to 1180 °C. Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.42**	**1.5**	**1.0**	**35**	**45.5**	**0.8**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm²:	≥ 450
tensile strength R_m N/mm²:	≥ 550
elongation A (L_0=5d_0) %:	≥ 6

(*) *u untreated, as-welded*

Operating Data

shielding gas:
100 % Argon
rod marking:
front: **35/45**

ø mm
2.0
2.4
3.2

Base Materials

GX45NiCrNbSiTi45-35

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 35/45 Nb
GMAW solid wire:	CN 35/45 Nb-IG

EN 12072:1999: G 25 4
W.Nr.: 1.4820

BÖHLER FA-IG

GMAW solid wire,
high-alloyed, heat resistant

Description

GMAW wire for gas-shielded welding of heat resisting, analogous or similar steels. Ferritic-austenitic deposit. The low Ni-content renders this filler metal especially recommendable for applications involving the attack of sulphurous oxidizing or reducing combustion gases.
Scaling resistance up to +1100 °C.

Typical Composition of Solid Wire

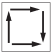
	C	Si	Mn	Cr	Ni
wt-%	**0.08**	**0.8**	**1.2**	**25.7**	**4.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**520**	(≥ 450)
tensile strength R_m N/mm²:		**690**	(≥ 630)
elongation A ($L_0 = 5d_0$) %:		**20**	(≥ 15)
impact work ISO-V KV J	+ 20 °C:	**50**	(≥ 30)

(*) *u untreated, as-welded – shielding gas Ar + 2.5 % CO_2*

Operating Data



shielding gases:
Argon + max. 2.5 % CO_2

ø mm
1.0
1.2

=+

Preheating and interpass temperature as required by the base metal.

Base Materials

ferritic-austenitic
1.4821 X 20 CrNiSi 25 4, 1.4823 G-X 40 CrNiSi 27 4
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25, 1.4710 X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 327; ASTM A297HC

Approvals and Certificates

UDT

Same Alloy Filler Metals

SMAW stick electrode: FOX FA
GTAW rod: FA-IG

EN 12072:1999:	G 22 12 H
AWS A5.9-93:	ER309(mod.)
W.Nr.:	1.4829

BÖHLER FF-IG

GMAW solid wire, high-alloyed, heat resistant

Description

GMAW wire for analogous, heat resisting rolled, forged and cast steels as well as for heat resisting, ferritic CrSiAl steels, e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. Austenitic deposited with a ferrite content of approx. 8 %. Preferably used for applications involving the attack of oxidizing gases. The final layer of joint welds in CrSiAl steels exposed to sulphurous gases must be deposited by means of FOX FA or FA-IG.
Scaling resistance up to +1000 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni
wt-%	**0.08**	**1.1**	**1.6**	**23.0**	**11.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**480**	(≥ 350)
tensile strength R_m N/mm²:		**620**	(≥ 540)
elongation A ($L_0 = 5d_0$) %:		**34**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**110**	(≥ 70)

(*) *u untreated, as-welded – shielding gas Ar + 2.5 % CO_2*

Operating Data

shielding gases:
Argon + max. 2.5 % CO_2

ø mm
1.0
1.2

=+

Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4828 X 15 CrNiSi 20 12, 1.4826 G-X 40 CrNiSi 22 9, 1.4833 X7 CrNi 23 14
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305; ASTM A297HF

Approvals and Certificates

TÜV-A (26), UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX FF	GTAW rod:	FF-IG
	FOX FF-A		

EN 12072:1999:	G 25 20 Mn
AWS A5.9-93:	ER310(mod.)
W.Nr.:	1.4842

BÖHLER FFB-IG

GMAW solid wire, high-alloyed, heat resistant

Description

GMAW wire for analogous, heat resisting, rolled, forged and cast steels, e.g. in annealing shops, hardening shops, steam boiler construction, the crude oil industry and the ceramics industry. Fully austenitic deposit. Preferably employed for applications involving the attack of oxidizing, nitrogen-containing or low-oxygen gases. The final layer of joint welds in heat resisting CrSiAl steels exposed to sulphurous gases must be deposited by means of FOX FA or FA-IG.
Scaling resistance up to +1200 °C. Cryogenic toughness down to - 196 °C.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni
wt-%	**0.12**	**0.9**	**3.2**	**25.0**	**20.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**400**	(≥ 350)
tensile strength R_m N/mm^2:		**620**	(≥ 540)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**95**	(≥ 63)
	- 196 °C:		(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gases:
Argon + max. 2.5 % CO_2

ø mm
0.8
1.0
1.2

=+

Preheating and interpass temperatures for ferritic steels 200 - 300 °C.

Base Materials

austenitic
1.4841 X 15 CrNiSi 25 20, 1.4845 X 12 CrNi 25 21, 1.4828 X 15 CrNiSi 20 12, 1.4840 G-X 15 CrNi 25 20, 1.4846 G-X 40 CrNi 25 21, 1.4826 G-X 40 CrNiSi 22 9
ferritic-perlitic
1.4713 X 10 CrAl 7, 1.4724 X 10 CrAl 13, 1.4742 X 10 CrAl 18, 1.4762 X 10 CrAl 25, 1.4710 G-X 30 CrSi 6, 1.4740 G-X 40 CrSi 17

AISI 305, 310, 314; ASTM A297 HF; A297 HJ

Approvals and Certificates

UDT, SEPROZ

Same Alloy Filler Metals

SMAW stick electrode:	FOX FFB FOX FFB-A	GTAW rod:	FFB-IG

EN 12072: 1999:	G Z21 33 Nb
W.No.:	1.4850(mod.)

BÖHLER CN 21/33 Mn-IG

GMAW solid wire, high-alloyed, heat resistant

Description

GMAW wire for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition. Suitable for operating temperatures up to +1050 °C in carburized low-sulphur gas. Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.2**	**0.2**	**2.3**	**22.0**	**33.0**	**1.7**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		≥ 380
tensile strength R_m N/mm^2:		≥ 600
elongation A (L_0=5d_0) %:		≥ 25
impact work ISO-V KV J	+20 °C:	≥ 50

(*) u *untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gas:	**ø mm**	
Argon + 2.5 % CO_2	1.0	=+
	1.2	

Base Materials

1.4876 X10 NiCrAlTi 32 20
1.4859 GX10 NiCrNb 32 20
1.4958 X5 NiCrAlTi 31 20
1.4959 X8 NiCrAlTi 32 21
Alloy 800 H, UNS N08800, N08810, N08811

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 21/33 Mn
GTAW rod:	CN 21/33 Mn-IG

EN 12072:1999:	G Z25 35 Nb
W.No.:	1.4853

BÖHLER CN 25/35 Nb-IG

GMAW solid wire, high-alloyed, heat resistant

Description

GMAW wire for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition Resistant to scaling up to 1150 °C. Typical alloy for welding of pyrolysis furnace tubes.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Nb	Fe
wt-%	**0.42**	**1.2**	**1.8**	**26**	**35**	**1.3**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 400
tensile strength R_m N/mm^2:	≥ 600
elongation A (L_0=5d_0) %:	≥ 8

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gas:	ø mm
Argon + 2.5 % CO_2	1.2

=+

Base Materials

GX40NiCrSiNb35-25 (1.4852)
G-X40 NiCrSi 35 25 (1.4857)

Approvals and Certificates

CL

Similar Alloy Filler Metals

SMAW stick electrode:	FOX CN 25/35 Nb
GTAW rod:	CN 25/35 Nb-IG

DIN EN12072:1999: G Z35 45 Nb H

BÖHLER CN 35/45 Nb-IG

GMAW solid wire
high-alloyed, heat resistant

Description

GMAW wire for joining and surfacing of heat resistant steels and cast steels of the same or similar chemical composition Resistant to scaling up to 1180 °C. Typicall alloy for welding of pyrolysis furnace tubes.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Nb
wt-%	**0.42**	**1.5**	**1.0**	**35**	**45.5**	**0.8**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 245
tensile strength R_m N/mm^2:	≥ 450
elongation A (L_0=5d_0) %:	≥ 6

(*) *u untreated, as-welded – shielding gas Argon + 2.5 % CO_2*

Operating Data

shielding gas:
Argon + 2.5 % CO_2

ø mm
1.2

=+

Base Materials

GX 45NiCrNbSiTi45-35

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW stick electrode:	FOX CN 35/45 Nb
GTAW rod:	CN 35/45 Nb-IG

Notes

Notes

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2.9. Nickel-base Filler Metals

Objectives

This section contains product information for nickel base filler metals. The main applications of these filler metals are welding of nickel base alloys, high temperature and creep resisting steels, heat resisting and cryogenic materials, dissimilar joints and low alloy problem steels.
Nickel and its alloys with Cr, Cu, Fe, Mo, Co, Al and Ti offer a broad and universal range of possibilities for use, e.g. for highly corrosion resisting offshore constructions, chemical and petrochemical plant engineering, in flue gas desulphurisation or for sea water desalination plants as well as for high temperature and heat resistant applications like the boiler fabrication or the construction of heating ovens and furnaces.
In addition some of the nickel base alloys are also suitable for cryogenic applications down to -196 °C.

Contents

Overview – Standard Classifications

Böhler	ENISO / DIN		AWS

SMAW stick electrodes

Böhler	ENISO / DIN		AWS
FOX NIBAS 60/15	ENISO14172:	E Ni 6620 (NiCr14Mo7Fe)	AWS 5.11-97: ENiCrMo-6
FOX NIBAS 625	ENISO14172:	E Ni 6625 (NiCr22Mo9Nb)	AWS A5.11-97: ENiCrMo-3
FOX NiCr 625*	DIN 1736:	EL-NiCr 20 Mo 9 Nb	
FOX NIBAS 70/15	ENISO14172:	E Ni 6182 (NiCr15Fe6Mn)	AWS A5.11-97: ENiCrFe-3
FOX NiCr 70/15*	DIN 1736:	EL-NiCr 16 FeMn	
FOX NIBAS 70/20	ENISO14172:	E Ni 6082 (NiCr20Mn3Nb)	AWS A5.11-97: ENiCrFe-3(mod.)
FOX NiCr 70 Nb*	DIN 1736:	EL-NiCr 19 Nb	
FOX NIBAS C 24	ENISO14172:	E Ni 6059 (NiCr23Mo16)	AWS A5.11-97: ENiCrMo-13
	DIN 1736:	EL-NiCr 22 Mo 16	
FOX NIBAS 617	ENISO14172:	E Ni 6617 (NiCr21Co12Mo)	AWS 5.11: ENiCrCoMo-1
	DIN 1736:	EL-NiCr 21 Co 12Mo	
FOX NIBAS C 276	ENISO14172:	E Ni 6276 (NiCr15Mo15Fe6W4)	AWS 5.11-97: ENiCrMo-4
	DIN 1736:	EL-NiMo 15 Cr 15 W	
FOX NIBAS 400	ENISO14172:	E Ni 4060 (NiCu30Mn3Ti)	AWS 5.11: ENiCu7
	DIN 1736:	EL-NiCu 30 Mn	

GTAW rods

Böhler	ENISO / DIN		AWS
NIBAS 625-IG	ENISO18274:	S Ni 6625 (NiCr22Mo9Nb)	AWS A5.14-97: ERNiCrMo-3
NiCr 625-IG*	DIN 1736:	SG-NiCr 21 Mo 9 Nb	
NIBAS 70/20-IG	ENISO18274:	S Ni 6082 (NiCr20Mn3Nb)	AWS A5.14-97: ERNiCr-3
NiCr 70 Nb-IG*	DIN 1736:	SG-NiCr 20 Nb	
NIBAS C 24-IG	ENISO18274:	S Ni 6059 (NiCr23Mo16)	AWS A5.14-97: ERNiCrMo-13
	DIN 1736:	SG-NiCr 23 Mo 16	
NIBAS 617-IG	ENISO18274:	S Ni 6617 (NiCr22Co12Mo)	AWS A5.14-97: ERNiCrCoMo-1
	DIN 1736:	SG-NiCr 22 Co 12 Mo 9	
NIBAS C 276-IG	ENISO18274:	S Ni 6276 (NiCr15Mo16Fe6W4)	AWS A5.14-97: ERNiCrMo-4
	DIN 1736:	SG-NiMo 16 Cr 16 W	
NIBAS 400-IG	ENISO18274:	S Ni 4060 (NiCu30Mn3Ti)	AWS A5.14-97: ERNiCu7
	DIN 1736:	SG-NiCu 30 Mn 3 Ti	

GMAW solid wires

Böhler	ENISO / DIN		AWS
NIBAS 625-IG	ENISO18274:	S Ni 6625 (NiCr22Mo9Nb)	AWS A5.14-97: ERNiCrMo-3
NiCr 625-IG*	DIN 1736:	SG-NiCr 21 Mo 9 Nb	
NIBAS 70/20-IG	ENISO18274:	S Ni 6082 (NiCr20Mn3Nb)	AWS A5.14-97: ERNiCr-3
NiCr 70 Nb-IG*	DIN 1736:	SG-NiCr 20 Nb	
NIBAS C24-IG	ENISO18274:	S Ni 6059 (NiCr23Mo16)	AWS A5.14-97: ERNiCrMo-13
	DIN 1736:	SG-NiCr 23 Mo 16	
NIBAS 617-IG	ENISO18274:	S Ni 6617 (NiCr22Co12Mo)	AWS A5.14-97: ERNiCrCoMo-1
	DIN 1736:	SG-NiCr 22 Co 12 Mo 9	
NIBAS C 276-IG	ENISO18274:	S Ni 6276 (NiCr15Mo16Fe6W4)	AWS A5.14-97: ERNiCrMo-4
	DIN 1736:	SG-NiMo 16 Cr 16 W	
NIBAS 400-IG	ENISO18274:	S Ni 4060 (NiCu30Mn3Ti)	AWS A5.14-97: ERNiCu7
	DIN 1736:	SG-NiCu 30 Mn 3 Ti	

GMAW flux cored wires

Böhler	ENISO / DIN		AWS
NIBAS 70/20-FD	ENISO14172:	Typ E Ni 6082 (NiCr20Mn3Nb)	AWS A5.34: ENiCr 3T0-4
FOX NIBAS 625-FD	ENISO14172:	E Ni 6625 (NiCr22Mo9Nb)	AWS A5.11-97: ENiCrMo-3T0-4

SAW wire/flux-combination

Böhler	ENISO / DIN		AWS
NIBAS 70/20-UP/BB 444	ENISO18274:	S Ni 6082 (NiCr20Mn3Nb)	AWS A5.14-97: ERNiCr-3
	DIN 1736:	UP-NiCr 20 Nb	
	Flux: EN760:	SA-FB 2 AC	
NIBAS 625-UP/BB 444	ENISO18274:	S Ni 6625 (NiCr22Mo9Nb)	AWS A5.14-97: ERNiCrMo-3
	DIN 1736:	UP-NiCr 21 Mo 9 Nb	
	Flux: EN760:	SA-FB 2 AC	
NIBAS C 24-UP/BB 444	ENISO18274:	S Ni 6059 (NiCr23Mo16)	AWS A5.14-97: ERNiCrMo-13
	DIN 1736:	SG-NiCr 23 Mo 16	
	Flux: EN760:	SA-FB 2 AC	
NIBAS 617-UP/BB 444	ENISO18274:	S Ni 6617 (NiCr22Co12Mo)	AWS A5.14-97: ERNiCrCoMo-1
	DIN 1736:	SG-NiCr 22 Co 12 Mo 9	
	Flux: EN760:	SA-FB 2 AC	
NIBAS C276-UP/BB 444	ENISO18274:	S Ni 6276 (NiCr15Mo16Fe6W4)	AWS A5.14-97: ERNiCrMo-4
	DIN 1736:	SG-NiMo 16 Cr 16 W	
	Flux: EN760:	SA-FB 2 AC	

* product name in Germany

◆ Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	Ti	Fe	Co	Ta	Al	
SMAW stick electrodes													
FOX NIBAS 60/15	<0.1	<0.6	3.0	14.0	bal.	6.5	1.0		<10.0				T 1.3
FOX NIBAS 625	0.025	0.4	0.7	22.0	≥60.0	9.0	3.3		0.5	≤0.05		≤0.4	
FOX NiCr 625*	0.025	0.4	0.7	22.0	≥60.0	9.0	3.3		0.5	≤0.05		≤0.4	
FOX NIBAS 70/15	0.025	0.4	6.0	16.0	≥67	≤0.5	2.2	+	6.0	≤0.08	≤0.08		
FOX NiCr 70/15*	0.025	0.4	6.0	16.0	≥67	≤0.5	2.2	+	6.0	≤0.08	≤0.08		
FOX NIBAS 70/20	0.025	0.4	5.0	19.0	≥67	≤1.2	2.2	+	3.0	≤0.08			
FOX NiCr 70 Nb*	0.025	0.4	5.0	19.0	≥67	≤1.2	2.2	+	3.0	≤0.08			
FOX NIBAS C 24	≤0.02	≤0.2	0.5	22.5	bal.	15.5			1				
FOX NIBAS 617	0.06	0.7	0.1	21.0	bal.	9.0		0.3	1.0	11.0		0.7	
FOX NIBAS C 276	<0.02	<0.2	0.6	16.5	bal.	16.5			5.0				T 4
FOX NIBAS 400	<0.05	0.7	3.0		bal.			0.7	1.0			0.3	Cu 29
GTAW rods													
NIBAS 625-IG	≤0.02	≤0.2	≤0.3	21.5	≥60.0	9.0	3.6		≤2.0				
NiCr 625-IG*	≤0.02	≤0.2	≤0.3	21.5	≥60.0	9.0	3.6		≤2.0				
NIBAS 70/20-IG	≤0.03	≤0.1	3.0	20.0	≥67		2.5	+	≤1.7				
NiCr 70 Nb-IG*	≤0.03	≤0.1	3.0	20.0	≥67		2.5	+	≤1.7				
NIBAS C 24-IG	0.01	0.1	<0.5	23.0	bal.	16.0			<1.0				
NIBAS 617-IG	0.05	0.1	0.1	21.5	bal.	9.0		0.5	1.0	11.0		1.0	
NIBAS C 276-IG	<0.01	0.1		16.0	bal.	16.0			6.0			T 3.5	V 0.2
NIBAS 400-IG	<0.02	0.3	3.2		bal.			2.4	1.0			<1.0	Cu 29
GMAW solid wires													
NIBAS 625-IG	≤0.02	≤0.2	≤0.3	21.5	≥60.0	9.0	3.6		≤2.0				
NiCr 625-IG*	≤0.02	≤0.2	≤0.3	21.5	≥60.0	9.0	3.6		≤2.0				
NIBAS 70/20-IG	≤0.03	≤0.3	3.0	20.0	≥67		2.5	+	≤1.7				
NiCr 70 Nb-IG*	≤0.03	≤0.3	3.0	20.0	≥67		2.5	+	≤1.7				
NIBAS C24-IG	<0.01	0.1	<0.5	23.0	bal.	16.0			<1.0				
NIBAS 617-IG	0.05	0.1	0.1	21.5	bal.	9.0		0.5	1.0	11.0		1.0	
NIBAS C 276-IG	<0.01	0.1		16.0	bal.	16.0			6.0			V 0.2	T 3.5
NIBAS 400-IG	<0.02	0.3	3.2		bal.			2.4	1.0			<1.0	Cu 29
GMAW flux cored wires													
NIBAS 70/20-FD	0.03	0.4	3.2	20.0	≥67		2.5		2.0				
FOX NIBAS 625-FD	0.05	0.4	0.4	22.0	≥60	8.5	3.3		<5.0				
SAW wire/flux-combination													
NIBAS 70/20-UP	0.01	0.15	3.2	20.5	bal.		2.6	0.35	<2.0				
NIBAS 70/20-UP/BB 444	0.01	0.25	3.0	20.0	bal.		2.2	0.15	0.8				
NIBAS 625-UP	0.010	0.1	0.2	22.0	bal.	9.0	3.6		<1.5				
NIBAS 625-UP/BB 444	0.015	0.25	0.2	21,5	bal.	8.5	3.3	0.1	0.4				
NIBAS C 24-UP	<0.012	<0.1	<0.5	23.0	bal.	15.5			<1.5				
NIBAS C 24-UP/BB 444	<0.020	0.2	0.25	22.0	bal.	15.5			0.25				
NIBAS 617-UP	<0.06	<0.2	<0.2	20.5	bal.	8.8		0.5	<1.0	10.4		1.0	
NIBAS 617-UP/BB 444	<0.06	<0.4	<0.3	20.0	bal.	8.8		0.25	<1.0	10.0		0.8	
NIBAS C276-UP	<0.012	<0.1	<0.5	15.5	bal.	16.0			<7.0				T 3.8
NIBAS C276-UP/BB 444	0.012	0.15	0.4	15.0	bal.	16.0			5.5				T 3.3

* product name in Germany

EN ISO 14172:2003:	E Ni 6620 (NiCr14Mo7Fe)
AWS 5.11-97:	ENiCrMo-6

BÖHLER FOX NIBAS 60/15

SMAW stick electrode, high efficiency nickel base

Description

The high-nickel electrode FOX NIBAS 60/15 is especially suited for welding cold-tough nickel steels, such as X8Ni9. High performance lime-type electrode, recovery appr. 170 %.
The electrode is designated for welding with ac, in order to avoid the magnetic arc blow effects which occur when welding cold-tough nickel steels with dc.
It is weldable in flat, horizontal and vertical-up position. Stable arc, easy slag removal.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Nb	Fe	W	Ni
wt-%	**<0.1**	**<0.6**	**3**	**14**	**6,5**	**1**	**<10.0**	**1.3**	**bal.**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		≥ 420
tensile strength R_m N/mm^2:		≥ 690
elongation A (L_0=5d_0) %:		≥ 35
impact work ISO-V KV J	-196 °C:	≥ 60

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying: if necessary			
250-300 °C, min. 2 h	2.5	300	70-100
electrode identification:	3.2	350	100-130
FOX NIBAS 60/15 NiCrMo 6	4.0	350	120-160

The weld zone must be bare and properly degreased. The electrode is welded with a slight tilt, short arc and sufficient high amperage adjustment. To avoid end crater cracks the crater must be filled properly and the arc drawn away to the side.

Base Materials

9 % nickel steel base metal:
X 8 Ni 9
ASTM A333, A334, A353, A522, A553, K81340

Approvals and Certificates

TÜV-D (10510.)

Same Alloy Filler Metals

–

BÖHLER FOX NIBAS 625, FOX NiCr 625*

ENISO14172:2003:	E Ni6625 (NiCr22Mo9Nb)
DIN 1736:	EL-NiCr 20 Mo 9 Nb
AWS A5.11-97:	ENiCrMo-3

SMAW stick electrode, nickel base

Description

Basic coated alloyed-core wire electrode for welding the nickel-base alloy Inconel 625 as well as CrNiMo-steels with high molybdenum content (e.g. "6 Mo" steels). It is also recommended for high temperature and creep resisting steels, heat resisting and cryogenic materials, dissimilar joints, and low-alloyed problem steels.
Suitable in pressure vessel fabrication for -196 °C to +550 °C, otherwise up to the scaling resistance temperature of +1200 °C (S-free atmosphere). Due to the weld metal embrittlement between 600 - 850 °C, this temperature range should be avoided. Highly resistant to hot cracking. Furthermore C-diffusion at high temperature or during heat treatment of dissimilar joints is largely reduced.
Extremely resistant to stress corrosion cracking and pitting (PRE_N 52). Thermal shock resistant, fully austenitic, low coefficient of thermal expansion between C-steel and austenitic CrNi (Mo)-steel.
Excellent welding characteristics in all positions except vertical-down, easy slag removal, high resistance to porosity. Electrodes and weld metal meet highest quality requirements.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Al	Nb	Co	Fe
wt-%	**0.025**	**0.4**	**0.7**	**22.0**	**≥ 60.0**	**9.0**	**≤ 0.4**	**3.3**	**≤ 0.05**	**0.5**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**530**	(≥ 450)
tensile strength R_m N/mm²:		**800**	(≥ 750)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**80**	(≥ 65)
	- 196 °C:	**45**	(≥ 32)

(*) *u untreated, as-welded*

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX NIBAS 625 E NiCrMo-3 resp.
FOX NiCr 625 E NiCrMo-3

ø mm	L mm	amps A
2.5	250	45 - 60
3.2	300	65 - 95
4.0	350	90 - 120

=+

Base Materials

2.4856 NiCr 22 Mo 9 Nb, 2.4858 NiCr 21 Mo, 2.4816 NiCr 15 Fe, 1.4583 X10CrNiMoNb18-12, 1.4876 X 10 NiCrAlTi 32 20 H, 1.4876 X 10 NiCrAlTi 32 21, 1.4529 X1NiCrMoCuN25-20-7, X 2 CrNiMoCuN 20 18 6, 2.4641 NiCr 21 Mo 6 Cu joint welds of listed materials with non alloy and low alloy steels, e.g P265GH, P285NH, P295GH, 16Mo3, S355N, X8Ni9, ASTM A 553 Gr.1, Alloy 600, Alloy 625, Alloy 800 (H), 9 % Ni-steels

Approvals and Certificates

TÜV-D (3773.), TÜV-A (478), Statoil, UDT, LTSS, SEPROS, (FOX NiCr 625: TÜV-D 3773.)

Same Alloy Filler Metals

GTAW rod: NIBAS 625-IG
GMAW solid wire: NIBAS 625-IG
GMAW flux cored wire: NIBAS 625-FD
SAW comb.: NIBAS 625-UP/BB 444

* product name in Germany

BÖHLER FOX NIBAS 70/15, FOX NiCr 70/15*

SMAW stick electrode, nickel base

ENISO14172:2003:	E Ni6182 (NiCr15Fe6Mn)
DIN 1736:	EL-NiCr 16 FeMn
AWS A5.11-97:	ENiCrFe-3

Description

Basic coated alloyed-core wire electrode corresponding to AWS E NiCrFe-3 for high grade welding of nickel-base alloys, high-temperature and creep resisting steels, heat resisting and cryogenic materials, low-alloyed problem steels and dissimilar joints. Ferritic-austenitic joints for service temperatures above +300 °C or for applications where a post weld heat treatment is required
Suitable in pressure vessel fabrication for -196 °C to +650 °C, otherwise up to the scaling resistance temperature of +1200 °C (S-free atmosphere). Insusceptible to embrittlement, highly resistant to hot cracking, furthermore, C-diffusion at high temperature or during heat treatment of dissimilar joints is largely reduced. Thermal shock resistant, stainless, fully austenitic, low coefficient of thermal expansion between the coefficient values of C-steel and austenitic CrNi (Mo)-steel.
Excellent welding characteristics in all positions except vertical-down, easy slag removal, high resistance to porosity. Electrode and weld metal meet highest quality requirements.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Ti	Ta	Nb	Co	Fe
wt-%	**0.025**	**0.4**	**6.0**	**16.0**	**≥ 67**	**≤ 0.05**	**+**	**≤ 0.08**	**2.2**	**≤ 0.08**	**6.0**

Mechanical Properties of All-weld Metal

(*)		u	s1	s2
yield strength R_e N/mm²:		**400** (≥ 360)	**400** (≥ 360)	**400** (≥ 360)
tensile strength R_m N/mm²:		**670** (≥ 600)	**670** (≥ 600)	**670** (≥ 600)
elongation A ($L_0 = 5d_0$) %:		**40** (≥ 30)	**40** (≥ 30)	**40** (≥ 30)
impact work ISO-V KV J	+ 20 °C:	**120** (≥ 90)	**120** (≥ 80)	**120** (≥ 80)
	- 196 °C:	**80** (≥ 32)	**70** (≥ 32)	**70** (≥ 32)

(*) *u untreated, as-welded*
s1 stress relieved, 650 °C/15 h/air
s2 stress relieved, 760 °C/10 h/air

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX NIBAS 70/15 E NiCrFe-3 resp.
FOX NiCr 70/15 E NiCrFe-3

ø mm	L mm	amps A
2.5	300	45 - 75
3.2	300	70 - 105
4.0	350	95 - 130

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Base Materials

NiCr 15 Fe (Inconel 600) as well as Ni-alloys of similar or same chemical composition; non alloy and low alloy steels for elevated temperatures, e.g. P235GH, P265GH, S255NB, P235GH-P355GH, 16Mo3, high temperature steels as well as constructional steels with comparable tensile strength; creep resistant austenitic steels, e.g. X8CrNiNb16-13, X8CrNiMoNb16-16, X8CrNiMoVNb16-13, Ni-steels containing 1.5% up to 5% Ni-steels; low alloyed constructional and pressure vessel steels, also X20CrMoV12-1 and X20CrMoWV12-1 on stainless and creep resistant austenitic steels; also suitable for Alloy 800.

Approvals and Certificates

TÜV-D (0842.), UDT, (FOX NiCr 70/15: TÜV-D (0842.), KTA 1408 1 (8037.00))

Similar and Same Alloy Filler Metals

GTAW rod: NIBAS 70/20-IG
GMAW solid wire: NIBAS 70/20-IG
GMAW flux cored wire: NIBAS 70/20-FD
SAW comb.: NIBAS 70/20-UP/BB 444

* product name in Germany

ENISO14172:2003:	E Ni6082 (NiCr20Mn3Nb)
DIN 1736:	EL-NiCr 19 Nb
AWS A5.11-97:	ENiCrFe-3(mod.)

BÖHLER FOX NIBAS 70/20, FOX NiCr 70 Nb*

SMAW stick electrode, nickel base

Description

Basic coated alloyed-core wire electrode corresponding to DIN EL-NiCr 19 Nb for high-grade welding of nickel-base alloys, high-temperature and creep resisting steels, heat resisting and cryogenic materials, low-alloyed problem steels and dissimilar joints. Ferritic-austenitic joints for service temperatures above +300 °C or for applications where a post weld heat treatment is required
Suitable in pressure vessel fabrication for -196 °C to +650 °C, otherwise up to the scaling resistance temperature of +1200 °C (S-free atmosphere). Insusceptible to embrittlement, highly resistant to hot cracking, furthermore, C-diffusion at high temperature or during heat treatment of dissimilar joints is largely reduced. Thermal shock resistant, stainless, fully austenitic, low coefficient of thermal expansion between the coefficient values of C-steel and austenitic CrNi (Mo)-steel.
Excellent welding characteristics in all positions except vertical-down, easy slag removal, high resistance to porosity, absence of undercuts, high degree of purity. Electrode and weld metal meet highest quality requirements.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Mo	Ti	Nb	Co	Fe
wt-%	**0.025**	**0.4**	**5.0**	**19.0**	**≥ 67.0**	**≤ 1.2**	**+**	**2.2**	**≤ 0.08**	**3.0**

Mechanical Properties of All-weld Metal

(*)		u		s1		s2	
yield strength R_e N/mm²:		**420**	(≥ 380)	**420**	(≥ 380)	**420**	(≥ 380)
tensile strength R_m N/mm²:		**680**	(≥ 620)	**680**	(≥ 620)	**680**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 30)	**42**	(≥ 30)	**43**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**120**	(≥ 90)	**120**	(80)	**120**	(≥ 80)
	- 196 °C:	**80**	(≥ 32)	**70**	(≥ 32)	**70**	(≥ 32)

(*) *u untreated, as-welded*
s1 stress relieved, 650 °C/15 h/air
s2 stress relieved, 750 °C/3 h/air

Operating Data

re-drying if necessary:
250 - 300 °C, min. 2 h
electrode identification:
FOX NIBAS 70/20 resp.
FOX NiCr 70 Nb

ø mm	**L mm**	**amps A**
2.5	300	40 - 70
3.2	300	70 - 105
4.0	350	90 - 125
5.0	400	120 - 160

=+

Base Materials

2.4816 Ni Cr 15 Fe, 2.4817 LC-NiCr 15 Fe, Alloy 600, Alloy 600 L
nickel and nickel alloys, low-temperature steels up to 5 % Ni-steels, unalloyed and alloyed, high-temperature, creep resisting, high-alloy Cr- and CrNiMo-steels particularly for joint welding of dissimilar steels, and nickel to steel combinations; also recommended for Alloy 800.

Approvals and Certificates

TÜV-D (4697.), TÜV-A (442), Statoil, UDT, LTSS, VUZ, SEPROS,
(FOX NiCr 70 Nb: TÜV-D (0889.), KTA 1408 1 (8039.00))

Same Alloy Filler Metals

GTAW rod: NIBAS 70/20-IG

GMAW solid wire: NIBAS 70/20-IG
GMAW flux cored wire: NIBAS 70/20-FD
SAW comb.: NIBAS 70/20-UP/BB 444

* product name in Germany

ENISO 14172-2003:	E Ni 6059(NiCr23Mo16)
DIN 1736:	EL-NiCr22Mo16
AWS A5.11-97:	ENiCrMo-13

BÖHLER FOX NIBAS C 24

SMAW stick electrode, nickel base

Description

Basic coated NiCrMo electrode for highest corrosion requirements and welding of the Ni base steel grades, e.g. UNS N06059, N06022, 2.4605, 2.4602 as well as for joining these grades with low alloyed and stainless steels. Also suitable for surfacing on low-alloyed steels. It is employed primarily for welding components in environmental plants and plants for chemical processes with highly corrosive media. Excellent resistance against pitting and crevice corrosion and chloride-induced stress corrosion cracking. In addition to its exceptional resistance to contaminated oxidating mineral acids, acetic acids and acetic anhydrides, hot contaminated sulphuric- and phosphoric acid. The electrode can be welded in all positions except vertical-down. Stable arc, easy slag removal.The special composition of the coating prevents the precipitation of intermetallic phases.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	Fe
wt-%	**≤ 0.02**	**≤ 0.2**	**0.5**	**22.5**	**15.5**	**bal.**	**1**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		≥ 450
tensile strength R_m N/mm^2:		≥ 720
elongation A (L_0=5d_0) %:		≥ 30
impact work ISO-V KV J	+20 °C:	≥ 75

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying: if necessary:			
250-300 °C, min. 2 h	2.5	250	50-70
electrode identification:	3.2	300	70-100
FOX NIBAS C 24 ENiCrMo-13	4.0	350	90-130

=+

The interpass temperature of 150 °C and a max. weaving width 2.5 x diameter of the electrode core wire should not be exceeded.

Base Materials

NiCr21Mo14W (2.4602), NiMo16Cr16Ti (2.4610), NiMo16Cr15W (2.4819), NiCr23Mo16Al (2.4605), X2CrNiMnMoNbN25-18-5-4 (1.4565), Alloy 59, UNS N06059, N06022, ASTM B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

TÜV-D (10513.), CL

Same Alloy Filler Metals

GTAW rod:	NIBAS C 24-IG
GMAW solid wire:	NIBAS C 24-IG
SAW combination:	NIBAS C 24-UP/BB 444

EN ISO 14172:	E Ni 6617 (NiCr21Co12Mo)
DIN 1736:	EL NiCr21Co12 Mo
AWS 5.11:	ENiCrCoMo-1

BÖHLER FOX NIBAS 617

SMAW stick electrode, nickel base

Description

Basic coated nickel base electrode is suitable for joining high-temperature and similar nickel-base alloys, heat resistant austenitic and cast alloys, such as 2.4663 (NiCr21Co12Mo), 2.4851 (NiCr23Fe), 1.4876 (X10 NiCrAlTi 32 20), 1.4859 (GX 10 NiCrNb 32 20). The weld metal is resistant to hot-cracking and is used for service temperatures up to +100 °C. Scale-resistance up to +1100 °C, high temperature resistant up to 1000 °C. High resistance to hot gases in oxidizing and carburized atmospheres, e.g. gas turbines, ethylene production plants.
BÖHLER FOX NIBAS 617 can be welded in all positions except vertical-down. It has a stable arc. Easy slag removal.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	Co	Fe	Al	Ti
wt-%	**0.06**	**0.7**	**0.1**	**21**	**9**	**bal.**	**11**	**1**	**0.7**	**0.3**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 450
tensile strength R_m N/mm^2:	≥ 700
elongation A (L_0=5d_0) %:	≥ 35
impact work ISO-V KV J	≥ 100

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
250-300 °C, min. 2h	2.5	250	40-55
electrode identification:	3.2	300	70-90
FOX NIBAS 617 ENiCrCoMo-1	4.0	350	90-110

=+

Base Materials

X10NiCrAlTi32-20 (1.4876)
NiCr23Fe (2.4851)
GX10NiCrNb32-20 (1.4859)
NiCr23Co12Mo (2.4663)
Alloy 617, UNS N06617

Approvals and Certificates

TÜV-D (applied)

Same-alloy Filler Metals

GTAW rod:	NIBAS 617-IG
GMAW solid wire:	NIBAS 617-IG
SAW combination:	NIBAS 617-UP/BB 444

DIN 1736:	EL NiMo15Cr15W
EN ISO 14172:2003:	E Ni 6276 (NiCr15Mo15Fe6W4)
AWS 5.11-97:	ENiCrMo-4

BÖHLER FOX NIBAS C 276

SMAW stick electrode, nickel base

Description

Basic coated nickel base electrode for welding of similar alloyed Ni base steel grades, e.g.N10276, 2.4819, NiMo16Cr15 W as well as for joining these grades with low alloyed and stainless steels. Also suitable for surfacing on low-alloyed steels. It is employed primarily for welding components in plants for chemical processes with highly corrosive media, but also for surfacing press tools, punches etc. which operate at high temperatures. In addition to its exceptional resistance to contaminated mineral acids, chlorine-contaminated media, and chloride containing media, it resists strong oxidisers such as ferric and cupric chlorides and is one of the few materials which will resist wet chlorine gas. The electrode can be welded in all positions except vertical-down. Stable arc, easy slag removal.
For avoidance of intermetallic precipitation the electrode should be welded with lowest possible heat input and minimum interpass temperature.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	W	Fe
wt-%	**< 0.02**	**< 0.2**	**0.6**	**16.5**	**16.5**	**bal.**	**4**	**5**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 450
tensile strength R_m N/mm^2:	≥ 720
elongation A (L_0=5d_0) %:	≥ 30
impact work ISO-V KV J	≥ 70

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
250-300 °C, min. 2-3 h	2.5	250	50-70
electrode identification:	3.2	300	70-100
FOX NIBAS C 276 ENiCrMo-4	4.0	350	90-130

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The interpass temperature of 150 °C and a max. weaving width 2.5 x diameter of the electrode core wire should not be exceeded.

Base Materials

NiMo16Cr15W (2.4819),
Alloy C-276, UNS N10276, B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

TÜV-D (10511.), CL

Same-alloy Filler Metals

GTAW rod:	NIBAS C 276-IG
GMAW solid wire:	NIBAS C276-IG
SAW combination:	NIBAS C276-UP/BB 444

DIN EN ISO 14172:	E Ni 4060 (NiCu30Mn3Ti)
DIN 1736:	EL-NiCu30Mn
AWS 5.11:	ENiCu7

BÖHLER FOX NIBAS 400

SMAW stick electrode nickel-copper

Description

Basic coated NiCu electrode for joining and surfacing of nickel-copper alloys and of nickel-copper-clad steels. Particularly suited for the following materials: Alloy 400, N04400, 2.4360 NiCu30Fe, 2.4375 NiCu30Al. It is also used for joining different materials, such as steel to copper and copper alloys, steel to nickel-copper alloys. Excellent corrosion resistance to chloride induced stress corrosion cracking and a wide range of marine and chemical requirements. These materials are employed in high-grade apparatus construction, primarily for the chemical and petrochemical industries. A special application field is the fabrication of seawater evaporation plants and marine equipment.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni	Cu	Fe	Ti	Al
wt-%	**< 0.05**	**0.7**	**3**	**bal.**	**29**	**1**	**0.7**	**0.3**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 300
tensile strength R_m N/mm^2:	≥ 450
elongation A (L_0=5d_0) %:	≥ 30
impact work ISO-V KV J	≥ 80

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:	2.5	300	55-70
200 °C, min. 2h	3.2	350	75-110
electrode identification:	4.0	350	90-130
FOX NIBAS 400 ENiCu-7			

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Base Materials

NiCu30Fe (2.4360), NiCu30Al (2.4375)
UNS N04400, N05500,
nickel copper alloys, Alloy 400, ASTM B 127, B 165

Approvals and Certificates

TÜV-D (10512.), ABS, GL, CL

Same Alloy Filler Metals

GTAW rod:	NIBAS 400-IG
GMAW solid wire:	NIBAS 400-IG

ENISO18274:2004:	S Ni6625 (NiCr22Mo9Nb)
DIN 1736:	SG-NiCr 21 Mo 9 Nb
AWS A5.14-97:	ERNiCrMo-3
W.Nr.:	2.4831

BÖHLER NIBAS 625-IG, NiCr 625-IG*

GTAW rod, nickel base

Description

GTAW rod for high-quality joint welding of high-molybdenum nickel-base alloys (e.g. Inconel 625 and Incoloy 825) as well as of CrNiMo steels with high Mo-content (e.g. "6Mo" steels). Additionally this brand is recommended for high-temperature or creep resisting, heat resisting and cryogenic materials, for low-alloy problem steels and joining dissimilar materials.
Can be used for pressure vessel fabrication for service temperatures from -196 °C to +550 °C, otherwise up to scaling resistance limit of +1200 °C (S-free atmosphere. Due to the weld metal embrittlement between +600 - 850 °C, this temperature range should be avoided. Highly resistant to hot cracking; furthermore, C-diffusion at high temperatures, or during heat treatment of dissimilar steels is largely inhibited.
Extremely resistant to stress corrosion cracking and pitting corrosion (PRE_N 52). Resistant to thermal shocks, stainless, fully austenitic. Low coefficient of thermal expansion (between C-steels and austenitic CrNi (Mo) steel). TIG-rod and deposit satisfy the highest quality standards.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Mo	Nb	Fe
wt-%	**≤ 0.02**	**0.1**	**0.1**	**21.5**	**≥ 60.0**	**9.0**	**3.6**	**≤ 2.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**540**	(≥ 460)
tensile strength R_m N/mm²:		**800**	(≥ 740)
elongation A ($L_0 = 5d_0$) %:		**38**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**160**	(≥ 120)
	- 196 °C:	**130**	(≥ 100)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:	**100 % Argon**	**ø mm**
	Ar + He mixture gases	1.6
rod marking:		2.0
front:	**2.4831**	2.4
back:	**ERNiCrMo-3**	

Base materials

2.4856 NiCr 22 Mo 9 Nb, 2.4858 NiCr 21 Mo, 2.4816 NiCr 15 Fe, 1.4583 X10CrNiMoNb18-12, 1.4876 X 10 NiCrAlTi 32 20 H, 1.4876 X 10 NiCrAlTi 32 20, 1.4529 X1NiCrMoCuN25-20-7, X 2 CrNiMoCuN 20 18 6, 2.4641 NiCr 21 Mo 6 Cu joint welds of listed materials with non alloy and low alloy steels, e.g P265GH, P285NH, P295GH, 16Mo3, S355N, X8Ni9, ASTM A 553 Gr.1, Alloy 600, Alloy 625, Alloy 800 (H), 9 % Ni-steels

Approvals and Certificates

TÜV-D (4324.), TÜV-A (436), Statoil, SEPROZ (NiCr 625-IG: TÜV-D (3938.))

Same Alloy Filler Metals

SMAW stick electrode:	FOX NIBAS 625
GMAW solid wire:	NIBAS 625-IG
GMAW flux cored wire:	NIBAS 625-FD
SAW comb.:	NIBAS 625-UP/BB 444

*product name in Germany

BÖHLER NIBAS 70/20-IG, NiCr 70 Nb-IG*

ENISO18274:2004:	S Ni6082 (NiCr20Mn3Nb)
DIN 1736:	SG-NiCr 20 Nb
AWS A5.14-97:	ERNiCr-3
W.Nr.:	2.4806

GTAW rod, nickel base

Description

GTAW rod for welding of nickel-base alloys, high-temperature and creep resisting steels, heat resisting and cryogenic materials, low-alloyed problem steels and dissimilar joints. Ferritic-austenitic joints for service temperatures above + 300 °C or for applications where a post weld heat treatment is required
Suitable in pressure vessel fabrication from -196 °C to +550 °C, otherwise resistant to scaling up to +1200 °C (S-free atmosphere). Not susceptible to embrittlement, C-diffusion at elevated temperatures largely inhibited.
Resistant to thermal shocks, corrosion resistant, fully austenitic, low coefficient of thermal expansion. between the coefficient values of C-steel and austenitic CrNi (Mo)-steel.
Both the TIG-rod and the weld deposit satisfy highest quality requirements.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Ni	Ti	Nb	Fe
wt-%	**≤ 0.03**	**0.1**	**3.0**	**20.0**	**> 67**	**+**	**2.5**	**≤ 1.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**440**	(≥ 400)
tensile strength R_m N/mm^2:		**680**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**42**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**190**	(≥ 150)
	- 196 °C:	**100**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases: **100 % Argon**
Ar + He mixture gases
rod marking:
front: **2.4806**
back: **ERNiCr-3**

ø mm
1.6
2.0
2.4

=−

Base Materials

2.4816 Ni Cr 15 Fe, 2.4817 LC-NiCr 15 Fe, Alloy 600, Alloy 600 L. nickel and nickel alloys, low-temperature steels up to 5 % Ni-steels, unalloyed and alloyed, high-temperature, creep resisting, high-alloy Cr- and CrNiMo-steels particularly for joint welding of dissimilar steels, and nickel to steel combinations; also recommended for Alloy 800.

Approvals and Certificates

TÜV-D (4328.), TÜV-A (434), Statoil, SEPROS (NiCr 70 Nb-IG TÜV-D (0891.), KTA 1408 1 (8035.00))

Same Alloy Filler Metals

SMAW stick electrode: FOX NIBAS 70/20
GMAW solid wire: NIBAS 70/20-IG
GMAW flux cored wire: NIBAS 70/20-FD
SAW comb.: NIBAS 70/20-UP/BB 444

*product name in Germany

EN ISO 18274:2004:	S Ni 6059 (NiCr23Mo16)
DIN 1736:	SG-NiCr23Mo16
AWS 5.14-97:	ERNiCrMo-13
W.Nr.:	2.4607

BÖHLER NIBAS C 24-IG

GTAW rod, nickel base

Description

GTAW rod for highest corrosion requirements and welding of the Ni base steel grades, e.g. UNS N06059, N06022, 2.4605, 2.4602 as well as for joining these grades with low alloyed and stainless steels. Also suitable for surfacing on low-alloyed steels.. It is employed primarily for welding components in environmental plants and plants for chemical processes with highly corrosive media. Excellent resistance against pitting and crevice corrosion and chloride-induced stress corrosion cracking. In addition to its exceptional resistance to contaminated oxidating mineral acids, acetic acids and acetic anhydrides, hot contaminated sulphuric- and phosphoric acid. Weld with possibly low heat input and low interpass temperature.

Typical Composition of Welding Rod

	C	Si	Mn	Cr	Mo	Ni	Fe
wt-%	**0.01**	**0.1**	**< 0.5**	**23**	**16**	**bal.**	**< 1**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 450
tensile strength R_m N/mm^2:	≥ 700
elongation A (L_0=5d_0) %:	≥ 35
impact work ISO-V KV J	≥ 120

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:
100 % Argon
Ar + He mixture gases
rod marking:
front: **2.4607**
back: **ERNiCrMo-13**

ø mm
1.6
2.0
2.4
3.2

=–

Base Materials

NiCr21Mo14W (2.4602), NiMo16Cr16Ti (2.4610), NiMo16Cr15W (2.4819), NiCr23Mo16Al (2.4605), X2 CrNiMnMoNbN25-18-5-4 (1.4565), Alloy 59, UNS, N06059; N06022, B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

TÜV-D (10523.), CL

Same Alloy Filler Metals

SMAW:	FOX NIBAS C 24
GMAW solid wire:	NIBAS C24-IG
SAW combination:	NIBAS C24-UP/BB 444

EN ISO 18274:2004:	S Ni 6617 (NiCr22Co12 Mo)
DIN 1736:	SG-NiCr22Co12Mo9
AWS 5.14-97:	ERNiCrCoMo-1
W.Nr.:	2.4627

BÖHLER NIBAS 617-IG

GTAW rod, nickel base

Description

GTAW rod for joining high-temperature and similar nickel-base alloys, heat resistant austenitic and cast alloys, such as 2.4663 (NiCr21Co12Mo), 2.4851 (NiCr23Fe), 1.4876 (X10 NiCrAlTi 32 20), 1.4859 (GX 10 NiCrNb 32 20). The weld metal is resistant to hot-cracking and is used for service temperatures up to +1100 °C. Scale-resistance up to +1100 °C, high temperature resistant up to 1000 °C. High resistance to hot gases in oxidizing and carburized atmospheres, e.g. gas turbines, ethylene production plants.

Typical Composition of Welding Rod

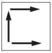
	C	Si	Mn	Cr	Mo	Ni	Co	Al	Ti	Fe
wt-%	**0.05**	**0.1**	**0.1**	**21.5**	**9**	**bal.**	**11**	**1**	**0.5**	**1**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 450
tensile strength R_m N/mm^2:	≥ 700
elongation A (L_0=5d_0) %:	≥ 30
impact work ISO-V KV J	≥ 60

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data



shielding gases:	**ø mm**
100 % Argon / Ar + He mixture gases	2.0
rod marking:	2.4
front: **2.4627**	
back: **ERNiCrCoMo-1**	

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Base Materials

X10NiCrAlTi32-20 (1.4876)
NiCr23Fe (2.4851)
GX10NiCrNb32-20 (1.4859)
NiCr23Co12Mo (2.4663)
Alloy 617, UNS N06617

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW:	FOX NIBAS 617
GMAW wire:	NIBAS 617-IG
SAW combination:	NIBAS 617-UP/BB 444

EN ISO 18274:2004:	S Ni 6276 (NiCr15Mo16Fe6W4)
DIN 1736:	SG-NiMo16Cr16W
AWS 5.14-97:	ERNiCrMo-4
W.Nr.:	2.4886

BÖHLER NIBAS C 276-IG

GTAW rod, nickel base

Description

GTAW rod for welding of similar alloyed Ni base steel grades, e.g. N10276, 2.4819, NiMo16Cr15 W as well as for joining these grades with low alloyed and stainless steels. Also suitable for surfacing on low-alloyed steels. steels. It is employed primarily for welding components in plants for chemical processes with highly corrosive media, but also for surfacing press tools, punches etc. which operate at high temperatures. In addition to its exceptional resistance to contaminated mineral acids, chlorine-contaminated media, and chloride containing media, it resists strong oxidisers such as ferric and cupric chlorides and is one of the few materials which will resist wet chlorine gas. Weld with possibly low heat input and low interpass temperature in order to avoid intermetallic precipitations.

Typical Composition of Welding Rod

	C	Si	Cr	Mo	Ni	T	Fe	V
wt-%	**< 0.01**	**0.1**	**16**	**16**	**bal.**	**3.5**	**6**	**0.2**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 450
tensile strength R_m N/mm^2:	≥ 750
elongation A (L_0=5d_0) %:	≥ 30
impact work ISO-V KV J	≥ 90

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:
100 % Argon
Ar + He mixture gases
rod marking:
front: **2.4886**
back: **ERNiCrMo-4**

ø mm
2.0
2.4

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Base Materials

NiMo16Cr15W (2.4819),
Alloy C-276, UNS N10276, B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

TÜV-D (10521.), CL

Same Alloy Filler Metals

SMAW:	FOX NIBAS C 276
GMAW solid wire:	NIBAS C276-IG
SAW combination:	NIBAS C276-UP/BB 444

EN ISO 18274:2004:	S Ni 4060 (NiCu30Mn3Ti)
DIN 1736:	SG-NiCu30Mn3Ti
AWS 5.14-97:	ERNiCu7
W.Nr.:	2.4377

BÖHLER NIBAS 400-IG

GTAW rod, nickel copper

Description

GTAW rod for joining and surfacing of nickel-copper alloys and of nickel-copper-clad steels. Particularly suited for the following materials: alloy 400, N04400, 2.4360 NiCu30Fe, 2.4375 NiCu30Al. It is also used for joining different materials, such as steel to copper and copper alloys, steel to nickel-copper alloys. Excellent corrosion resistance to chloride induced stress corrosion cracking and a wide range of marine and chemical requirements. These materials are employed in high-grade apparatus construction, primarily for the chemical and petrochemical industries. A special application field is the fabrication of seawater evaporation plants and marine equipment.

Typical Composition of Welding Rod

	C	Si	Mn	Ni	Cu	Ti	Fe	Al
wt-%	**< 0.02**	**0.3**	**3.2**	**bal.**	**29**	**2.4**	**1**	**< 1.0**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 300
tensile strength R_m N/mm^2:	≥ 500
elongation A (L_0=5d_0) %:	≥ 35
impact work ISO-V KV J	≥ 150

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:
100 % Argon / Ar + He mixture gases
rod marking:
front: **2.4377**
back: **ERNiCu7**

ø mm
1.6
2.0
2.4

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Base Materials

NiCu30Fe (2.4360), NiCu30Al (2.4375)
UNS N04400, N05500,
nickel copper alloys, Alloy 400, ASTM B 127, B 165

Approvals and Certificates

TÜV-D (10519.), ABS, GL, CL

Same Alloy Filler Metals

SMAW:	FOX NIBAS 400
GMAW solid wire:	NIBAS 400-IG

ENISO18274:2004:	S Ni6625 (NiCr22Mo9Nb)
DIN 1736:	SG-NiCr 21 Mo 9 Nb
AWS A5.14-97:	ERNiCrMo-3
W.Nr.:	2.4831

BÖHLER NIBAS 625-IG, NiCr 625-IG*

GMAW solid wire, nickel base

Description

GMAW wire for high-quality joint welding of nickel-base alloys like Inconel 625 and Incoloy 825 as well as of CrNiMo stainless steels with high Mo-content (e.g. "6Mo" steels). Additionally it is recommended for high-temperature or creep resisting, heat resisting and cryogenic materials, joining of dissimilar steels, and also for problem steels.
Can be used for pressure vessel fabrication for service temperatures in the -196 °C to +550 °C range, otherwise up to scaling resistance limit of +1200°C (S-free atmosphere). Due to the weld metal embrittlement between +600 - 850 °C, this temperature range should be avoided. Highly resistant to hot cracking; furthermore, C-diffusion at high service temperatures or during post weld heat treatment of dissimilar steels is largely inhibited.
Extremely resistant to stress corrosion cracking and pitting (PRE$_N$ 52). Resistant to thermal shocks, fully austenitic. Low coefficient of thermal expansion (between C-steels and austenitic CrNi (Mo) steel).
Wire and weld metal satisfy highest quality standards.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Mo	Nb	Fe
wt-%	**≤ 0.02**	**≤ 0.2**	**≤ 0.3**	**21.5**	**≥ 60.0**	**9.0**	**3.6**	**≤ 2.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**510**	(≥ 460)
tensile strength R_m N/mm²:		**780**	(≥ 740)
elongation A (L_0 = 5d_0) %:		**40**	(≥ 25)
impact work ISO-V KV J	+ 20 °C:	**130**	(≥ 100)
	- 196 °C:	**80**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 40 % Helium*

Operating Data

shielding gases:	**ø mm**
Argon + 40% He	1.0
Ar + He + small amounts of active gas	1.2

Welding with puls technic will be advantageous.

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Base Materials

2.4856 NiCr 22 Mo 9 Nb, 2.4858 NiCr 21 Mo, 2.4816 NiCr 15 Fe, 1.4583 X10CrNiMoNb18-12, 1.4876 X 10 NiCrAlTi 32 20 H, 1.4876 X 10 NiCrAlTi 32 20, 1.4529 X1NiCrMoCuN25-20-7, X 2 CrNiMoCuN 20 18 6, 2.4641 NiCr 21 Mo 6 Cu joint welds of listed materials with non alloy and low alloy steels, e.g P265GH, P285NH, P295GH, 16Mo3, S355N, X8Ni9, ASTM A 553 Gr.1, Alloy 600, Alloy 625, Alloy 800, 9 % Ni-steels

Approvals and Certificates

TÜV-D (4323.), TÜV-A (437), Statoil, UDT, SEPROZ (NiCr 625-IG: TÜV-D (3937.))

Same Alloy Filler Metals

SMAW stick electrode: FOX NIBAS 625

GTAW rod: NIBAS 625-IG

GMAW flux cored wire: NIBAS 625-FD

SAW comb.: NIBAS 625-UP/BB 444

* product name in Germany

BÖHLER NIBAS 70/20-IG, NiCr 70 Nb-IG*

GMAW solid wire, nickel base

ENISO18274:2004:	S Ni6082 (NiCr20Mn3Nb)
DIN 1736:	SG-NiCr 20 Nb
AWS A5.14-97:	ERNiCr-3
W.Nr.:	2.4806

Description

Special GMAW wire for welding of nickel-base alloys, high-temperature and creep resisting steels, heat resisting and cryogenic materials, low-alloyed problem steels and dissimilar joints. Ferritic-austenitic joints for service temperatures above +300 °C or for applications where a post weld heat treatment is required. Suitable for pressure vessel fabrication for the service temperature range -196 °C to +550°C, otherwise resistant to scaling up to +1200 °C (S-free atmosphere).
Not susceptible to embrittlement, C-diffusion at elevated temperatures largely inhibited. Resistant to thermal shocks, corrosion resistant, fully austenitic. Low coefficient of thermal expansion (between C-steels and austenitic CrNi (Mo) steel).
Both the wire and the deposit satisfy the highest quality requirements.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Ni	Ti	Nb	Fe
wt-%	**≤ 0.03**	**≤ 0.3**	**3.0**	**20.0**	**≥ 67**	**+**	**2.5**	**≤ 1.7**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm²:		**420**	(≥ 400)
tensile strength R_m N/mm²:		**680**	(≥ 620)
elongation A ($L_0 = 5d_0$) %:		**40**	(≥ 35)
impact work ISO-V KV J	+ 20 °C:	**160**	(≥ 150)
	- 196 °C:	**80**	(≥ 32)

(*) *u untreated, as-welded – shielding gas Argon + 40 % Helium*

Operating Data

shielding gases:	**ø mm**
Argon + 40 % He	0.8
Ar + He + small quantities active gas	1.0
	1.2

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Welding with puls technic will be advantageous.

Base Materials

2.4816 Ni Cr 15 Fe, 2.4817 LC-NiCr 15 Fe, Alloy 600, Alloy 600 L
nickel and nickel alloys, low-temperature steels up to X8Ni9, unalloyed and alloyed, high-temperature, creep resisting, high-alloy Cr- and CrNiMo-steels particularly for joint welding of dissimilar steels, and nickel to steel combinations; also recommended for Alloy 800 (H).

Approvals and Certificates

TÜV-D (4327.), TÜV-A (435), Statoil, UDT, SEPROZ, (NiCr 70 Nb-IG TÜV-D (0890.))

Same Alloy Filler Metals

SMAW stick electrode:	FOX NIBAS 70/20	GTAW rod:	NIBAS 70/20-IG
GMAW flux cored wire:	NIBAS 70/20-FD	SAW comb.:	NIBAS 70/20-UP / BB 444

* product name in Germany

EN ISO 18274:2004:	S Ni 6059 (NiCr23Mo16)
DIN 1736:	SG-NiCr23Mo16
AWS 5.14-97:	ERNiCrMo-13
W.Nr.:	2.4607

BÖHLER NIBAS C 24-IG

GMAW solid wire nickel base

Description

GMAW wire for highest corrosion requirements and welding of the Ni base steel grades, e.g. UNS N06059, N06022, 2.4605, 2.4602 as well as for joining these grades with low alloyed and stainless steels. Also suitable for surfacing on low-alloyed steels. It is employed primarily for welding components in environmental plants and plants for chemical processes with highly corrosive media. Excellent resistance against pitting and crevice corrosion and chloride-induced stress corrosion cracking. In addition to its exceptional resistance to contaminated oxidating mineral acids, acetic acids and acetic anhydrides, hot contaminated sulphuric- and phosphoric acid. Weld with possibly low heat input and low interpass temperature.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo	Ni	Fe
wt-%	**< 0.01**	**0.1**	**< 0.5**	**23**	**16**	**bal.**	**< 1**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 420
tensile strength R_m N/mm^2:	≥ 700
elongation A (L_0=5d_0) %:	≥ 35
impact work ISO-V KV J	≥ 100

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:	**ø mm**
100 % Argon	1.0
M 11 + 28 % He	1.2

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Base Materials

NiCr21Mo14W (2.4602), NiMo16Cr16Ti (2.4610), NiMo16Cr15W (2.4819), NiCr23Mo16Al (2.4605), X2 CrNiMnMoNbN25-18-5-4 (1.4565), Alloy 59,
UNS, N06059; N06022, B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

TÜV-D (10522.), CL

Same Alloy Filler Metals

SMAW:	FOX NIBAS C 24
GTAW rod:	NIBAS C24-IG
SAW combination:	NIBAS C24-UP/BB 444

EN ISO 18274:2004:	S Ni 6617 (NiCr22Co12 Mo)
DIN 1736:	SG-NiCr22Co12Mo9
AWS 5.14-97:	ERNiCrCoMo-1
W.Nr.:	2.4627

BÖHLER NIBAS 617-IG

GMAW solid wire nickel base

Description

GMAW wire for joining high-temperature and similar nickel-base alloys, heat resistant austenitic and cast alloys, such as 2.4663 (NiCr21Co12Mo), 2.4851 (NiCr23Fe), 1.4876 (X10 NiCrAlTi 32 20), 1.4859 (GX 10 NiCrNb 32 20). The weld metal is resistant to hot-cracking and is used for service temperatures up to +1100 °C. Scale-resistance up to +1100 °C, high temperature resistant up to 1000 °C. High resistance to hot gases in oxidizing and carburized atmospheres, e.g. gas turbines, ethylene production plants.

Typical Composition of Solid Wire

	C	Si	Mn	Cr	Mo	Ni	Co	Al	Ti	Fe
wt-%	**0.05**	**0.1**	**0.1**	**21.5**	**9**	**bal.**	**11**	**1**	**0.5**	**1**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 400
tensile strength R_m N/mm^2:	≥ 700
elongation A (L_0=5d_0) %:	≥ 40
impact work ISO-V KV J	≥ 100

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:	ø mm
100 % Argon	1.0
M 11 + 28 % He	1.2
Ar + 30 % He + 0.5 % CO_2	

=+

Base Materials

X10NiCrAlTi32-20 (1.4876)
NiCr23Fe (2.4851)
GX10NiCrNb32-20 (1.4859)
NiCr23Co12Mo (2.4663)
Alloy 617, UNS N06617

Approvals and Certificates

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Same Alloy Filler Metals

SMAW:	FOX NIBAS 617
GTAW rod:	NIBAS 617-IG
SAW combination:	NIBAS 617-UP/BB 444

DIN 1736:	SG-NiMo16Cr16W
EN ISO 18274:2004:	S Ni 6276 (NiCr15Mo16Fe6W4)
AWS 5.14-97:	ERNiCrMo-4
W.Nr.:	2.4886

BÖHLER NIBAS C 276-IG

GMAW solid wire nickel base

Description

GMAW wire for welding of similar alloyed Ni base steel grades, e.g.N10276, 2.4819, NiMo16Cr15 W as well as for joining these grades with low alloyed and stainless steels and surfacing on low-alloyed steels. It is employed primarily for welding components in plants for chemical processes with highly corrosive media, but also for surfacing press tools, punches etc. which operate at high temperatures. In addition to its exceptional resistance to contaminated mineral acids, chlorine-contaminated media, and chloride containing media, it resists strong oxidisers such as ferric and cupric chlorides and is one of the few materials which will resist wet chlorine gas. Weld with possibly low heat input and low interpass temperature in order to avoid intermetallic precipitations.

Typical Composition of Solid Wire

	C	Si	Cr	Mo	Ni	T	Fe	V
wt-%	**< 0.01**	**0.1**	**16**	**16**	**bal.**	**3.5**	**6**	**0.2**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 450
tensile strength R_m N/mm^2:	≥ 750
elongation A (L_0=5d_0) %:	≥ 30
impact work ISO-V KV J	≥ 90

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:	**ø mm**	**=+**
100 % Argon	1.2	
M 11 + 28 % He		

Base Materials

NiMo16Cr15W (2.4819),
Alloy C-276, UNS N10276, B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

TÜV-D (10520.), CL

Same Alloy Filler Metals

SMAW:	FOX NIBAS C 276
GTAW rod:	NIBAS C276-IG
SAW combination:	NIBAS C276-UP/BB 444

EN ISO 18274:2004:	S Ni 4060 (NiCu30Mn3Ti)
DIN 1736:	SG-NiCu30Mn3Ti
AWS 5.14-97:	ERNiCu7
W.Nr.:	2.4377

BÖHLER NIBAS 400-IG

GMAW solid wire
nickel copper

Description

GMAW wire for joining and surfacing of nickel-copper alloys and of nickel-copper-clad steels. Particularly suited for the following materials: alloy 400, N04400, 2.4360 NiCu30Fe, 2.4375 NiCu30Al. It is also used for joining different materials, such as steel to copper and copper alloys, steel to nickel-copper alloys. Excellent corrosion resistance to chloride induced stress corrosion cracking and a wide range of marine and chemical requirements. These materials are employed in high-grade apparatus construction, primarily for the chemical and petrochemical industries. A special application field is the fabrication of seawater evaporation plants and marine equipment.

Typical Composition of Solid Wire

	C	Si	Mn	Ni	Cu	Ti	Fe	Al
wt-%	**< 0.02**	**0.3**	**3.2**	**bal.**	**29**	**2.4**	**1**	**< 1.0**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 300
tensile strength R_m N/mm^2:	≥ 500
elongation A (L_0=5d_0) %:	≥ 35
impact work ISO-V KV J	≥ 150

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gases:	**ø mm**
100 % Argon	1.0
M 11 + 28 % He	1.2

=+

Base Materials

NiCu30Fe (2.4360), NiCu30Al (2.4375)
UNS N04400, N05500,
nickel copper alloys, Alloy 400, ASTM B 127, B 165

Approvals and Certificates

TÜV-D (10518.), ABS, GL, CL

Same Alloy Filler Metals

SMAW: FOX NIBAS 400
GTAW rod: NIBAS 400-IG

BÖHLER NIBAS 70/20-FD

ENISO 14172:2003: Typ Ni 6082 (NiCr20Mn3Nb)
AWS A5.34: ENiCr-3TO-4

GMAW flux cored wire, nickel base

Description

Rutile flux cored welding wire with basic elements, especially designed for downhand and horizontal welding positions. The easy operation and the high rate of deposition of Böhler NIBAS 70/20-FD leads to high productivity, with excellent operating characteristic, self releasing slag, almost no spatter formation and temper discoloration, smooth weld finish, good side wall wetting and safe penetration. Beside considerable savings in time and money and little demand for cleaning and pickling, Böhler also guarantees a high quality level and a reduction of welding defects.
Suitable for high quality weld joints of nickelbase alloys, high temperature and creep resisting materials, scaling resistant and low-temperature steels, dissimilar joints and difficult weldable steel grades. Ferritic-austenitic joints for service temperatures above +300 °C or for applications where a post weld heat treatment is required.
Suitable for pressure vessel fabrication for the service temperature range -196 °C to +550 °C, otherwise resistant to scaling up to +1200 °C (S-free atmosphere).
Not susceptible to embrittlement, C-diffusion at elevated temperatures largely inhibited. Resistant to thermal shocks, corrosion resistant, fully austenitic, low coefficient of thermal expansion.
Out of position weldability is limited, in special cases pulse arc welding shows advantages.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Ni	Nb	Fe
wt-%	**0.03**	**0.4**	**3.2**	**20.0**	**≥ 67.0**	**2.5**	**2.0**

Mechanical Properties of All-weld Metal

(*)		u	
yield strength R_e N/mm^2:		**400**	(≥ 360)
tensile strength R_m N/mm^2:		**650**	(≥ 600)
elongation A ($L_0 = 5d_0$) %:		**39**	(≥ 30)
impact work ISO-V KV J	+ 20 °C:	**135**	(≥ 110)
	- 196 °C:	**110**	(≥ 80)

(*) u untreated, as-welded – shielding gas Argon + 20 % CO_2

Operating Data

re-drying if necessary:
Argon + 15-25 % CO_2

ø mm	L mm	amps A
1.2	130 - 260	24 - 36
1.6	150 - 350	23 - 32

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welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °).
The gas flow should be 15 - 20 l/min.

Base Materials

2.4816 Ni Cr 15 Fe, 2.4817 LC-NiCr 15 Fe, Alloy 600, Alloy 600 L
nickel and nickel alloys, low-temperature steels up to 5 % Ni-steels, unalloyed and alloyed, high-temperature, creep resisting, high-alloy Cr- and CrNiMo-steels particularly for joint welding of dissimilar steels, and nickel to steel combinations; also recommended for Alloy 800 (H).

Approvals and Certificates

TÜV-D (10298.)

Same Alloy Filler Metals

SMAW stick electrode:	FOX NIBAS 70/20	GTAW rod:	NIBAS 70/20-IG
GMAW solid wire:	NIBAS 70/20-IG		

ENISO 14172:2003	Typ Ni 6625 (NiCr22Mo9Nb)
AWS A5.34:	ENiCrMo-3TO-4

BÖHLER NIBAS 625-FD

GMAW flux cored wire nickel base

Description

Rutile flux cored for high-quality joint welding of nickel-base alloys like Alloy 625 and Alloy 825 as well as of CrNiMo stainless steels with high Mo-content (e.g. "6Mo" steels). Additionally it is recommended for high-temperature or creep resisting, heat resisting and cryogenic materials, joining of dissimilar steels, and also for problem steels. Can be used for pressure vessel fabrication for service temperatures in the -196 °C to +550 °C range, otherwise up to scaling resistance limit of +1200 °C (S-free atmosphere). Due to the weld metal embrittlement between 600-850 °C, this temperature range should be avoided. Highly resistant to hot cracking; furthermore, C-diffusion at high service temperatures or during post weld heat treatment of dissimilar steels is largely inhibited. Extremely resistant to stress corrosion cracking and pitting (PRE_N 52). Resistant to thermal shocks, fully austenitic. Low coefficient of thermal expansion (between C-steels and austenitic CrNi (Mo) steel). Out of position weldability is limited, in special cases pulse arc welding shows advantages.

Typical Composition of All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	Nb	Fe
wt-%	**0.05**	**0.4**	**0.4**	**22.0**	**8.5**	**≥ 60.0**	**3.3**	**< 5.0**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		**490**
tensile strength Rm N/mm^2:		**750**
elongation A (L0=5d0) %:		**30**
impact work ISO-V KV J	+20 °C:	**60**
	-196 °C:	**47**

(*) *u untreated, as-welded – shielding gas Argon + 20 % CO_2*

Operating Data

shielding gases:	**ø mm**	**Amperage**	**Voltage**
Argon + 15-25 % CO_2	1.2	130-260	24-36

=+

welding with standard GMAW-facilities possible, slightly trailing torch position (angel appr. 80 °), the gas flow should be 15-20 l/min

Base Materials

2.4856 NiCr 22 Mo 9 Nb, 2.4858 NiCr 21 Mo, 2.4816 NiCr 15 Fe, 1.4583 X10CrNiMoNb18-12, 1.4876 X 10 NiCrAlTi 32 20 H, 1.4876 X 10 NiCrAlTi 32 20, 1.4529 X1NiCrMoCuN25-20-7, X 2 CrNiMoCuN 20 18 6, 2.4641 NiCr 21 Mo 6 Cu,
joint welds of listed materials with non alloy and low alloy steels, e.g P265GH, P285NH, P295GH, 16Mo3, S355N, X8Ni9, ASTM A 553 Gr.1, Alloy 600, Alloy 625, Alloy 800

Approvals and Certificates

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Same Alloy Filler Metals

SMAW stick electrode:	FOX NIBAS 625	GMAW solid wire:	NIBAS 625-IG
GTAW rod:	NIBAS 625-IG		

Wire:	
DIN 1736:	UP-NiCr20Nb
EN ISO 18274:2004:	S Ni 6082 (NiCr20Mn3Nb)
AWS 5.14-97:	ER NiCr-3
Flux:	
DIN EN 760:1996:	SA-FB 2 AC

BÖHLER NIBAS 70/20-UP/BB 444

SAW wire / flux-combination nickel base

Description

For SAW wire flux combination welding of Ni base alloy metals and special metals if the use of wire electrodes with high Ni content is requested. The weld metals show excellent mechanical properties with high hot cracking resistance. It is applicable for chemical apparatus construction on high temperature metals as well as in low temperature sections up to -196 °C.
BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Ni	Nb	Fe	Ti
SAW wire wt-%	**0.010**	**0.15**	**3.2**	**20.5**	**bal.**	**2.6**	**<2.0**	**0.35**
all-weld metal %	**0.012**	**0.25**	**3.0**	**20.0**	**bal.**	**2.2**	**0.8**	**0.15**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		**370**
tensile strength R_m N/mm²:		**600**
elongation A ($L0=5d_0$) %:		**40**
impact work ISO-V KV J	+20 °C:	**120**
	-196 °C:	**100**

(*) *u untreated, as-welded*

Operating Data

Redrying of sub arc flux:	**ø mm**
400-450 °C/2 h	2.4

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Preheat and interpass temp. as required by the base metal

Base Materials

2.4816 Ni Cr 15 Fe, 2.4817 LC-NiCr 15 Fe, Alloy 600, Alloy 600 L, UNS N06600, ASTM B168 nickel and nickel alloys, low-temperature steels up to 5 % Ni-steels, unalloyed and alloyed, high-temperature, creep resisting, high-alloy Cr- and CrNiMo-steels particularly for joint welding of dissimilar steels, and nickel to steel combinations; also recommended for Alloy 800

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW:	FOX NIBAS 70/20
GTAW rod:	NIBAS 70/20-IG
GMAW solid wire:	NIBAS 70/20-IG
GMAW flux cored wire:	NIBAS 70/20-FD

Wire:	
DIN 1736:	UP-NiCr21Mo9Nb
EN ISO18274:2004:	S Ni 6625 (NiCr22Mo9Nb)
AWS 5.14-97:	ERNiCrMo-3
Flux:	
DIN EN760:1996:	SA-FB 2 AC

BÖHLER NIBAS 625-UP/BB 444

SAW wire / flux-combination nickel base

Description

For SAW wire and flux combination, suitable for welding of the 6 % Mo superaustenitic grades S31254, N 08926, N 08367 and the matching alloy 625. Weld metal meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52. BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	Nb	Fe
SAW wire wt-%	**0.010**	**0.10**	**0.2**	**22.0**	**9.0**	**bal.**	**3.6**	**<1.5**
All-weld metal %	**0.015**	**0.25**	**0.2**	**21.5**	**8.5**	**bal.**	**3.3**	**0.4**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		**450**
tensile strength R_m N/mm²:		**720**
elongation A (L_0=5d_0) %:		**40**
impact work ISO-V KV J	+20 °C:	**130**
	-196 °C:	**70**

(*) *u untreated, as-welded*

Operating Data

Redrying of sub arc flux:	**ø mm**
400-450 °C/2 h	2.4

Preheat and interpass temp. as required by the base metal

=±

Base Materials

2.4856 NiCr 22 Mo 9 Nb, 2.4858 NiCr 21 Mo, 2.4816 NiCr 15 Fe, 1.4583 X10CrNiMoNb18-12, 1.4876 X 10 NiCrAlTi 32 20 H, 1.4876 X 10 NiCrAlTi 32 20, 1.4529 X1NiCrMoCuN25-20-7, X 2 CrNiMoCuN 20 18 6, 2.4641 NiCr 21 Mo 6 Cu;
joint welds of listed materials with non alloy and low alloy steels, e.g P265GH, P285NH, P295GH, 16Mo3, S355N, X8Ni9, ASTM A 553 Gr.1, B443,B446, UNS N06625
Alloy 600, Alloy 625, Alloy 800, 9 % Ni-steels

Approvals and Certificates

TÜV-D (applied)

Same Alloy Filler Metals

SMAW:	FOX NIBAS 625	GMAW solid wire:	NIBAS 625-IG
GTAW rod:	NIBAS 625-IG	GMAW flux cored wire:	NIBAS 625-FD

Wire:	
EN ISO18274:2004:	S Ni 6059 (NiCr23Mo16)
DIN 1736:	SG-Ni Cr23 Mo16
AWS 5.14-97:	ERNiCrMo-13
W.Nr.:	2.4607
Flux:	
DIN EN760:1996:	SA-FB 2 AC

BÖHLER NIBAS C 24-UP/BB 444

SAW wire / flux-combination, nickel base

Description

For SAW wire and flux combination, suitable for highest corrosion requirements and welding of the Ni base steel grades, e.g. UNS N06059, N06022, 2.4605, 2.4602 as well as for joining these grades with low alloyed and stainless steels. Also suitable for surfacing on low-alloyed steels.. It is employed primarily for welding components in environmental plants and plants for chemical processes with highly corrosive media. Excellent resistance against pitting and crevice corrosion and chloride-induced stress corrosion cracking. In addition to its exceptional resistance to contaminated oxidating mineral acids, acetic acids and acetic anhydrides, hot contaminated sulphuric- and phosphoric acid. Weld with possibly low heat input and low inter-pass temperature. BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	Fe
SAW wire wt-%	**< 0.012**	**< 0.10**	**< 0.5**	**23.0**	**15.5**	**bal.**	**< 1.5**
all-weld metal %	**0.020**	**0.20**	**0.25**	**22.0**	**15.5**	**bal.**	**0.25**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		**480**
tensile strength R_m N/mm²:		**720**
elongation A ($L_0=5d_0$) %:		**38**
impact work ISO-V KV J	+20 °C:	**80**
	-196 °C:	**50**

(*) u untreated, as-welded

Operating Data

Redrying of sub arc flux:	**ø mm**
400-450 °C/2 h	2.0

=±

Base Materials

NiCr21Mo14W (2.4602), NiMo16Cr16Ti (2.4610), NiMo16Cr15W (2.4819), NiCr23Mo16Al (2.4605), X2CrNiMnMoNbN25-18-5-4 (1.4565), Alloy 59, UNS, N06059; N06022, B575, B626 joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW:	FOX NIBAS C 24
GTAW rod:	NIBAS C 24-IG
GMAW solid wire:	NIBAS C 24-IG

Wire:	
EN ISO18274:2004:	S Ni 6617 (NiCr22Co12 Mo)
DIN 1736:	SG-NiCr22Co12Mo9
AWS 5.14-97:	ERNiCrCoMo-1
W.Nr.:	2.4627
Flux:	
DIN EN 760:1996:	SA-FB 2 AC

BÖHLER NIBAS 617-UP/BB 444

SAW wire / flux-combination, nickel base

Description

For SAW wire flux combination for joining high-temperature and similar nickel-base alloys, heat resistant austenitic and cast alloys, such as 2.4663 (NiCr21Co12Mo), 2.4851 (NiCr23Fe), 1.4876 (X10 NiCrAlTi 32 20), 1.4859 (GX 10 NiCrNb 32 20). The weld metal is resistant to hot-cracking and is used for service temperatures up to +1100 °C. Scale-resistance up to +1100 °C, high temperature resistant up to 1000 °C. High resistance to hot gases in oxidizing and carburized atmospheres, e.g. gas turbines, ethylene production plants.
BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	Ti	Co	Al	Fe
SAW wire wt-%	**< 0.06**	**< 0.20**	**< 0.20**	**20.5**	**8.8**	**bal.**	**0.5**	**10.4**	**1.0**	**< 1**
all-weld metal %	**< 0.06**	**< 0.40**	**< 0.30**	**20.0**	**8.8**	**bal.**	**0.25**	**10.0**	**0.8**	**< 1**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm²:	> 420
tensile strength R_m N/mm²:	> 700
elongation A (L_0=5d_0) %:	> 35
impact work ISO-V KV J	> 80

(*) *u untreated, as-welded*

Operating Data

Redrying of sub arc flux:	**ø mm**
400-450 °C/2 h	2.0

Preheat and interpass temp. as required by the base metal

=±

Base Materials

X10NiCrAlTi32-20 (1.4876)
NiCr23Fe (2.4851)
GX10NiCrNb32-20 (1.4859)
NiCr23Co12Mo (2.4663)
Alloy 617, UNS N06617

Approvals and Certificates

–

Same Alloy Filler Metals

SMAW:	FOX NIBAS 617
GTAW rod:	NIBAS 617-IG
GMAW solid wire:	NIBAS 617-IG

Wire:	
EN ISO18274:2004:	S Ni 6276 (NiCr15Mo16Fe6W4)
DIN 1736:	SG-NiMo16Cr16W
AWS 5.14-97:	ERNiCrMo-4
W.Nr.:	2.4886
Flux:	
DIN EN760:1996:	SA-FB 2 AC

BÖHLER NIBAS C 276-UP/BB 444

SAW wire / flux-combination, nickel base

Description

For SAW wire and flux combination, suitable for welding of similar alloyed Ni base steel grades, e.g. N10276, 2.4819, NiMo16Cr15 W as well as for joining these grades with low alloyed and stainless steels and surfacing on low-alloyed steels. It is employed primarily for welding components in plants for chemical processes with highly corrosive media, but also for surfacing press tools, punches etc. which operate at high temperatures. In addition to its exceptional resistance to contaminated mineral acids, chlorine-contaminated media, and chloride containing media, it resists strong oxidisers such as ferric and cupric chlorides and is one of the few materials which will resist wet chlorine gas. Weld with possibly low heat input and low interpass temperature in order to avoid intermetallic precipitations.
BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.

Typical Composition of Solid Wire and All-weld Metal

	C	Si	Mn	Cr	Mo	Ni	T	Fe
SAW wire wt-%	**< 0.012**	**< 0.10**	**< 0.5**	**15.5**	**16.0**	**bal.**	**3.8**	**< 7**
all-weld metal %	**< 0.012**	**0.15**	**< 0.4**	**15.0**	**16.0**	**bal.**	**3.3**	**5.5**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm^2:		**420**
tensile strength Rm N/mm$_2$:		**710**
elongation A (L0=5d0) %:		**40**
impact work ISO-V KV J	+20 °C:	**80**
	-196 °C:	**70**

(*) *u untreated, as-welded*

Operating Data

Redrying of sub arc flux: **ø mm**
400-450 °C/2 h 2.4
Preheat and interpass temp. as required by the base metal

=±

Base Materials

NiMo16Cr15W (2.4819),
Alloy C-276, UNS N10276, B575, B626
joint welds of listed materials with low alloy and stainless steels

Approvals and Certificates

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Same Alloy Filler Metals

SMAW:	FOX NIBAS C 276
GTAW rod:	NIBAS C 276-IG
GMAW solid wire:	NIBAS C 276-IG

Notes

2.10. NON FERROUS ALLOYS

Contents

Overview – Standard Classifications

Böhler	ENISO / DIN		AWS
SMAW stick electrodes			
FOX CuNi30Fe	DIN 1733:	EL-CuNi 30 Mn	AWS 5.6: ECuNi
GTAW rods			
CuNi30Fe-IG	ENISO14640:	S Cu 7158 (CuNi30)	AWS A5.7-04: ERCuNi
ER Ti 2-IG	–		AWS A5.16-04: ERTi2

Overview – Typical Chemical Composition

Böhler	C	Si	Mn	Cr	Ni	Mo	Nb	Ti	Fe	Co	Ta	Al	
SMAW stick electrodes													
FOX CuNi30Fe	0.03	0.3	1.2		30.0				0.6				Cu bal.
GTAW rods													
CuNi30Fe-IG	<0.05		0.8		30.0			<0.5	0.6				Cu bal.
ER Ti 2-IG	<0.03							bal.	<0.2				O<0.1 H<0.008 N<0.02

DIN 1733:	EL-CuNi30Mn
AWS 5.6:	ECuNi

BÖHLER FOX CuNi 30Fe

SMAW stick electrode copper-nickel

Description

CuNi base electrode for joining and surfacing of similar alloyed base metals with up to 30 % Nickel, as well as for non ferrous alloys and steels of different nature. Due to the excellent resistance to sea water the electrode is best suitable for offshore applications, oil refineries, seawater desalination plants, ship building and also for chemical and food industry.
The electrode can be operated in all positions except vertical down.

Typical Composition of All-weld Metal

	C	Si	Mn	Ni	Fe	Cu
wt-%	**0.03**	**0.3**	**1.2**	**30**	**0.6**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 240
tensile strength R_m N/mm^2:	≥ 390
elongation A (L_0=5d_0) %:	≥ 30
impact work ISO-V KV J	≥ 80

(*) *u untreated, as-welded*

Operating Data

	ø mm	L mm	amps A
re-drying if necessary:			
–	2.5	300	60-80
electrode identification:	3.2	350	80-105
FOX CuNi 30Fe ECuNi	4.0	350	110-130

=+

Base Materials

Copper nickel alloys with up to 30 % nickel
CuNi 10 Fe 1 Mn (2.0872), CuNi20Fe (2.0878), CuNi30Fe 2.0882)
UNS C 71500, C70600

Approvals and Certificates

TÜV-D (10515.), GL, CL

Same Alloy Filler Metals

GTAW rod: CuNi 30Fe-IG

EN 14640:2005:	S Cu 7158 (CuNi30)
AWS A 5.7-04	ERCuNi
W.Nr.:	2.0837

BÖHLER CuNi 30Fe-IG

GTAW rod, CuNi-alloys

Description

GTAW rod for joining and surfacing of similar alloyed base metals with up to 30 % Nickel, as well as for non ferrous alloys and steels of different nature. Due to the excellent resistance to sea water, it is best suitable for offshore applications, oil refineries, seawater desalination plants, ship building and also for chemical and food industry.

Typical Composition of Welding Rod

	C	Mn	Ni	Fe	Ti	Cu
wt-%	**< 0.05**	**0.8**	**30**	**0.6**	**< 0.5**	**bal.**

Mechanical Properties of All-weld Metal

(*)	u
yield strength R_e N/mm^2:	≥ 200
tensile strength R_m N/mm^2:	≥ 360
elongation A (L_0=5d_0) %:	≥ 30
	HB 120

(*) *u untreated, as-welded – shielding gas Argon*

Operating Data

shielding gas:
100 % Argon
rod marking:
front: **2.0837**
back: **ERCuNi7**

ø mm
1.6
2.0
2.4

=–

Base Materials

Copper nickel alloys with up to 30 % nickel
CuNi10Fe1Mn (2.0872), CuNi20Fe (2.0878), CuNi30Fe (2.0882)
UNS C71500, C70600

Approvals and Certificates

TÜV-D (10517.), GL, CL

Same Alloy Filler Metals

SMAW stick electrode: FOX CuNi 30 Fe

AWS A5.16-04:	ERTi2
UNS:	R50120
W.Nr.:	3.7035

BÖHLER ER Ti 2-IG

GTAW rod, Titanium

Description

GTAW rod for welding of pure Titan and Titan alloys with similar chemical composition. Titanium can be tungsten arc welded employing techniques similar to those used for welding of stainless steel. However, Titanium requires a greater cleanliness and the use of auxiliary gas shielding to protect the molten puddleand cooling weld zone from atmospheric contamination.

Typical Composition of Welding Rod

	C	Ti	Fe	O	H	N
wt-%	**< 0.03**	**Bal.**	**< 0.2**	**< 0.10**	**< 0.008**	**< 0.02**

Mechanical Properties of All-weld Metal

(*)		u
yield strength R_e N/mm²:		**295***
tensile strength R_m N/mm²:		**500***
elongation A (L_0=5d_0) %:		**42***
impact work ISO-V KV J	+20 °C:	**76***

(*) *u untreated, as-welded – shielding gas 100 % Argon*
* *depend of the pollutants in the weld metal*

Operating Data

shielding gases:	**ø mm**
100% Argon	1.6
rod marking:	2.0
front: **ERTi2**	2.4

=–

Base Materials

Pure Titan and Titan alloys with a similar composition.
ASTM Grade 1-4
UNS R50400H

Approvals and Certificates

–

2.11. Sub-arc Welding Fluxes

Objectives

This section contains a brief description of the characteristic features of sub-arc welding fluxes from BÖHLER Welding.

Basically the flux has decisive effect on the result of welding operations. Its influence on the melting characteristics and various other physical properties such as viscosity, surface tension, density, thermal expansion, and conductivity in turn has a considerable bearing on the appearance of the bead surface and the slag removability.

Another major consideration here is the influence which the flux exerts through the metallurgical reaction on the chemical composition, and thus also on the mechanical properties of the deposit.

Contents

Overview – Standard Classifications

Böhler	EN	AWS
Sub-arc Welding Flux		
BB 24	EN 760: SA FB 1 65 DC H5	–
BB 25	EN 760: SA FB 1 68 AC H5	–
BB 33 M	EN 760: SA AR 1 97 AC	SAW fluxes are not specified
BF 16	EN 760: SF MS 1 78 AC	according to AWS-standards
BB 202	EN 760: SA FB 2 DC	–
BB 430	EN 760: SA FB 1 55 AC	–
BB 444	EN 760: SA FB 2	–
BB 910	EN 760: SA FB 2 55 DC	–

Overview – Typical Chemical Composition

Böhler	SiO_2+ TiO_2	CaO+ MgO	CaF_2	Al_2O_3+ MnO	Al_2O_3+ CaO	FeO	K_2O+ Na_2O
SAW Welding Flux							
BB 24	15	37	25	19	–	–	3
BB 25	15	29.5	25	23.5	–	–	–
BB 33 M	27	5	5	54	–	–	–
BF 16	44 (SiO_2)	13	3	38	–	1	–
BB 202	10	–	50	–	38 (Al_2O_3)	–	–
BB 203	20	26	32	18 (Al_2O_3)	–	–	–
BB 430	15	35	26	21	–	–	–
BB 444	4 (SiO_2)	55	-	30 (Al_2O_3)	–	9 (F-)	2
BB 910	14	32	31	18	–	–	–

EN 760: SA FB 1 65 DC H5

BÖHLER BB 24

SAW flux, fluoride-basic type

Description

BÖHLER BB 24 is an agglomerated welding flux of the fluoride-basic type. It is characterised by its neutral metallurgical behaviour. When used in combination with suitable wire electrodes the weld metal displays high toughness properties at low/subzero temperatures. The flux is designed for joining and surfacing applications on general-purpose structural steels, fine-grained high strength and low temperature steels, and high-temperature steel grades. BÖHLER BB 24 is a hydrogen-controlled welding flux with hydrogen contents of maximum 5 ml/100 g weld deposit.

Composition of Sub-arc Welding Flux

	SiO_2+TiO_2	CaO+MgO	Al_2O_3+MnO	CaF_2	K_2O+Na_2O
wt-%	**15**	**37**	**19**	**25**	**3**

Properties and Operating Data

→

basicity acc. Boniczewski: **2.6**
bulk density: **1.0** kg/dm³
grain size acc. EN 760: **0.3 - 2.0** mm
flux consumption: **1.0** kg flux per kg wire
maximum amperage: **800 A**. re-drying: **300 – 350 °C, 2 h – 10 h**

=±

Base Materials

mild steels, high temperature and creep resistant steels, cryogenic steels, fine-grained steels

Typical Composition of All-weld Metal with different Wires

Böhler SAW wires	C	Si	Mn	Cr	Ni	Mo	V	W
Böhler EMS 2	**0.07**	**0.25**	**1.05**					
Böhler EMS 3	**0.08**	**0.30**	**1.50**					
Böhler EMS 2 Mo	**0.08**	**0.25**	**1.15**			**0.45**		
Böhler EMS 2 CrMo	**0.08**	**0.25**	**1.0**	**1.0**		**0.45**		
Böhler CM 2-UP	**0.07**	**0.25**	**0.8**	**2.3**		**0.95**		
Böhler CM 5-UP	**0.05**	**0.50**	**0.75**	**5.5**		**0.55**		
Böhler 20 MVW-UP	**0.16**	**0.3**	**0.78**	**10.3**	**0.4**	**0.85**	**0.25**	**0.45**
Böhler 3 NiMo1-UP	**0.08**	**0.45**	**1.55**		**0.95**	**0.55**		
Böhler 3 NiCrMo 2.5-UP	**0.06**	**0.3**	**1.5**	**0.5**	**2.2**	**0.50**		
Böhler Ni 2-UP	**0.07**	**0.25**	**1.05**		**2.2**			

Designation	**wire class. according EN**	**classification for wire flux/combination according EN 756**	**according AWS 5.17 / 5.23**
BÖHLER EMS 2	S 2	S 38 4 FB S2	F 7 A 8-EM12K / F 48 A 6-EM12K
BÖHLER EMS 3	S 3	S 42 4 FB S3	F 7 A 4-EH10K / F 48 A 4-EH10K
BÖHLER 3 NiMo1-UP	S Z 3Ni1Mo	S 50 4 FB S3Ni1Mo	F9A4-EF3(mod)-F3/F62A4-EF3(mod.)-F3
BÖHLER 3 NiCrMo 2.5-UP	S Z 3Ni2CrMo	S 69 6 FB S3Ni2CrMo	F11A8-EM4(mod)-M4/F76A6-EM4(mod)-M4
BÖHLER Ni 2-UP	S 2Ni2	S 46 6 FB S2Ni2	F8A8-ENi2-Ni2 / F55A6-ENi2-Ni2
BÖHLER EMS 2 Mo	S 2 Mo	S 46 4 FB S2Mo	F 8 A 4-EA2-A2 / F 55 A 4-EA2-A2
BÖHLER EMS 2 CrMo	S CrMo1	-	F 8 P 4-EB2-B2 / F 55 P 4-EB2-B2
BÖHLER CM 2-UP	S CrMo2	-	F 9 P 2-EB3-B3 / F 55 P 0-EB3-B3
BÖHLER CM 5-UP	S CrMo5	-	F 9 P Z-EB6-B6 / F 62 P Z-EB6-B6
BÖHLER 20 MVW-UP	S CrMoWV12	-	-

Approvals and Certificates

DB (51.014.02), ÖBB; Approval is available for BÖHLER BB 24 together with the BÖHLER-wires: **TÜV-D:** EMS 2, EMS 3, EMS 2 Mo, EMS 2 CrMo, CM 2-UP, 3 NiMo 1-UP, 20 MVW-UP; **UDT:** EMS 2, EMS 2 Mo, EMS 2 CrMo, CM 2-UP, CM 5-UP, Ni2-UP, 3NiCrMo2,5-UP, 3NiMo1-UP

EN 760: SA FB 1 68 AC H5

BÖHLER BB 25

SAW flux, fluoride-basic type

Description

BÖHLER BB 25 is an agglomerated basic flux suitable for welding of mild and low alloyed steels with good weld metal impact values at low temperatures. Suitable for single and multi-pass technique.
The flux is active and shows some pickup of manganese and silicon. BÖHLER BB 25 is a hydrogen-controlled welding flux with hydrogen contents of maximum 5 ml/100 g weld deposit.

Composition of Sub-arc Welding Flux

	SiO_2+TiO_2	CaO+MgO	Al_2O_3+MnO	CaF_2
wt-%	**15**	**29.5**	**23.5**	**25**

Properties and Operating Data

basicity acc. Boniczewski: **2.2**
bulk density: **1.0** kg/dm³
grain size acc. EN 760: **0.2 - 2.0** mm
flux consumption: **1.0** kg flux per kg wire

maximum amperage: **800 A**
re-drying: **300 – 350 °C, 2 h – 10 h**

Base Materials

mild steels, high temperature steels, fine-grained steels

Typical Composition of All-weld Metal with different Wires

Böhler SAW-Wires	C	Si	Mn	Cr	Mo
Böhler EMS 2	**0.07**	**0.4**	**1.45**		
Böhler EMS 3	**0.06**	**0.4**	**1.90**		
Böhler EMS 2 Mo	**0.07**	**0.4**	**1.50**		**0.5**
Böhler EMS 2 CrMo	**0.07**	**0.4**	**1.35**	**1**	**0.5**

Designation	**wire class. according EN**	**classification for wire flux/combination according EN 756**	**according AWS 5.17 / 5.23**
BÖHLER EMS 2	S 2	S 42 4 FB S2	F 7 A 4-EM12K / F 48 A 4-EM12K
BÖHLER EMS 3	S 3	S 42 3 FB S3	F 7 A 3-EH10K / F 48 A 2-EH10K
BÖHLER EMS 2 Mo	S 2 Mo	S 46 3 FB S2Mo	F 8 A 4-EA2-A2 / F 55 A 4-EA2-A2
BÖHLER EMS 2 CrMo	S CrMo 1	–	F 8 P 4-EB2-B2 / F 55 P 4-EB2-B2

Approvals and Certificates

Approval is available for BÖHLER BB 25 together with the BÖHLER-wires:
TÜV-D: EMS 2 Mo, EMS 2 CrMo; **TÜV-A:** EMS 2, EMS 2 Mo, EMS 2 CrMo; **UDT:** EMS 2, EMS 2 Mo, EMS 2 CrMo; **ABS:** EMS 2 CrMo

EN 760: SA AR 1 97 AC

BÖHLER BB 33 M

SAW flux, aluminium-rutile-type

Description

BÖHLER BB 33 M is an agglomerated welding flux. It is a aluminium-rutile-type suited for high-speed welding of mild and low-alloyed steels.
It produces smooth welding beads even at travel speeds higher than 1.5 m/min.

Composition of Sub-arc Welding Flux

	Al_2O_3+MnO	SiO_2+TiO_2	CaO+MgO	CaF_2
wt-%	**54**	**27**	**5**	**5**

Properties and Operating Data

basicity acc. Boniczewski:	**0.6**
bulk density:	**1.4** kg/dm³
grain size acc. EN 760:	**0.2 - 2.0** mm
flux consumption:	**1.3** kg flux per kg wire

maximum amperage: **800 A**
re-drying: **275 – 325 °C, 2 h – 4 h**

Base Materials

mild steels and low alloy steels

Typical Composition of All-weld Metal with different Wires

Böhler SAW-Wires	C	Si	Mn	Mo
Böhler EMS 2	**0.08**	**0.7**	**1.3**	**–**
Böhler EMS 3	**0.08**	**0.8**	**1.7**	**–**
Böhler EMS 2 Mo	**0.07**	**0.8**	**1.5**	**0.5**

Designation	**wire class. according EN**	**classification for wire flux/combination according EN 756**	**according AWS 5.17 / 5.23**
BÖHLER EMS 2	S 2	S 46 0 AR S2	F 7 A Z-EM12K / F 48 A 0-EM12K
BÖHLER EMS 3	S 3	S 50 0 AR S3	F 7 A Z-EH10K / F 48 A 0-EH10K
BÖHLER EMS 2 Mo	S 2 Mo	S 46 Z AR S2Mo	F 8 A Z-EA2-A2(mod) F 55 A 0-EA2-A2(mod)

Approvals and Certificates

DB (51.014.01), ÖBB
Approval is available for BÖHLER BB 33 M together with BÖHLER-wires. **TÜV-D:** EMS 2, EMS 2 Mo. **TÜV-A:** EMS 2, EMS 2 Mo. **UDT:** EMS 2

EN 760: SF MS 1 78 AC

BÖHLER BF 16

SAW flux, manganese-silicate-type

Description

BÖHLER BF 16 is a fused manganese-silicate welding flux with acid characteristic. It is very homogeneous and not susceptible to moisture. The welding flux provides smooth beads together with a good slag detachability.
Its metallurgical behaviour shows a slight pick up of manganese and silicon.
It is suited for joint welds of mild steel constructural work of thinner walled (< 20 mm) components as well as for hardfacing applications and allows a high current carrying capacity on both AC and DC.

Composition of Sub-arc Welding Flux

	SiO_2	CaO+MgO	Al_2O_3+MnO	CaF_2	FeO
wt-%	**44**	**13**	**38**	**3**	**1**

Properties and Operating Data

basicity acc. Boniczewski:	**0.7**
bulk density:	**1.6** kg/dm^3
grain size acc. EN 760:	**0.2 - 2.0** mm
flux consumption:	**1.1 - 1.4** kg flux per kg wire

maximum amperage: **1300 A**
re-drying: **250 – 350 °C, 1 h – 10 h**

Base Materials

mild steels

Typical Composition of All-weld Metal with different Wires

Böhler SAW-Wires	C	Si	Mn
Böhler EMS 2	**0.04**	**0.5**	**1.3**
Böhler EMS 3	**0.04**	**0.5**	**1.7**

Designation	**wire class. according EN**	**classification for wire flux/combination according EN 756**	**according AWS 5.17 / 5.23**
BÖHLER EMS 2	S 2	S 38 0 MS S2	F 6 A 0-EM12K / F 43 A 2-EM12K
BÖHLER EMS 3	S 3	S 38 0 MS S3	F 6 A 0-EH10K / F 43 A 3-EH10K

Approvals and Certificates

Approval is available for BÖHLER BF 16 together with BÖHLER-wires.
TÜV-A: EMS 2, EMS 2 Mo.
UDT: EMS 2

EN 760: SA FB 2 DC

BÖHLER BB 202

SAW flux, fluoride-basic type

Description

BÖHLER BB 202 is an agglomerated fluoride-basic flux for single and multipass welding of Cr-steels and non stabilised and stabilised austenitic CrNi(Mo)-steels as well as ferritic-austenitic Duplex-steels. The flux BB 202 produces well contoured and smooth welding beads, easy slag removal without any slag residues and good welding characteristics even for fillet welds are very much appreciated by users. It offers an especially low flux consumption.
The weld deposits show high purity and good mechanical properties.

Composition of Sub-arc Welding Flux

	SiO_2+TiO_2	Al_2O_3	CaF_2
wt-%	**10**	**38**	**50**

Properties and Operating Data

basicity acc. Boniczewski: **2.3**
bulk density: **1.0** kg/dm^3
grain size acc. EN 760: **2 - 12** (0.2 - 1.2 mm)
flux consumption: **0.7** kg flux per kg wire
maximum amperage: **800 A**
re-drying: **300 – 350 °C, 2 h – 10 h**

=±

Base Materials

Cr-steels and unstabilised or stabilised austenitic CrNi(Mo)-steels as well as austenitic-ferritic duplex steels.

Typical Composition of All-weld Metal with different Wires

Böhler SAW-Wires	C	Si	Mn	Cr	Ni	Mo	Nb	Cu	N
Böhler CN 18/11-UP	**0.04**	**0.55**	**1.2**	**18.4**	**9.3**				
Böhler EAS 2-UP	**0.02**	**0.60**	**1.3**	**19.8**	**9.8**				
Böhler SAS 2-UP	**0.045**	**0.65**	**1.3**	**19.3**	**9.5**		**0.50**		
Böhler EAS 4 M-UP	**0.02**	**0.60**	**1.3**	**18.3**	**12.2**	**2.7**			
Böhler SAS 4-UP	**0.025**	**0.65**	**1.3**	**18.8**	**11.4**	**2.7**	**0.45**		
Böhler CN 22/9 N-UP	**0.015**	**0.55**	**1.3**	**22.5**	**8.9**	**3.1**			**0.14**
Böhler CN 23/12-UP	**0.015**	**0.65**	**1.3**	**23.4**	**13.1**				

Designation	**class. for wire acc. EN 12072**	**classification for wire flux/combination according EN**	**according AWS 5.9**
BÖHLER CN 18/11-UP	S 19 9 H	-	(ER19-10H)
BÖHLER EAS 2-UP	S 19 9 L	-	(ER308L)
BÖHLER SAS 2-UP	S 19 9 Nb	-	(ER347)
BÖHLER EAS 4 M-UP	S 19 12 3 L	-	(ER316L)
BÖHLER SAS 4-UP	S 19 12 3 Nb	-	(ER318)
BÖHLER CN 22/9 N-UP	S 22 9 3 NL	-	(ER2209)
BÖHLER CN 23/12-UP	S 23 12 L	-	(ER309L)

Approvals and Certificates

Approval is available for BÖHLER BB 202 together with the following BÖHLER-wires: **TÜV-D:** EAS 2-UP, EAS 4 M-UP, SAS 2-UP, SAS 4-UP, CN 22/9 N-UP; **TÜV-A:** SAS 2-UP, SAS 4-UP, CN 20/25 M-UP, CN 22/9 N-UP; **ABS:** CN 22/9 N-UP; **GL:** CN 22/9 N-UP; **CL:** CN 22/9 N-UP; **LR:** CN 22/9 N-UP; **DNV:** CN 22/9 N-UP, CN 23/12-UP; **UDT:** CN 18/11-UP, EAS 2-UP, EAS 4 M-UP, SAS 2-UP, SAS 4-UP, CN 22/9 N-UP, CN 23/12-UP

EN 760: SA FB 2 DC

BÖHLER BB 203

SAW flux, fluoride-basic type

Description

BÖHLER BB 203 is an agglomerated fluoride-basic flux with high basicity for joint welding of soft martensitic CrNi-steels and austenitic CrNi(Mo)-steels especially for thick walled components with high restraint and where low hydrogen contents are important.
BÖHLER BB 203 produces well contoured and smooth welding beads. It offers an especially low flux consumption. Beside a good slag detachability the flux features good fillet weld capabilities. The weld deposits show high purity and good mechanical properties.

Composition of Sub-arc Welding Flux

	SiO_2+TiO_2	CaO+MgO	Al_2O_3	CaF_2
wt-%	**20**	**26**	**18**	**32**

Properties and Operating Data

=±

basicity acc. Boniczewski: **2.7**
bulk density: **1.0** kg/dm^3
grain size acc. EN 760: **2 - 12** (0.2 - 1.25 mm)
flux consumption: **0.8** kg flux per kg wire

maximum amperage: **800 A**
re-drying: **300 – 350 °C, 2 h – 10 h**

Base Materials

soft-martensitic Cr-Ni-steels and unstabilised or stabilised austenitic CrNi(Mo)-steels as well as high corrosion resistant fully austenitic Cr-Ni-Mo-steels

Typical Composition of All-weld Metal with different Wires

Böhler SAW-Wires	C	Si	Mn	Cr	Ni	Mo	Nb	Cu	N
Böhler CN 13/4-UP	**0.025**	**0.75**	**0.6**	**12.1**	**4.7**	**0.5**			
Böhler ASN 5-UP	**0.02**	**0.2**	**4.5**	**18.5**	**16.3**	**4.0**			**0.14**
Böhler A 7 CN-UP	**0.08**	**0.9**	**6.8**	**18.5**	**8.8**				

Designation	**class. for wire acc. EN 12072**	**classification for wire flux/combination according EN**	**according AWS 5.9**
BÖHLER CN 13/4-UP	S 13 4	-	(ER410NiMo mod.)
BÖHLER ASN 5-UP	S 18 16 5 NL	-	(ER317LN mod.)
BÖHLER A 7CN-UP	S 18 8 Mn	-	(ER307 mod.)

Approvals and Certificates

Approval is available for BÖHLER BB 203 together with BÖHLER-wires.
TÜV-D: EAS 2-UP, EAS4 M-UP, SAS2-UP, SAS 4-UP, CN 22/9 N-UP, CN 20/25 M-UP;
UDT: A 7 CN-UP, ASN 5-UP, CN 13/4-UP; **SEPROS:** CN 13/4-UP, CN 20/25 M-UP;

EN 760: 1996: SA FB 1 55 AC

BÖHLER BB 430

SAW flux
fluoride-basic type

Description

BÖHLER BB 430 is a basic agglomerated welding flux with high basicity, for welding high temperature and creep resistant steels. It is characterised by its neutral metallurgical behaviour. When used in combination with suitable wire electrodes the weld metal displays high toughness properties at low/subzero temperatures, even after step-cooling heat treatment

Composition of Sub-arc Welding Flux

	SiO_2+TiO_2	CaO+MgO	Al_2O_3+MnO	CaF_2
wt-%	15	35	21	26

Properties and Operating Data

basicity acc. Boniczewski:	**3.4**
bulk density:	**1.0** kg/dm^3
grain size acc. EN 760:	**0.3 - 1.6** mm
flux consumption:	**1.0** kg flux per kg wire
maximum amperage:	**800 A**
re-drying:	**300 - 350 °C / 2h**

Base Materials

HCM2S (P23/T23 acc. to ASTM A213 code case 2199)
7CrMoVTiB10-10, P24 acc. to ASTM A 213(Draft)

Typical Composition of All-weld Metal with different Wires

BÖHLER SAW wires	C	Si	Mn	Cr	Mo	V	T	Nb	Ti	N	B
BÖHLER P 23-UP	0.05	0.27	0.9	2.05		0.22	1.7	0.05		0.01	
BÖHLER P 24-UP	0.06	0.20	0.7	2.2	1.0	0.22		0.007	0.027		<0.003

Designation	**wire classification.** **acc. EN**	**acc. AWS**
BÖHLER P 23-UP	S ZCrWV2	EG
BÖHLER P 24-UP	S ZCrWV2	EG

Approvals and Certificates

TÜV-D-for combination BÖHLER BB 430 together with the following BÖHLER-wires:
P 23-UP, P 24-UP

Same Alloy Filler Metals

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EN 760: 1996: SA FB 2

BÖHLER BB 444

SAW flux
fluoride-basic type

Description

BÖHLER BB 444 is a highly basic agglomerated welding flux, designed for welding and cladding of NiCr(Mo) alloys. Highly resistant against hot cracking thanks to its low level of Si pick up.

Typical Analysis of Sub-arc Welding Flux

	SiO_2	CaO+MgO	Al_2O_3	K_2O+Na_2O	F^-
wt-%	**4**	**55**	**30**	**2**	**9**

Properties and Operating Data

basicity acc. Boniczewski:	**5.1**
bulk density:	**1.0** kg/dm³
grain size acc. EN 760:	**0.4 -1.4** mm
flux consumption:	**1.0** kg flux per kg wire
maximum amperage:	**800 A**
re-drying:	**300 - 400 °C / 1h - 2h**

Base Materials

nickel and nickel alloys

Typical Composition of All-weld Metal with different wires

BÖHLER SAW wires	C	Si	Mn	Cr	Mo	Ni	Nb	Ti	T	Co	Fe
BÖHLER NIBAS 70/20-UP	0.010	0.25	3.1	20.0		bal.	2.2				0.8
BÖHLER NIBAS 625-UP	0.015	0.25	0.2	21.5	8.5	bal.	3.3	0.10			0.4
BÖHLER NIBAS C 24-UP	0.020	0.20	0.25	22.0	15.5	bal.					0.25
BÖHLER NIBAS 617-UP	<0,06	<0,40	<0.30	20.0	8.8	bal.		0.25		10.0	<1,0
BÖHLER NIBAS C 276-UP	<0.015	0.13	0.41	15.0	16.0	bal.			3.3		5.5

Designation	**wire classification.** acc. EN	acc. AWS
BÖHLER NIBAS 70/20-UP	SNi 6082 (NiCr20Mn3Nb)	ERNiCr-3
BÖHLER NIBAS 625UP	SNi 6625 (NiCr22Mo9Nb)	ERNiCrMo-3
BÖHLER NIBAS C 24-UP	SNi 6059 (NiCr23Mo16)	ERNiCrMo-13
BÖHLER NIBAS 617-UP	S Ni 6617 (NiCr22Co12 Mo)	ERNiCrCoMo-1
BÖHLER NIBAS C 276-UP	SNi 6276 (NiCr15Mo16Fe6W4)	ERNiCrMo-4

Approvals and Certificates

TÜV-D-for combination BÖHLER BB 444 together with the following BÖHLER-wires:
NIBAS 70/20-UP, NIBAS 625-UP

Same Alloy Filler Metals

–

EN 760: SA FB 2 55 DC 8

BÖHLER BB 910

SAW flux, fluoride-basic type

Description

BÖHLER BB 910 is an agglomerated fluoride-basic special welding flux with high basicity for multipass welding of creep resistant 9 % Cr-steels like P91/T91/P92/T92. The metallurgical behaviour concerning Si and Mn is neutral.
The flux BB 910 produces well contoured and smooth welding beads with good slag release as well as appropriate weld metal ductility and impact behaviour after tempering.
BÖHLER BB 910 is a hydrogen-controlled welding flux with hydrogen contents of maximum 5 ml/100 g weld deposit.

Composition of Sub-arc Welding Flux

	SiO_2+TiO_2	CaO+MgO	Al_2O_3+MnO	CaF_2
wt-%	**14**	**32**	**18**	**31**

Properties and Operating Data

basicity acc. Boniczewski: **2.9**
bulk density: **1.0** kg/dm³
grain size acc. EN 760: **0.3 - 2.0** mm
flux consumption: **1.0** kg flux per kg wire

maximum amperage: **800 A**
re-drying: **300 – 350 °C, 2 h – 10 h**

Base Materials

high creep resistant 9 %Cr-steels like grade P91/T91, and NF616

Typical Composition of All-weld Metal with different Wires

Böhler SAW-Wires	C	Si	Mn	Cr	Ni	Mo	V	Nb	W	N
Böhler C 9 MV-UP	**0.11**	**0.30**	**0.6**	**9.0**	**0.7**	**0.80**	**0.2**	**0.05**		
Böhler P 92-UP	**0.09**	**0.45**	**0.4**	**8.6**	**0.6**	**0.35**	**0.2**	**0.04**	**1.50**	

Designation	**class. for wire acc. EN 12070**	**classification for wire flux/combination according EN**	**according AWS 5.23**
BÖHLER C 9 MV-UP	S CrMo91	-	F 9 P Z-EB9-B9 / F 62 P Z-EB9-B9
BÖHLER P 92-UP	S Z CrMo92	-	-

Approvals and Certificates

Approval is available for BÖHLER BB 910 together with the BÖHLER-wires:
ÜV-D: C 9 MV-UP, P 92-UP; **CL:** C9MV-UP; **UDT:** C9 MV-UP, P92-UP; **SEPROS:** C9MV-UP

Notes

Notes

Notes

3. Selection Guide

Contents

3.1 SELECTION GUIDE FOR THE OFFSHORE INDUSTRY

	Welding processes					
	Base metal UNS/ASTM AISI/API	SMAW	FCAW	GTAW	GMAW	SAW
Mild steels Re < 380 MPa	A106Gr.B	FOX EV 50	Ti 52 W-FD HL 51-FD	EML 5		EMS 2 + BB 400
API Pipe steels	API 5L-X52	FOX EV PIPE FOX BVD 85	Ti 52 W-FD	EML 5	SG 3-P	EMS 2 + BB 400
	API X56-X65	FOX BVD 85 FOX BVD 90 M	Ti 60-FD	I 52 Ni	SG 3-P (max. X60) K-Nova Ni	EMS 2 + BB 400
	API X60-X65	FOX EV 60 PIPE FOX BVD 85		I 52 Ni	K-Nova Ni	
	API X70	FOX EV 70 PIPE FOX BVD 90			K-Nova Ni	
High strength steels Re > 380 MPa	S420-S460	FOX EV 60	Ti 60-FD	EML 5	K-Nova Ni	3NiMo1-UP + BB 420TTR
	S500	FOX EV 65		I 52 Ni	K-Nova Ni	3NiMo1-UP + BB 420TTR
	AISI 4130	FOX NiMO 100			NiMo 1-IG	3NiMo1-UP + BB 420TTR
	S690Q	FOX EV 85		I 52 Ni (Root pass only)	NiCrMo2.5-IG	3 NiCrMo2.5-UP + BB 420TTR BB 420TTRC
Stainless steels **Martensitic** 13Cr 4Ni		FOX CN 13/4 FOX CN 13/4 Supra	CN 13/4-MC	CN 13/4-IG	CN 13/4-MC CN 13/4-IG CN 13/4-MC (F)	
Austenitic 316L	S31600	FOX EAS 4 M-A FOX EAS 4 M	EAS 4 PW-FD EAS 4M-FD	EAS 4M-IG	EAS 4M-IG (Si) EAS 4 MC	EAS 4M-UP + BB 431
310	S31000	FOX FFB-A FOX FFB		FFB-IG	FFB-IG	

904	N08904	FOX CN 20/25M-A FOX CN 20/25M		CN 20/25M-IG	CN 20/25M-IG (Si)	
Type 6 Mo	S31254 N08926 N08367	FOX NIBAS 625	NIBAS 625-FD	NIBAS 625-IG	NIBAS 625-IG	
Duplex 22Cr	S31803 S32205	FOX CN 22/9 N FOX CN 22/9 N-B	CN 22/9 PW-FD CN 22/9 N-FD	CN 22/9N-IG	CN 22/9N-IG	CN 22/9N-UP + BB 431
Superduplex 25Cr	S32550 S32750 S32760	FOX CN 25/9 CuT		CN 25/9 CuT-IG	CN 25/9 CuT-IG	
Dissimilar joints		FOX CN 23/12-A FOX CN 23/12Mo-A FOX NIBAS 625 FOX NIBAS C 24	CN 23/12 PW-FD CN 23/12Mo PW-FD NIBAS 625 FD	CN 23/12-IG NIBAS 625-IG NIBAS C 24-IG	CN 23/12-IG CN 23/12-MC NIBAS 625-IG NIBAS C 24-IG	CN 23/12-UP + BB 431
Nickel base alloys						
Alloy 625	N06625	FOX NIBAS 625	NIBAS 625-FD	NIBAS 625-IG	NIBAS 625-IG	
Alloy 59	N06059	FOX NIBAS C 24		NIBAS C 24-IG	NIBAS C 24-IG	
Alloy C 276	N10276	FOX NIBAS C 276		NIBAS C 276-IG	NIBAS C 276-IG	
Alloy 400	N04400	FOX NIBAS 400		NIBAS 400-IG	NIBAS 400-IG	
Allloy 600	N06600	FOX NIBAS 70/20	NIBAS 70/20-FD	NIBAS 70/20-IG	NIBAS 70/20-IG	
Alloy 800/800HT	N08810	FOX CN 21/33 Mn		CN 21/33 Mn-IG	CN 21/33 Mn-IG	
Non ferrous alloys						
Copper base alloys Cu-Ni 90-10 Cu-Ni 70-30	C70600 C71500	FOX CuNi 30Fe		CuNi 30Fe-IG		
Titanium Ti grade 2	R50400			ER Ti 2		

3.1 SELECTION GUIDE FOR THE CHEMICAL AND PETROCHEMICAL INDUSTRY

	Base metals AISI/UNS/ASTM	Welding processes SMAW	FCAW	GTAW	GMAW	SAW	Page
High temperature and creep resistant steels							
0,5Mo	P/T1	FOX DMO Ti, Kb		DMO-IG	DMO-IG	EMS 2Mo+BB 24	
1Cr 0,5Mo	P/T11	FOX DCMS Ti, Kb		DCMS-IG	DCMS-IG	EMS 2CrMo+BB 24	
0,5Cr 1Mo +V	–	FOX DMV 83Kb		DMV 83-IG	DMV 83-IG		
$2^1/_4$Cr 1Mo	P/T22	FOX CM 2Kb		CM 2-IG	CM 2-IG	CM 2-UP+BB 24	
$2^1/_4$Cr 1Mo (mod.)	P/T23	FOX P 23		P 23-IG		P 23-UP+BB 430	
	P/T24	FOX P 24		P 24-IG		P 24-UP+BB 430	
5Cr 0,5Mo	P/T5	FOX CM 5 Kb		CM 5-IG	CM 5-IG	CM 5-UP+BB 24	
9Cr 1Mo	P/T9	FOX CM 9 Kb		CM 9-IG			
9Cr 1Mo +V(W)	P/T91	FOX C 9 MV		C 9 MV-IG	C 9 MV-IG, C 9 MV-MC	C 9 MV-UP+BB 910	
	P/T911	FOX C 9 MVW		C 9 MVW-IG			
	P/T92	FOX P 92		P 92-IG		P 92-UP+BB 910	
12Cr 1Mo +VW	–	FOX 20 MVW		20 MVW-IG		20 MVW-UP+BB 24	
18Cr 11Ni	304H	FOX CN 18/11		CN 18/11-IG	CN 18/11-IG	CN 18/11-UP+BB 202	
	321H	FOX E 308 H	E 308 H-FD	ER 308 H-IG			
			E 308 H PW-FD				
18Cr 10Ni +Nb	347H	FOX E 347 H					
Stainless steels Austenitic							
19Cr 9Ni L	304L	FOX EAS 2	EAS 2-FD	EAS 2-IG	EAS 2-IG (Si)	EAS 2-UP+BB 202	
		FOX EAS 2-A	EAS 2 PW-FD		EAS 2-MC		
		FOX EAS 2-VD					
19Cr 9Ni 3Mo L	316L	FOX EAS 4 M	EAS 4 M-FD	EAS 4 M-IG	EAS 4 M-IG (Si)	EAS 4 M-UP+BB 202	
		FOX EAS 4 M-A	EAS 4 PW-FD		EAS 4 M-MC		
		FOX EAS 4 M-VD					
		FOX EAS 4 M-TS					
19Cr 13Ni 4Mo L	317L	FOX E 317L	E 317L-FD			ASN 5 SY-UP+BB 202	
			E 317L PW-FD				
18Cr 16Ni 5Mo NL	317LN	FOX ASN 5		ASN 5-IG	ASN 5-IG (Si)	ASN 5-UP+BB 203	
		FOX ASN 5-A					

22Cr 18Ni 4Mo L	–	FOX AM 400		AM 400-IG	AM 400-IG		
19Cr 12Ni 3Mo Nb	316Ti	FOX SAS 4	SAS 4-FD	SAS 4-IG	SAS 4-IG (Si)	SAS 4-UP+BB 202	
		FOX SAS 4-A	SAS 4 PW-FD				
19Cr 9Ni Nb	347	FOX SAS 2	SAS 2-FD	SAS 2-IG	SAS 2-IG (Si)	SAS 2-UP+BB 202	
		FOX SAS 2-A	SAS 2 PW-FD				
20Cr 25Ni 5Mo CuNL	904L	FOX CN 20/25 M		CN 20/25 M-IG	CN 20/25 M-IG (Si)		
		FOX CN 20/25 M-A					
Ferritic / Martensitic							
13Cr NbL	409				KW 5 Nb-IG		
13Cr	410	FOX KW 10			KW 10-IG		
17Cr	431	FOX SKWA			SKWA-IG, KWA-IG		
17Cr Mo	–	FOX SKWAM			SKWAM-IG	SKWAM-UP+BB 203	
18Cr NbL	430Cb				CAT 430 L Cb-IG		
Soft martensitic							
13Cr 4Ni	CA6NM	FOX CN 13/4 SUPRA		CN 13/4-IG	CN 13/4-MC	CN 13/4-UP+BB 203	
	S41500	FOX CN 13/4			CN 13/4-MC (F)		
16Cr 6Ni Mo	–	FOX CN 16/6 M-HD			CN 13/4-IG		
Precipitation hardening							
17Cr 4Ni Cu	–	FOX CN 17/4 PH					
Duplex / Superduplex							
22Cr	S31803	FOX CN 22/9 N-B	CN 22/9 N-FD	CN 22/9 N-IG	CN 22/9 N-IG	CN 22/9N-UP+BB 202	
		FOX CN 22/9 N	CN 22/9 PW-FD				
25Cr	S32750	FOX CN 25/9 CuT		CN 25/9 CuT-IG	CN 25/9 CuT-IG		

3.1 SELECTION GUIDE FOR THE CHEMICAL AND PETROCHEMICAL INDUSTRY

	Base metal AISI/UNS/ASTM	SMAW	FCAW	GTAW	GMAW	SAW	Page
Special applications							
18Cr 8Ni Mn		FOX A 7	A 7-FD	A 7 CN-IG	A 7-IG	A 7 CN-UP+BB 203	
		FOX A 7-A	A 7 PW-FD		A 7-MC		
20Cr 10Ni 3Mo	Dissimilar joints,	FOX CN 19/9 M		CN 19/9 M-IG	CN 19/9 M-IG		
23Cr 12Ni L	corrosion	FOX CN 23/12-A	CN 23/12-FD	CN 23/12-IG	CN 23/12-IG	CN 23/12-UP+BB 202	
	resistant claddings		CN 23/12 PW-FD		CN 23/12-MC		
23Cr 12Ni 2Mo L		FOX CN 23/12 Mo-A	CN 23/12 Mo-FD				
			CN 23/12 Mo PW-FD				
24Cr 13Ni L	Buffer layers	FOX CN 24/13					
24Cr 13Ni NbL		FOX CN 24/13 Nb					
29Cr 9Ni	Problem steels	FOX CN 29/9					
		FOX CN 29/9-A					
19Cr 14Ni Si	Against nitric acid	FOX EAS 2 Si		EASN 2 Si-IG			
25Cr 22Ni 2Mo NL	UREA plant engineering	FOX EASN 25 M		EASN 25 M-IG			
Low temperature							
2.5Ni	A633 Gr. E	FOX 2.5 Ni		2.5 Ni-IG	2.5 Ni-IG	Ni 2-UP+BB 24	
19Cr 9Ni L	304L	FOX EAS 2	EAS 2-FD	EAS 2-IG	EAS 2-IG (Si)	EAS 2-UP+BB 202	
			EAS 2 PW-FD				
			EAS 2 PW-FD (LF)				
9Ni	K81340	FOX NIBAS 60/15	NIBAS 625-FD	NIBAS 625-IG	NIBAS 625-IG	NIBAS 625-UP+BB 444	
Heat resistant							
25Cr 4Ni	327	FOX FA		FA-IG	FA-IG		
22Cr 12Ni	309	FOX FF		FF-IG	FF-IG		
		FOX FF-A					
25Cr 20Ni	310	FOX FFB		FFB-IG	FFB-IG		
		FOX FFB-A					
21Cr 33Ni Mn	N08810 / 800H	FOX CN 21/33 Mn		CN 21/33 Mn-IG	CN 21/33 Mn-IG		

25Cr 35Ni Nb	–	FOX CN 25/35 Nb		CN 25/35 Nb-IG	CN 25/35 Nb-IG		
35Cr 45Ni Nb	–	FOX CN 35/45 Nb		CN 35/45 Nb-IG	CN 35/45 Nb-IG		
Nickel base alloys							
Alloy 600	N06600	FOX NIBAS 70/15					
Alloy 600	N06600	FOX NIBAS 70/20	NIBAS 70/20-FD	NIBAS 70/20-IG	NIBAS 70/20-IG	NIBAS 70/20-UP+BB 444	
Alloy 625	N06625	FOX NIBAS 625	NIBAS 625-FD	NIBAS 625-IG	NIBAS 625-IG	NIBAS 625-UP+BB 444	
Alloy C 276	N10276	FOX NIBAS C 276		NIBAS C 276-IG	NIBAS C 276-IG	NIBAS C 276-UP+BB 444	
Alloy 59	N06059	FOX NIBAS C 24		NIBAS C 24-IG	NIBAS C 24-IG	NIBAS C 24-UP+BB 444	
Alloy 400	N04400	FOX NIBAS 400		NIBAS 400-IG	NIBAS 400-IG		
Alloy 617	N06617	FOX NIBAS 617		NIBAS 617-IG	NIBAS 617-IG	NIBAS 617-UP+BB 444	
Non-ferrous alloys							
Cu-Ni 90-10	C70600	FOX CuNi 30Fe		CuNi 30Fe-IG			
Cu-Ni 90-30	C71500	FOX CuNi 30Fe		CuNi 30Fe-IG			
Ti grade 2	R50400			ER Ti 2-IG	ER Ti 2-IG		

3.1 SELECTION GUIDE FOR THERMAL POWER PLANTS

	Base metals AISI/UNS/ASTM	Welding processes: SMAW	FCAW	GTAW	GMAW	SAW	Page
Mild steels Re ≤ 380 MPa	SA106A+B	FOX EV 50	Ti 52-FD	EMK 6	EMK 6	EMS 2+BB 24	
High strength steels Re ≤ 500 MPa	SA508Cl.2	FOX EV 65			NiMo 1-IG	3 NiMo 1-UP+BB 24	
High Temperature and creep resistant steels							
0,5Mo	P/T1	FOX DMO Ti, Kb	(DMO)	DMO-IG	DMO-IG	EMS 2Mo+BB 24	
1Cr 0,5Mo	P/T11	FOX DCMS Ti, Kb	(DCMS)	DCMS-IG	DCMS-IG	EMS 2 CrMo+BB 24	
1.25Cr 1Mo+V	–	FOX DCMV					
0,5Cr 1Mo +V	–	FOX DMV 83Kb		DMV 83-IG	DMV 83-IG		
2.25Cr 1Mo	P/T22	FOX CM 2Kb		CM 2-IG	CM 2-IG	CM 2-UP+BB 24	
2.25Cr 1Mo (mod.)	P/T23	FOX P 23		P 23-IG		P 23-UP+BB 430	
	P/T24	FOX P 24		P 24-IG		P 24-UP+BB 430	
5Cr 0,5Mo	P/T5	FOX CM 5Kb		CM 5-IG	CM 5-IG	CM 5-UP+BB 24	
9Cr 1Mo	P/T9	FOX CM 9Kb		C M 9-IG			
9Cr 1Mo +V(W)	P/T91	FOX C 9 MV		C 9 MV-IG	C 9 MV-IG, C 9 MV-MC	C 9 MV-UP+BB 910	
	–	FOX C 9 MVW		C 9 MVW-IG			
	P/T92	FOX P 92		P 92-IG		P 92-UP+BB 910	
12Cr 1Mo +VW	–	FOX 20 MVW		20 MVW-IG		20 MVW-UP+BB 24	
18Cr 11Ni	304H	FOX CN 18/11		CN 18/11-IG	CN 18/11-IG	CN 18/11-UP+BB 202	
		FOX E 308 H	E 308 H-FD	ER 308 H-IG			
			E 308 H PW-FD				
18Cr 10Ni +Nb	347H	FOX E 347 H					

Special applications							
18Cr 8Ni Mn	dissimilar joints, repair and maintenance	FOX A 7	A 7-FD	A 7 CN-IG	A 7-IG	A 7 CN-UP+BB 203	
		FOX A 7-A	A 7 PW-FD		A 7-MC		
Heat resistant							
25Cr 4Ni	327	FOX FA		FA-IG	FA-IG		
22Cr 12Ni	309	FOX FF		FF-IG	FF-IG		
		FOX FF-A					
25Cr 20Ni	310	FOX FFB		FFB-IG	FFB-IG		
		FOX FFB-A					
21Cr 33Ni Mn	N08800	FOX CN 21/33 Mn		CN 21/33 Mn-IG	CN 21/33 Mn-IG		
Nickel base alloys							
Alloy 800	N06600	FOX NIBAS 70/15					
Alloy 600	N06600	FOX NIBAS 70/20	NIBAS 70/20-FD	NIBAS 70/20-IG	NIBAS 70/20-IG	NIBAS 70/20-UP+BB 444	
Alloy 625	N06625	FOX NIBAS 625	NIBAS 625-FD	NIBAS 625-IG	NIBAS 625-IG	NIBAS 625-UP+BB 444	
Alloy 617	N06617	FOX NIBAS 617		NIBAS 617-IG	NIBAS 617-IG	NIBAS 617-UP+BB 444	

3.1 SELECTION GUIDE FOR HYDRO POWER PLANTS

	Base metals AISI/UNS/ASTM	Welding processes: SMAW	FCAW	GTAW	GMAW	SAW	Page
API Pipe steels							
Re ≤ 450 MPa	X42-X65	FOX BVD 85					
Re ≤ 555 MPa	X70, X80	FOX BVD 90					
	X80	FOX BVD 100					
High strength steels							
Re ≤ 500 MPa	A302 Gr.A-D	FOX EV 65			NiMo 1-IG	3NiMo 1-UP+BB 24	
Re ≤ 600 MPa	A517 Gr.A-C	FOX EV 75					
Re ≤ 690 MPa	USS-T1	FOX EV 85			X 70-IG	3NiCrMo 2.5-UP+BB 24	
Stainless steels							
Soft martensitic 13Cr 4Ni	CA6NM	FOX CN 13/4			CN 13/4-MC		
		FOX CN 13/4 SUPRA		CN 13/4-IG	CN 13/4-MC (F)	CN 13/4-UP+BB 203	
					CN 13/4-IG		
16Cr 6Ni Mo	–	FOX CN 16/6 M-HD					
Austenitic 19Cr 9Ni 3Mo L	316L	FOX EAS 4 M	EAS 4 M-FD	EAS 4 M-IG	EAS 4 M-IG (Si)	EAS 4 M-UP+BB 202	
		FOX EAS 4 M-A	EAS 4 PW-FD		EAS 4 M-MC		
		FOX EAS 4 M-TS					
Special applications							
18Cr 8Ni Mn	dissimilar joints,	FOX A 7	A 7 -FD	A 7 CN-IG	A 7-IG	A 7 CN-UP+BB 203	
	repair and	FOX A 7-A	A 7 PW-FD		A 7-MC		
23Cr 12Ni L	maintenance	FOX CN 23/12-A	CN 23/12-FD	CN 23/12-IG	CN 23/12-IG	CN 23/12-UP+BB 202	
			CN 23/12 PW-FD		CN 23/12-MC		
23Cr 12Ni 2Mo L		FOX CN 23/12 Mo-A	CN 23/12 Mo-FD				
			CN 23/12 Mo PW-FD				

Notes

Notes

3.2. Selection Tables
base material oriented selection

Overview

The selection range provided from the materials science point of view attempts to respond to the behaviour of the base metal and matches the welding parameters and the temperature input to this behaviour although choosing from the selection tables provides quicker and more direct access to the appropriate filler metals.
However, it has to be noted that this section does not go into detail about the welding technology used for processing the filler metals listed. The appropriate subsection of the next chapter or the individual data sheets of the filler metals themselves should be referred to for this.

Contents

3.2.1 High Temperature Steels

Stick Electrodes for High Temperature Steels

Material Group	W-No.	ASTM AISI UNS	Service Tempe-rature up to °C	FOX DMO Kb	FOX DMO Ti	FOX EV 65	FOX EV 70 Mo	FOX DCMS Kb	FOX DCMS Ti	FOX DCMV	DOX DMV 83 Kb	FOX CM 2 Kb	FOX CM 5 Kb	FOX CM 9 Kb		
boiler, plate and	1.0405	A 106, Gr. A	500	X	X											
tube steels	1.0461	A 516, Gr. 55	400	X	X											
	1.0481	A 106, Gr. C	500	X	X											
	1.0482	A 515, Gr. 70	500	X	X	X	X									
	1.5415	A 335, Gr. P1	530	X	X											
	1.7335	A 335, Gr. P11, P12	560					X	X							
	1.7715	A 405, Gr. P24	560								X					
	1.7380	A 335, Gr. P22	590									X				
high temperature	1.0619	A 216, Gr. WCA-C	450	X												
cast steels	1.5419	A 217, Gr. WC1	500	X			X									
	1.7357	A 217, Gr. WC6	550					X								
	1.7706	I 21610	550							X	(x)					
	1.7379	A 217, Gr. WC9	600									X				
high pressure	1.7218	A 519, Gr. 4130	300					X								
hydrogen-resistant	1.7273		400									X				
steels	1.7362	A 335, Gr. P5	600										X			
	1.7386	A 335, Gr. P9	600											X		
special grades for	1.6368		500	X		X	X									
high temperature	1.6311	A 508, Cl. 3	550	X		X										
application	1.7733	A 389. Gr. C 23	550								X					
	1.8070	A 389, Gr. C 24	550							X	(x)					
	1.7375		590									X				
special grades for	1.6369		375			X	X									
reactor construction	1.6310	A 533, Gr. BCl.1	375			X										
caustic cracking	1.0407		-	X				X								
resistant steels	1.0569		-	X				X								

(x) limited suitability for application

GTAW and Gas Welding Rods, GMAW or SAW Wires for High Temperature Steels

Material Group	W-No.	ASTM AISI UNS	Service Tempe-rature up to °C	DMO-IG	DCMS-IG	DMV 83-IG	CM 2-IG	CM 5-IG	CM 9-IG	EMS 2 Mo	EMS 2 CrMo	CM 2-UP	CM 5-UP	DMO	DCMS	CM2		
boiler, plate and tube steels	1.0405	A 106, Gr. A	500	X						X				X				
	1.0461	A 516, Gr. 55	400	X						X				X				
	1.0481	A 106, Gr. C	500	X						X				X				
	1.0482	A 515, Gr. 70	500	X						X				X				
	1.5415	A 335, Gr. P1	530	X						X				X				
	1.7335	A 335, Gr. P11, P12	560		X						X				X			
	1.7715	A 405, Gr. P24	560			X												
	1.7380	A 335, Gr. P22	590				X					X				X		
high temperature cast steels	1.0619	A 216, Gr. WCA-C	450	X						X								
	1.5419	A 217, Gr. WC1	500	X						X								
	1.7357	A 217, Gr. WC6	550		X						X							
	1.7706	I 21610	550			(x)												
	1.7379	A 217, Gr. WC9	600				X					X						
high pressure hydrogen-resistant steels	1.7218	A 519, Gr. 4130	300		X						X							
	1.7273		400				X					X						
	1.7362	A 335, Gr. P5	600					X					X					
	1.7386	A 335, Gr. P9	600						X									
special grades for high temperature application	1.6368		500	X						(x)								
	1.6311	A 508, Cl. 3	550	X						(x)								
	1.7733	A 389. Gr. C 23	550			X						(x)						
	1.8070	A 389, Gr. C 24	550			(x)												
	1.7375		590				X											
special grades for reactor construction	1.6369		375	X														
	1.6310	A 533, Gr. BCl.1	375	X														
caustic cracking resistant steels	1.0407		-	X	X													
	1.0569		-	X	X													

(x) limited suitability for application

3.2.2 Creep-resistant Steels

Stick Electrodes for Creep-resistant Steels

Material Group	W-No.	ASTM AISI UNS	Service Tempe-rature up to °C	FOX 20 MVW	FOX C 9 MV	FOX C 9 MVW	FOX P 92	FOX CN 18/11	FOX E 308 H	FOX CN 16/13	FOX NIBAS 70/20	FOX NIBAS 70/15	
high temperature and creep resistant steels	1.4922	-	600	X							(x)[2]	(x)[2]	
	1.4923	-	580	X							(x)[2]	(x)[2]	
	1.4926	-	600	X							(x)[2]	(x)[2]	
	1.4931	-	600	X							(x)[2]	(x)[2]	
	1.4935	-	580	X							(x)[2]	(x)[2]	
	-	A 335, Gr. P91	650		X						(x)[2]	(x)[2]	
	-	A 335, Gr. P911	650			X					(x)[2]	(x)[2]	
	-	A 335, Gr. P92	650				X			(x)[2]	(x)[2]		
creep-resistant austenitic steels	1.4948	304 H	700					X	X		(x)	(x)	
	1.4949	304 N	700					X	X		(x)	(x)	
	1.4941	-	700					X	X		(x)	(x)	
	1.4919	316 H	700							(x)[1]	(x)	(x)	
	1.4910	-	750							(x)[1]	(x)	(x)	
	1.4961	TP 347 H	750							X	(x)	(x)	
	1.4981	-	750							(x)[1]	(x)	(x)	
	1.4988	-	650							(x)[1]	(x)	(x)	
nickel-base alloys	1.4958	-	700								(x)	(x)	
	1.4959	-	1000								(x)	(x)	

X = same or similar alloyed filler metals
(x) = dissimilar alloyed filler metals
[1] = weld metal contains no molybdenum, corrosion resistance requirements have to be checked
[2] = strength values of weld metal are lower than base material

GTAW Rods, GMAW and SAW Wires for Creep-resistant Steels

Material Group	W-No.	ASTM AISI UNS	Service Tempe-ratur up to °C	20 MVW-IG	C 9 MV-IG	C 9 MVW-IG	P 92-IG	CN 18/11-IG	ER 308 H-IG	CN 16/13-IG	E 308 H-FD, E 308 H PW-FD	NIBAS 70/20-IG NIBAS 70/20-FD	20 MVW-UP*	C 9 MV-UP*	P 92-UP*	
high temperature	1.4922	-	600	X								(x)[2]	X			
and creep resistant	1.4923	-	580	X								(x)[2]	X			
steels	1.4926	-	600	X								(x)[2]	X			
	1.4931	-	600	X								(x)[2]	X			
	1.4935	-	580	X								(x)[2]	X			
	-	A 335, Gr. P91	650		X							(x)[2]		X		
	-	A 335, Gr. P911	650			X						(x)[2]				
	-	A 335, Gr. P92	650				X					(x)[2]			X	
creep-resistant	1.4948	304 H	700					X	X		X	(x)				
austenitic	1.4949	304 N	700					X	X		X	(x)				
steels	1.4941	-	700					X	X		X	(x)				
	1.4919	316 H	700							(x)[1]		(x)				
	1.4910	-	750							(x)[1]		(x)				
	1.4961	TP 347 H	750							X		(x)				
	1.4981	-	750							(x)[1]		(x)				
	1.4988	-	650							(x)[1]		(x)				
nickel-base alloys	1.4958	-	700									(x)				
	1.4959	-	1000									(x)				

X = same or similar alloyed filler metals
(x) = dissimilar alloyed filler metals
[1] = weld metal contains no molybdenum, corrosion resistance requirements have to be checked
[2] = strength values of weld metal are lower than base material
* suitable sub-arc welding fluxes can be found in the data sheets of SAW wire

3.2.3 Dissimilar Welds with High Temperature Steels

Recommendations for suitable filler metals and optimum heat treatment

Base Material Combination		Filler Metals[1)] Stick Electrodes	GTAW/GMAW	SAW	Annealing temp.[2)] °C
P235G1TH	16Mo3	FOX SPEM	EML 5	EMS 2	530-600
P255G1TH		FOX EV 47	EMK 6	EMS 3	
		FOX EV 50	EMK 7 – EMK 8	EMS 2 Mo	
		FOX DMO Kb or Ti	DMO-IG		
			DMO Kb-FD, DMO Ti-FD		
P295GH	16Mo3	FOX EV 47	EML 5	EMS 2	530-580
		FOX EV 50	EMK 6	EMS 3	
		FOX DMO Kb or Ti	EMK 7 - EMK 8		
			DMO-IG		
			DMO Kb-FD, DMO Ti-FD		
P310GH	16Mo3	FOX DMO Kb or Ti	EML 5	EMS 3	530-580
			EMK 6	EMS 2 Mo	
			EMK 7 – EMK 8		
			DMO-IG		
			DMO Kb-FD, DMO Ti-FD		
P235G1TH	13CrMo4-5	FOX EV 47	EML 5		540-600
P255G1TH		FOX EV 50	EMK 6		
		FOX DMO Kb or Ti	EMK 7 – EMK 8		
			DMO-IG		
			DMO Kb-FD, DMO Ti-FD		
16Mo3	13CrMo4-5	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	550-620
			DMO Kb-FD, DMO Ti-FD		
16Mo3	10CrMo9-10	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	570-620
			DMO Kb-FD, DMO Ti-FD		
13CrMo4-5	10CrMo9-10	FOX DCMS Kb	DCMS-IG	(EMS 2 CrMo)	650-720
			DCMS Kb-FD		
14MoV6-3	13CrMo4-5	FOX DCMS Kb	DCMS-IG	EMS 2 CrMo	680-720
			DCMS Kb-FD		
14MoV6-3	10CrMo9-10	FOX CM 2 Kb	CM 2-IG	(CM 2-UP)	690-730
			CM 2 Kb-FD		
14MoV6-3	X20CrMoV12-1	FOX DMV 83 Kb	DMV 83-IG		670-720
		FOX 20 MVW	20 MVW-IG		

Recommendations for suitable filler metals and optimum heat treatment (continued)

Base Material Combination		Filler Metals[1)] Stick Electrodes	GTAW/GMAW	SAW	Annealing temp.[2)] °C
10CrMo9-10	X20CrMoV12-1	FOX CM 2 Kb or	CM 2-IG or	(CM 2-UP)	700-750
		FOX NIBAS 70/20 or	NIBAS 70/20-IG or		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
		FOX DMV 83 Kb	DMV 83-IG		680-730
		FOX 20 MVW	20 MVW-IG	20 MVW-UP	700-750
17 MnMoV 74	P235G1TH	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	530-590
	P255G1TH		DMO Kb-FD, DMO Ti-FD		
	16Mo3				
15 NiCuMoNb 5	13CrMo4-5				
11 NiMoV 53	P235G1TH	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	530-590
	P255G1TH		DMO Kb-FD, DMO Ti-FD		
	16Mo3				
	13CrMo4-5				
20MnMoNi4-5	P235G1TH	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	550-600
	P255G1TH		DMO Kb-FD, DMO Ti-FD		
	16Mo3				
	13CrMo4-5	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	530-590
			DMO Kb-FD, DMO Ti-FD		
		FOX DCMS Kb	DCMS-IG		
			DCMS Kb-FD	MS 2 CrMo	
15 MnMoNiV 53	P235G1TH	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	530-590
	P255G1TH		DMO Kb-FD, DMO Ti-FD		
	16Mo3				
	13CrMo4-5				
22 NiMoCr 37	P235G1TH	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	580-640
	P255G1TH		DMO Kb-FD, DMO Ti-FD		
	16Mo3				
	13CrMo4-5				
GP240GH	P235G1TH	FOX EV 47 or	EML 5	EMS 2	560-620
	P255G1TH	FOX EV 50	EMK 6	EMS 3	
			EMK 7		
	16Mo3	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	560-620
			DMO Kb-FD, DMO Ti-FD		
22Mo4	16Mo3	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	560-620
			DMO Kb-FD, DMO Ti-FD		
	13CrMo4-5	FOX DMO Kb or Ti	DMO-IG	EMS 2 Mo	560-620
		FOX DCMS Kb	DCMS-IG	EMS 2 CrMo	
22Mo4	21 CrMoV 511	FOX DCMS Kb	DCMS-IG	EMS 2 CrMo	650-720
			DCMS Kb-FD		

Recommendations for suitable filler metals and optimum heat treatment (continued)

Base Material Combination		Filler Metals[1)] Stick Electrodes	GTAW/GMAW	SAW	Annealing temp.[2)] °C
G17CrMo5-5	16Mo3	FOX DMO Kb	DMO-IG	EMS 2 Mo	640-700
			DMO Kb-FD, DMO Ti-FD		
	13CrMo4-5	FOX DCMS Kb	DCMS-IG	EMS 2 CrMo	640-700
	10CrMo9-10		DCMS Kb-FD		
	14MoV6-3				670-720
G17CrMoV5-11	13CrMo4-5	FOX DCMS Kb	DCMS-IG	EMS 2 CrMo	650-730
			DCMS Kb-FD		
	10CrMo9-10	FOX CM 2 Kb	CM 2-IG	CM 2-UP	670-720
			CM 2 Kb-FD		
	14MoV6-3	FOX DMV 83 Kb	DMV 83-IG	(CM 2-UP)	680-730
		FOX CM 2 Kb	CM 2-IG		
			CM 2 Kb-FD		
	21CrMoV5-1-1	FOX DMV 83 Kb	DMV 83-IG		
	X8CrNiNb16-13	FOX NIBAS 70/20	NIBAS 70/20-IG		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
	X20CrMoV12-1	FOX DMV 83 Kb	DMV 83-IG		
		FOX 20 MVW	20 MVW-IG		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
		FOX NIBAS 70/20	NIBAS 70/20-IG		
GX22CrMoV12-1	14MoV6-3	FOX CM 2-IG	DMV 83-IG		670-730
		FOX NIBAS 70/20	NIBAS 70/20-IG		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
	14MoV6-3	FOX DMV 83 Kb	DMV 83-IG		680-730
		FOX NIBAS 70/20	NIBAS 70/20-IG		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
	21CrMoV5-1-1	FOX DMV 83 Kb	20 MVW-IG		670-730
		FOX NIBAS 70/20	NIBAS 70/20-IG		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
	X20CrMoV12-1	FOX 20 MVW			
		FOX NIBAS 70/20	NIBAS 70/20-IG		
		FOX NiCr 70 Nb	NiCr 70 Nb-IG		
	X8CrNiNb16-13	FOX NiCr 70 Nb	NiCr 70 Nb-IG		
		FOX NIBAS 70/20	NIBAS 70/20-IG		

( ) Use subject with reservations. Before selection please consult your next BÖHLER representative and give exact description of service conditions and requirements.

1) The material recommendations have been chosen in a way to ensure that the relevant filler metal is lower alloy ed and thus tougher than the base metal.

2) The annealing temperatures have been chosen in a way to ensure that the lowest Ac1 temperature of the two materials involved is not exceeded. The annealing time depends on the relevant work piece thickness; it has to be at least 15 minutes for thicknesses of 15 mm, at least 30 minutes for thicknesses of 15-20 mm and at least 60 minutes for thicknesses above 30 mm. For work pieces of low thicknesses a medium annealing time should be chosen, whereas in thick-walled components the surface should be reach a temperature within the upper range.

Notes

3.2.4 Ferritic Chromium Steels

Stick Electrodes for Ferritic Chromium Steels

W-No.	material designation	ASTM AISI UNS	FOX KW 10	FOX SKWA	FOX SKWAM	FOX A7, -A	FOX CN 19/9 M	FOX CN 23/12-A	FOX CN 23/12 Mo-A	FOX CN 29/9, -A	FOX EAS 2, -A, -VD	FOX EAS 4M, -A, -TS, -VD	FOX SAS 2, -A	FOX SAS 4, -A	FOX NIBAS 70/20 FOX NiCr 70 Nb			
1.4000	X6Cr13	403	(x)	(x)		X		X		X	X		X					
1,4001	X7Cr14	429	(x)	(x)		X		X		X	X		X					
1.4002	X6CrAl13	405	(x)	(x)		X									X			
1.4003	X2CrNi12					X					X							
1.4006	X12Cr13	410	(x)	(x)		X		X		X	X		X					
1.4008	GX8CrNi13	CA 15	(x)	(x)		X		X		X	X		X					
1.4016	X6Cr17	430		(x)		X		X		X	X		X					
1.4021	X20Cr13	420	(x)	(x)		X		X		X	X		X					
1.4024	X15Cr13	410	(x)	(x)		X		X		X	X		X					
1.4027	GX20Cr14	A 217				X		X		X					X			
1.4034	X46Cr13					X		X		X					X			
1.4057	X17CrNi16-2	431		X	(x)	X		X		X	X		X	X				
1.4059	GX22CrNi17	A 743		X	(x)	X		X		X	X		X	X				
1.4113	X6CrMo17-1	434			(x)		X		X			X		X				
1.4120	X20CrMo13				(x)		X		X			X		X				
1.4120	GX20CrMo13				(x)		X		X			X		X				
1.4122	X39CrMo17-1				X		X		X			X		X				
1.4122	GX35CrMo17-1				X		X		X			X		X				

GTAW Rods and GMAW Wires for Ferritic Chromium Steels

W-No.	material designation	ASTM AISI UNS	KW 10-IG	KWA-IG	SKWA-IG	SKWAM-IG	A7-IG/A7CN-IG, A7 (PW)-FD	CN 19/9 M-IG	CN 23/12-IG	CN 23/12-FD, PW-FD	EAS 2-IG, -IG (Si)	EAS 2-FD, PW-FD	EAS 4 M-IG, -IG (Si)	EAS 4 M-FD, PW-FD	SAS 2-IG, -IG (Si)	SAS 2-FD, PW-FD	SAS 4-IG, -IG (Si)	SAS 4-FD, PW-FD	NIBAS 70/20-IG	NIBAS 70-20 FD
1.4000	X6Cr13	403	(x)	(x)	(x)		X		X	X	X	X			X	X				
1,4001	X7Cr14	429	(x)	(x)	(x)		X		X	X	X	X			X	X				
1.4002	X6CrAl13	405	(x)	(x)	(x)		X												X	X
1.4003	X2CrNi12						X				X	X								
1.4006	X12Cr13	410	(x)	(x)	(x)		X				X	X			X	X				
1.4008	GX8CrNi13	CA 15	(x)	(x)	(x)		X				X	X			X	X				
1.4016	X6Cr17	430			(x)		X				X	X			X	X				
1.4021	X20Cr13	420	(x)	(x)			X				X	X			X	X				
1.4024	X15Cr13	410	(x)	(x)			X				X	X			X	X			X	X
1.4027	GX20Cr14	A 217					X												X	X
1.4034	X46Cr13						X												X	X
1.4057	X17CrNi16-2	431			X	(x)	X													
1.4059	GX22CrNi17	A 743			X	(x)	X													
1.4113	X6CrMo17-1	434			X	(x)		X					X	X			X	X		
1.4120	X20CrMo13					(x)		X					X	X			X	X		
1.4120	GX20CrMo13					(x)		X					X	X			X	X		
1.4122	X39CrMo17-1					X		X					X	X			X	X		
1.4122	GX35CrMo17-1					X		X					X	X			X	X		

3.2.5 Chemical Resistant Steels

Stick Electrodes for Chemical Resistant Steels

W-No.	material designation	ASTM AISI UNS	FOX AM 400	FOX ASN 5, -A	FOX CN 13/4, (-Supra)	FOX CN 20/25 M, -A	FOX CN 22/9 N, -B	FOX EAS 2, -A, -VD	FOX EAS 2 Si	FOX EAS 4M, -A, -TS, -VD	FOX NIBAS 625	FOX NiCr 625	FOX SAS 2, -A	FOX SAS 4, -A	FOX SKWA			
1.3952	X2CrNiMoN18-14-3		X															
1.3964	X2CrNiMnMoNNb21-16-5-3	S20910	X															
1.4301	X5CrNi18-10	304						X					(x)					
1.4303	X4CrNi18-12	305						X					(x)					
1.4306	X2CrNi19-11	304L						X					(x)					
1.4308	GX5CrNi19-10							X					(x)					
1.4311	X2CrNiN18-10	304LN						X					(x)					
1.4312	GX10CrNi18-8							X					(x)					
1.4313	X3CrNiMo13-4	S41500			X													
1.4317	G-X 4CrNi 13-4				X													
1.4361	X1CrNiSi18-15-4								X									
1.4401	X5CrNiMo17-12-2	316								X				(x)				
1.4404	X2CrNiMo17-12-2	316L								X				(x)				
1.4406	X2CrNiMoN17-11-2	316L		(x)						X				(x)				
1.4407	GX5CrNiMo13-4	CAGNM			X													
1.4408	GX5CrNiMo19-11-2									X				(x)				
1.4409	GX2CrNiMo19-11-2									X				(x)				
1.4429	X2CrNiMoN17-13-3	316LN		(x)						X				(x)				
1.4435	X2CrNiMo18-14-3	317L		(x)						X				(x)				
1.4436	X3CrNiMo17-13-3	S31600		(x)						X				(x)				
1.4437	GX6CrNiMo18-12	S31600		(x)						X				(x)				
1.4438	X2CrNiMo18-15-4	S31703		(x)		(x)												
1.4439	X2CrNiMoN17-13-5	S 31726	(x)	(x)		(x)												
1.4446	GX2CrNiMoN17-13-4			(x)		(x)												
1.4448	GX6CrNiMo17-13			(x)		(x)												
1.4462	X2CrNiMoN22-5-3	S31803					X											
1.4500	GX7NiCrMoCuNb25-20					X												
1.4505	X4NiCrMoCuNb20-18-2					(x)												
1.4506	X5NiCrMoCuTi20-18					(x)												
1.4510	X3CrTi17	430 Ti											(x)		X			

Stick Electrodes for Chemical Resistant Steels (continued).

W-No.	material designation	ASTM AISI UNS	FOX AM 400	FOX ASN 5, -A	FOX CN 13/4, (-Supra)	FOX CN 20/25 M, -A	FOX CN 22/9 N, -B	FOX EAS 2, -A, -VD	FOX EAS 2 Si	FOX EAS 4M, -A, -TS, -VD	FOX NIBAS 625	FOX NiCr 625	FOX SAS 2, -A	FOX SAS 4, -A	FOX SKWA			
1.4511	X3CrNb17	430 Cb											(x)		X			
1.4512	X2CrTi12	S40900						(x)							(x)			
1.4529	X1NiCrMoCuN25-20-7	N08925									X	X						
1.4531	GX2NiCrMoCuN20-18					(x)												
1.4536	GX2NiCrMoCuN25-20					X					(x)	(x)						
1.4539	X1NiCrMoCu25-20-5	N08904				X					(x)	(x)						
1.4541	X6CrNiTi18-10	321						(x)					X					
1.4550	X6CrNiNb18-10	347						(x)					X					
1.4552	GX5CrNiNb19-11	CF8C						(x)					X					
1.4558	X2NiCrAlTi32-20	B407									(x)	(x)						
1.4571	X6CrNiMoTi17-12-2	316 Ti								(x)				X				
1.4577	X3CrNiMoTi25-25	S31640				(x)												
1.4580	X6CrNiMoNb17-12-2	316 Cb								(x)				X				
1.4581	GX5CrNiMoNb19-11-2									(x)				X				
1.4583	X10CrNiMoNb18-12	316 Cb												X				
1.4585	GX7CrNiMoCuNb18-18					(x)												
1.4586	X5NiCrMoCuNb22-18					(x)												
2.4856	NiCr22Mo9Nb	N06625									X	X						
2.4858	NiCr21Mo	N08825									(x)	(x)						

GTAW Rods, GMAW Wires for Chemical Resistant Steels

W-No.	material designation	ASTM AISI UNS	AM 400-IG	ASN 5-IG, -IG(Si)	E 317L-FD, E 317L PW-FD	CN 13/4-IG, CN 13/4-MC	CN 20/25M-IG, -IG(Si)	CN 22/9N-IG	CN 22/9 N-FD, PW-FD	EAS 2-FD, -PW-FD	EAS 2-IG, -IG(Si)	EASN 2 Si-IG	EAS 4M-IG, -IG(Si)	EAS 4 M-FD, PW-FD	NIBAS 625-IG, NiCr 625-IG	SAS 2-IG, -IG(Si), -FD, PW-FD	SAS 4-IG, -IG(Si), -FD, PW-FD	SKWA-IG	
1.3952	X2CrNiMoN18-14-3		X																
1.3964	X2CrNiMnMoNNb21-16-5-3	S20910	X																
1.4301	X5CrNi18-10	304								X	X					(x)			
1.4303	X4CrNi18-12	305								X	X					(x)			
1.4306	X2CrNi19-11	304L								X	X					(x)			
1.4308	GX5CrNi19-10									X	X					(x)			
1.4311	X2CrNiN18-10	304LN								X	X					(x)			
1.4312	GX10CrNi18-8									X	X					(x)			
1.4313	X3CrNiMo13-4	S41500				X													
1.4361	X1CrNiSi18-15-4											X							
1.4401	X5CrNiMo17-12-2	316											X	X			(x)		
1.4404	X2CrNiMo17-12-2	316L											X	X			(x)		
1.4406	X2CrNiMoN17-11-2	316L		(x)									X	X			(x)		
1.4407	GX5CrNiMo13-4	CAGNM				X													
1.4408	GX5CrNiMo19-11-2												X	X			(x)		
1.4409	GX2CrNiMo19-11-2												X	X			(x)		
1.4429	X2CrNiMoN17-13-3	316LN		(x)	X								X	X			(x)		
1.4435	X2CrNiMo18-14-3	317L		(x)	X								X	X			(x)		
1.4436	X3CrNiMo17-13-3	S31600		(x)	X								X	X			(x)		
1.4437	GX6CrNiMo18-12	S31600		(x)									X	X			(x)		
1.4438	X2CrNiMo18-15-4	S31703		X	X		(x)												
1.4439	X2CrNiMoN17-13-5	S 31726		X			(x)												
1.4446	GX2CrNiMoN17-13-4			X			(x)												
1.4448	GX6CrNiMo17-13			X			(x)												
1.4462	X2CrNiMoN22-5-3	S31803						X	X										
1.4500	GX7NiCrMoCuNb25-20						(x)												
1.4505	X4NiCrMoCuNb20-18-2						(x)												
1.4506	X5NiCrMoCuTi20-18						(x)												
1.4510	X3CrTi17	430 Ti														(x)		X	
1.4511	X3CrNb17	430 Cb														(x)		X	
1.4512	X2CrTi12	S40900									(x)							(x)	
1.4529	X1NiCrMoCuN25-20-7	N08925													X				

GTAW Rods, GMAW Wires for Chemical Resistant Steels (continued)

W-No.	material designation	ASTM AISI UNS	AM 400-IG	ASN 5-IG, -IG(Si)	CN 13/4-IG, CN 13/4-MC	CN 20/25M-IG, -IG(Si)	CN 22/9N-IG, -FD, PW-FD	EAS 2-FD, PW-FD	EAS 2-IG, -IG(Si)	EASN 2 Si-IG	EAS 4M-IG, -IG(Si)	EAS 4 M-FD, PW-FD	NIBAS 625-IG NiCr 625-IG	SAS 2-IG, -IG(Si)	SAS 2-FD, PW-FD	SAS 4-IG, -IG(Si)	SAS 4-FD, PW-FD	SKWA-IG
1.4531	GX2NiCrMoCuN20-18					(x)												
1.4536	GX2NiCrMoCuN25-20					X							(x)					
1.4539	X1NiCrMoCu25-20-5	N08904				X							(x)					
1.4541	X6CrNiTi18-10	321						(x)	(x)					X	X			
1.4550	X6CrNiNb18-10	347						(x)	(x)					X	X			
1.4552	GX5CrNiNb19-11	CF8C						(x)	(x)					X	X			
1.4558	X2NiCrAlTi32-20	B407											(x)					
1.4571	X6CrNiMoTi17-12-2	316 Ti									(x)	(x)				X	X	
1.4577	X3CrNiMoTi25-25	S31640				(x)												
1.4580	X6CrNiMoNb17-12-2	316 Cb									(x)	(x)				X	X	
1.4581	GX5CrNiMoNb19-11-2										(x)	(x)				X	X	
1.4583	X10CrNiMoNb18-12	316 Cb									(x)	(x)				X	X	
1.4585	GX7CrNiMoCuNb18-18					(x)												
1.4586	X5NiCrMoCuNb22-18					(x)												
2.4856	NiCr22Mo9Nb	N06625											X					
2.4858	NiCr21Mo	N08825											X					

Sub-arc Wire/Flux Combinations for Chemical Resistant Steels

W-No	material designation	ASTM AISI UNS	ASN 5-UP/BB 203	CN 13/4-UP/BB 203	CN 20/25M-UP/BB 203	CN 22/9N-UP/BB 203	EAS 2-UP/BB 202	EAS 4M-UP/BB 202	SAS 2-UP/BB 202	SAS 4-UP/BB 202
1.3952	X2CrNiMoN18-14-3		(x)							
1.3964	X2CrNiMnMoNNb21-16-5-3	S20910			(x)					
1.4301	X5CrNi18-10	304					X		(x)	
1.4303	X4CrNi18-12	305					X		(x)	
1.4306	X2CrNi19-11	304L					X		(x)	
1.4308	GX5CrNi19-10						X		(x)	
1.4311	X2CrNiN18-10	304LN					X		(x)	
1.4312	GX10CrNi18-8						X		(x)	
1.4313	X3CrNiMo13-4	S41500		X						
1.4401	X5CrNiMo17-12-2	316						X		(x)
1.4404	X2CrNiMo17-12-2	316L						X		(x)
1.4406	X2CrNiMoN17-11-2	316L	(x)					X		(x)
1.4407	GX5CrNiMo13-4	CAGNM		X						
1.4408	GX5CrNiMo19-11-2							X		(x)
1.4409	GX2CrNiMo19-11-2							X		(x)
1.4429	X2CrNiMoN17-13-3	316LN	(x)					X		(x)
1.4435	X2CrNiMo18-14-3	317L	(x)					X		(x)
1.4436	X3CrNiMo17-13-3	S31600	(x)					X		(x)
1.4437	GX6CrNiMo18-12	S31600	(x)					X		(x)
1.4438	X2CrNiMo18-15-4	S31703	X		(x)					
1.4439	X2CrNiMoN17-13-5	S 31726	X		(x)					
1.4446	GX2CrNiMoN17-13-4		X		(x)					
1.4448	GX6CrNiMo17-13		X		(x)					
1.4462	X2CrNiMoN22-5-3	S31803				X				
1.4500	GX7NiCrMoCuNb25-20				X					
1.4505	X4NiCrMoCuNb20-18-2				(x)					
1.4506	X5NiCrMoCuTi20-18				(x)					
1.4510	X3CrTi17	430 Ti							(x)	
1.4511	X3CrNb17	430 Cb							(x)	
1.4512	X2CrTi12	S40900							(x)	
1.4529	X1NiCrMoCuN25-20-7	N08925			(x)					

Sub-arc Wire/Flux Combinations for Chemical Resistant Steels (continued)

W-No.	material designation	ASTM AISI UNS	ASN 5-UP/BB 203	CN 13/4-UP/BB 203	CN 20/25M-UP/BB 203	CN 22/9N-UP/BB 203	EAS 2-UP/BB 202	EAS 4M-UP/BB 202	SAS 2-UP/BB 202	SAS 4-UP/BB 202
1.4531	GX2NiCrMoCuN20-18				(x)					
1.4536	GX2NiCrMoCuN25-20				X					
1.4539	X1NiCrMoCu25-20-5	N08904			X					
1.4541	X6CrNiTi18-10	321					X		(x)	
1.4550	X6CrNiNb18-10	347					X		(x)	
1.4552	GX5CrNiNb19-11	CF 8 C					(x)			X
1.4571	X6CrNiMoTi17-12-2	316 Ti						(x)		X
1.4577	X3CrNiMoTi25-25	S31640			(x)					
1.4580	X6CrNiMoNb17-12-2	316 Cb						(x)		X
1.4581	GX5CrNiMoNb19-11-2							(x)		X
1.4583	X10CrNiMoNb18-12	316 Cb								X
1.4585	GX7CrNiMoCuNb18-18				(x)					
1.4586	X5NiCrMoCuNb22-18				(x)					

3.2.6 Heat Resistant Steels

Stick Electrodes for Heat Resistant Steels

Material Group	W-No	ASTM AISI UNS	Service Temperature up to °C	FOX FA	FOX FF, -A	FOX FFB, -A	FOX SAS 2, -A	FOX A 7, -A	FOX NIBAS 70/20 FOX NiCr 70 NB	FOX NIBAS 70/15 FOX NiCr 70/15	
heat resistant steels	1.4710 [2]		850	(x)	(x)[1]			(x)[1]			
	1.4712		850	(x)	(x)[1]			(x)[1]			
	1.4713		800	(x)	(x)[1]			(x)[1]			
	1.4724	405	850	(x)	(x)[1]			(x)[1]			
	1.4729 [2]		900	(x)	(x)[1]				(x)[1]	(x)[1]	
	1.4740 [2]		950	(x)	(x)[1]				(x)[1]	(x)[1]	
	1.4742	430	1050	(x)	(x)[1]						
	1.4745 [2]		1050	(x)		(x)[1]			(x)[1]	(x)[1]	
	1.4762	446	1200	X		(x)[1]					
	1.4821	327	1100	X		(x)[1]					
	1.4822 [2]		1100	X		(x)[1]					
	1.4825	A 297, Gr. CF20	800		(x)		X[3]	(x)			
	1.4826	A 297, Gr. HF	950		X	(x)					
	1.4828	309	1050		X	(x)[1]					
	1.4832		1000		X	(x)			(x)	(x)	
	1.4837	A 297, Gr. HH	1150			X			(x)	(x)	
	1.4841	314, 310	1150			X					
	1.4845	310	1050			X					
	1.4861		1200						(x)	(x)	
	1.4864	330	1100						(x)	(x)	
	1.4865	330	1120						(x)	(x)	
	1.4876	B163	1150						(x)	(x)	
	1.4878	321	800				X[3]	(x)			
	1.0569		-	X	X						

X = same or similar alloyed filler metal
(x) = dissimilar or higher alloyed filler metal (please check the service requirements)
[1] = austenitic weld deposit with higher ductility; application in sulphur-containing environment or similar-colour requirement demands the usage of similar alloyed welding consumables
[2] = weldability of base material is limited
[3] = in the case of service temperatures above 400°C FOX CN 18/11, FOX E 308 H or FOX NIBAS 70/20 has to be used

GTAW Rods and GMAW Wires for Heat Resistant Steels

Material Group	W-No.	ASTM AISI UNS	Service Tempe- rature up to °C	FA-IG	FF-IG	FFB-IG	SAS 2-IG, -IG (SI)	SAS 2-FD, PW-FD	A7 CN-IG	A 7-IG, -FD, PW-FD	NIBAS 70/20-IG	NIBAS 70/20-FD
heat resistant steels	1.4710 [2]		850	(x)	(x)[1]				(x)[1]	(x)[1]		
	1.4712		850	(x)	(x)[1]				(x)[1]	(x)[1]		
	1.4713		800	(x)	(x)[1]				(x)[1]	(x)[1]		
	1.4724	405	850	(x)	(x)[1]				(x)[1]	(x)[1]		
	1.4729 [2]		900	(x)	(x)[1]						(x)[1]	(x)[1]
	1.4740 [2]		950	(x)	(x)[1]						(x)[1]	(x)[1]
	1.4742	430	1050	(x)	(x)[1]							
	1.4745 [2]		1050	(x)		(x)[1]					(x)[1]	(x)[1]
	1.4762	446	1200	X		(x)[1]						
	1.4821	327	1100	X		(x)[1]						
	1.4822 [2]		1100	X		(x)[1]						
	1.4825	A 297, Gr. CF20	800		(x)		X[3]	X[3]	(x)	(x)		
	1.4826	A 297, Gr. HF	950		X	(x)						
	1.4828	309	1050		X	(x)[1]						
	1.4832		1000		X	(x)					(x)	(x)
	1.4837	A 297, Gr. HH	1150			X					(x)	(x)
	1.4841	314, 310	1150			X						
	1.4845	310	1050			X						
	1.4861		1200								(x)	(x)
	1.4864	330	1100								(x)	(x)
	1.4865	330	1120								(x)	(x)
	1.4876	B163	1150								(x)	(x)
	1.4878	321	800				X[3]	X[3]	(x)	(x)		
	1.0569		-	X	X							

X = same or similar alloyed filler metal
(x) = dissimilar or higher alloyed filler metal (please check the service requirements)
[1] = austenitic weld deposit with higher ductility; application in sulphur-containing environment or similar-colour requirement demands the usage of similar alloyed welding consumables
[2] = weldability of base material is limited
[3] = in the case of service temperatures above 400°C CN 18/11-IG, ER 308 H-IG, E 308 H-FD, E 308 H PW-FD or NIBAS 70/20IG has to be used

Notes

3.3. Process-based Selection of Consumables

Overview

The choice of welding process is a significant point in the construction of an economic weld. This section therefore attempts to characterise briefly the various welding procedures pointing out the most important advantages and disadvantages.

Content

3.3.1 Manual Metal Arc Welding with Covered Electrodes

In manual metal arc welding using coated stick electrodes, the coating assumes the function of a protective gas shield on one hand and of forming a slag on the other, thereby protecting the metal droplets transferred and the weld metal in turn against contact with atmospheric oxygen. Further functions of the coating are de-oxidation of the weld metal, increasing the metal recovery, offsetting burn-off and ensuring good flow behaviour.

In practical use there are three significant types of coating: rutile, basic and cellulose coated stick electrodes as well as mixtures of these.

Rutile-coated stick electrode (R)
This type of coating is the one most commonly used in practice. The reason for this is found in a series of *advantages* such as:
- Easier handling for the welder
- May be welded with direct and alternating current
- Good starting and re-starting properties
- Suitable for all welding positions – depending on the type and thickness of coating
- Good slag removal properties
- Not susceptible to moisture (only applies however to non-alloy and low-alloy types)

The *disadvantages* of rutile-coated stick electrodes are:
- Not suitable for thick-walled components (above 20-25 mm)
- Low notch toughness at temperatures below zero
- Higher hydrogen contents (20 ml/100 g weld metal)
- Not suitable for high-carbon steels (C < 0.2 %)

Basic-coated stick electrode (B)
Basic-coated stick electrodes stand out for their excellent ductility properties above all in the low-temperature range. Other *advantages* are:
- Extremely low hydrogen content (< 5 ml/100 g)
- Suitable for all wall thicknesses
- Also suitable for welding high-carbon steels (C > 0.2 %).

Disadvantages are:
- Slightly more difficult handling for the welder
- In part only weldable with direct current
- Less favourable slag removal properties and rougher weld surface
- Certain amount of susceptibility to moisture absorption

Cellulose-coated stick electrode (C)
This type of coating was specially developed for vertical-down welding of large pipes. An arc with high stability and intensity is generated due to the large proportion of cellulose in the coating. This ensures pore-free welds and reliable root fusion even at high welding speeds and larger electrode diameters.

The mechanical property values are comparable with those of the basic-coated stick electrodes. However, due to the organic constituents in the coating the hydrogen content of the weld metal is considerably higher (50 ml/100 g), therefore attention must be paid to good weldability of the parent metals and the welding technology must be suitably matched (pre-heating).

Mixed types (RC, RB)
In addition to these three important basic types there is a large number of so-called “mixed types” such as RC or RB coatings. The aim of these is to combine as many positive characteristics as possible in one stick electrode.

Coated stick electrodes are universally suitable in practically all materials with good weldability. The cost of equipment is relatively small although the economic profitability of this procedure is deemed poor due to the low deposition rate.

3.3.2 Gas Shielded Tungsten Arc Welding (TIG-Process)

In TIG welding an arc burning under the protection of an inert gas is used as the heat source. Pure tungsten rods or tungsten rods alloyed with cerium or thorium are used as the electrode.

The shielding gas consists of argon, helium or argon and helium mixtures with a minimum purity of 99.95 %. In this case the shielding gas fulfils several functions. It protects the highly heated tungsten electrode against oxidation by atmospheric oxygen, cools it down and enables the formation of a stable arc. At the same time the liquid weld pool and the filler wire burning off are also shielded from the ambient air.

During TIG welding the filler metal is introduced into the arc laterally at zero current. Rods approximately 1 m in length are used as filler metals for manual welding and wires coiled onto rolls are used for mechanised TIG welding.

C-Mn steels as well as low-alloy and high-alloy steels are welded almost exclusively with direct current and the negative pole on the electrode. From the following table it is possible to determine how high the load on the tungsten electrodes can be depending on diameter:

diameter of rod ø [mm]	amperage (direct current polarity negative) [A]	
	pure-tungsten electrode	thorium-coated electrodes
1.0	25 - 70	max. 80
1.6	50 - 110	15 - 150
2.4	80 - 160	50 - 220
3.2	120 - 220	80 - 320
4.0	150 - 300	120 - 400

The scope of application stretches from the welding of thin sheet metal in non-alloy to high-alloy qualities and to high-grade root welding in thicker plates and tubes in the materials referred to previously.

3.3.3 Gas Shielded Metal Arc Welding (MIG/MAG-Process)

The MIG/MAG process is a mechanised gas-shielded weld in which a metal arc burns under shielding gas between the wire electrode carrying the current and the workpiece. The wire, which melts off in its own arc, is fed mechanically by a roller and serves as the electrode.

Argon, helium or mixtures of these gases are used as shielding gases in the MIG process. Shielding gases of argon with the addition of oxygen, helium with the addition of oxygen, carbon dioxide (CO_2) or mixtures of the gases mentioned are used in the MAG process. The shielding gas promotes the creation of a stable arc and protects the molten weld pool from coming into contact with the atmospheric air. The addition of oxygen to the shielding gases reduces the surface tension of the weld pool and leads to the formation of a flatter weld surface with good transitions to the weld edges. The transfer of metal in the arc also becomes finer.

Excessive alloying of the wire electrodes equalises the burn-off of the alloying elements which occurs. It is imperative that the welding area is free from draughts. At high welding speeds and rapid oscillation care must be taken to ensure complete shielding of the molten weld pool by using appropriate quantities of shielding gas and nozzle shapes.

Only direct current converters or rectifiers come into question as power sources with the positive pole mainly on the electrode. Although welding with the negative pole increases the metal deposition efficiency, droplet transfer is higher and the arc less steady. Welding is termed spray-arc and short-arc depending on the intensity of the arc voltage.

Spray-arc Welding

Welds using the spray arc are primarily fabricated with wires between 1.0 and 1.6 mm Æ and also to some extent with 0.8, 2.0 and 2.4 mm Æ. The main area of application is for normal joint welds in workpieces over 4 mm thick and in the field of weld surfacing.

The smaller wire diameters provide cost-effective benefits in spite of the higher wire price since the deposition efficiency increases noticeably at the same current intensity and arc voltage due to the wire electrode's higher specific current load (up to 300 A/mm^2).

Mixed gases generally give rise to a finer droplet transfer and as a result improved stabilisation of the arc plus reduced spatter. It is also possible to reduce spatter by observing the lower limit values for the arc voltage.

The following table contains reference values for current intensities, wire feed and deposit efficiency using different wire diameters for carbon and low-alloy steels. Average values are selected for manual welding whilst the higher values are used for mechanised welding. The current intensity should be set 10 – 15 % lower in the case of austenitic wire electrodes.

diameter of wire [mm]	amperage [A]	voltage [V]	wire feed [m/min]	deposition rate [kg/h]
0.8	140 - 190	22 - 26	4.0 - 15.0	2.1 - 3.7
1.0	170 - 260	23 - 27	3.5 - 12.0	2.4 - 4.0
1.2	220 - 320	25 - 30	2.5 - 10.0	2.8 - 4.6
1.6	260 - 390	26 - 34	2.0 - 6.0	3.2 - 6.2
2.4	340 - 490	30 - 36	2.5 - 3.5	3.2 - 8.0
3.2	400 - 580	34 - 38	1.2 - 2.2	4.5 - 8.5

One extension of the application when welding using spray arc is welding with the addition of currentless cold wire. A second currentless wire Δ 1.6 mm or Δ 2.4 mm is fed into the arc from the side. The deposition rate is increased by up to 80 %; the burn-off losses and penetration are reduced considerably. This is an advantage for surfacing. This procedure has also established itself for filling large weld cross-sections.

Short-arc Welding
Short-arc welding is performed preferably using wires between 0.8 – 1.0 mm Æ and also to some extent with 1.2 and 1.6 mm Æ. This process requires the use of appropriate power sources with adjustable open-circuit voltage and also to some extent with adjustable characteristic curve. Depending on the wire diameter the arc voltage lies between14 and 22 Volt at current intensities of 60 to 220 A.

As a result of the considerably colder weld pool it is possible to fabricate perfect welds on thin metal sheets above 0.8 mm thick. This process is also used for root welding of larger wall thicknesses and for out-of-position welding due to the excellent gap bridging ability and the smooth formation of the back of the weld.

The following table contains reference values for current intensities, voltage, wire feed and deposition efficiency for the short-arc process.

diameter of wire [mm]	amperage [A]	voltage [V]	wire feed [m/min]	deposition rate [kg/h]
0.8	60 - 130	15 - 17	2.9 - 13.0	0.7 - 2.9
1.0	70 - 160	16 - 19	2.4 - 7.8	0.9 - 2.9
1.2	100 - 180	17 - 20	2.1 - 5.4	1.1 - 2.9
1.6	150 - 210	19 - 22	1.7 - 4.5	1.6 - 2.4

Long-arc Welding
Droplet transfers where free transfers are mixed with short-circuit transfers are termed long-arc. The droplets are bigger than in the spray-arc. A long-arc occurs when welding with carbon dioxide or argon mixtures with over 20 % carbon dioxide. Higher spatter losses may occur since the droplet transfers take place partly under short-circuit.

In the upper operating range the long arc's scope of application is comparable with the spray arc. In many cases it can also be used for out-of-position welds in the lower to middle operating range. Above all vertical-down welds could be securely welded using the CO_2 arc. The resistance to pores and the certainty of penetration increases as the proportion of carbon dioxide in the shielding gas rises. The long-arc's area of application is basically restricted to the welding of non-alloy and low-alloy steels.

Pulsed-arc Welding
With the pulsed arc it is possible to achieve a short-circuit-free, low-spatter droplet detachment from the wire electrode. This is achieved even with low arc wattages that otherwise lead to short arcs (sometimes long arcs) and thus to short-circuiting with spatter formation.

The welding current has a pulse-shaped curve during where the following processes take place during welding:

- The arc burns at a low background current intensity and melts the wire electrode and the parent metal.
- An increased pulse current overlays the background current and detaches one or several droplets which transfer to the weld pool without short-circuit.
- The current intensity drops back to background current intensity, the arc burns until the next pulse of current.
- The number of droplets can be controlled selectively using the pulse frequency.

The pulsed arc technique enables the use of thicker and thus more easily fed wire electrodes. Depending on the application, thinner (above 2 mm) or thicker plates, root, filler or cover pass weld, out-of-position welding, it is possible to create the best possible setting parameters for spatter-free droplet transfer by altering the pulse frequency.

Argon-rich gas mixtures with no more than 18 % carbon dioxide are suitable as shielding gases. The particular advantages of the pulsed arc become apparent with aluminium, nickel and corrosion-resistant chrome or chrome-nickel (molybdenum) steels. It is also particularly suitable for welding high-tensile, fine-grain constructional steels or cryogenic steels due to selective heat input.

T.I.M.E. Process

The Transferred Ionised Molten Energy process is understood to be a MAG welding procedure consisting essentially of a 4-constituent shielding gas, a matched set of equipment and a solid input of know-how. The most significant advantages of T.I.M.E. process are:

- Further development of the MAG procedure
- Solid wire electrodes 0.8 to 1.2 mm Æ
- Higher deposition efficiencies due to higher wire feed speeds
- Improved mechanical property values due to lower oxidation
- Favourable penetration
- Good weld appearance
- Very good positional welding capability
- Low tendency to notch formation with good wetting of the weld edges

The shielding gas used for the T.I.M.E. process has a typical composition He 26.5 %, CO_2 8.0 %, O_2 0.5 % and Ar as the remainder. This combination of gases utilises the special properties of the individual gases (thermal conductivity in the arc, creators of a steady column of plasma, reduction of the surface tension, etc.).

This process uses an inverter type of power source which enables very accurate setting of the welding parameters and universal application even for other processes.
The solid wire electrodes BÖHLER EMK 6-T and BÖHLER EMK 8-T in Böhler Welding's range have been matched specifically to the T.I.M.E. process.

Feasibility studies show that this process offers financial advantages above all in fully-automated welds. A detailed time study may also render its application desirable for manual welding.

Shielding gases

The choice of shielding gases is determined by the alloy make-up of the materials to be welded and the demands made in respect of weld quality and absence of spatter.

Carbon dioxide (CO_2) is used primarily for the welding of non-alloy constructional steels and for anti-wear surfacing.

Mixed gases are favoured for use in the welding of non-alloy and low-alloy steels, such as high-temperature steels in boiler and pipeline construction. The high weld quality, good even penetration and extensive absence of spatter satisfy the requirements placed on high-quality welds.

Argon with the addition of 1-5 % oxygen or 2-3 % fractions of CO_2 is employed above all in the welding of high-alloy ferritic and austenitic filler metals. By comparison with mixed gases and carbon dioxide, the alloy losses during arc transfer are lower and the droplet transfer is very fine and virtually spatter-free.

Classification of Shielding Gases according EN 439

short designation[1]		components in vol-%						typical applications	remarks
group	no.	oxidising		inert		de-oxidising	slow-reaction		
		CO_2	O_2	Ar	He	H_2	N_2		
R	1			bal.[2]		>0-15		WIG, plasma welding, plasma cutting, root formation	de-oxidising
	2			bal.[2]		>15-35			
I	1			100	100			MIG; WIG, plasma welding, root formation	inert
	2			bal.	>0-95				
	3								
M1	1	>0-5		bal.[2]		>0-5		MAG	slightly oxidising
	2	>0-5		bal.[2]					
	3		>0-3	bal.[2]					
	4	>0-5	>0-3	bal.[2]					
M2	1	>5-25		bal.[2]					
	2		>3-10	bal.[2]					
	3	>0-5	>3-10	bal.[2]					
	4	>5-25	>0-8	bal.[2]					
M3	1		>10-15	bal.[2]					
	2	>25-50	>8-15	bal.[2]					
	3	>5-50		bal.[2]					
C	1	100							strong oxidising
	2	bal.	>0-30						
F	1						100	plasma cutting, root formation	slow reaction de-oxidising
	2					>0-50	bal.		

[1] if components are added which are not listed in this table the shielding gas has to be classified as special gas using the leading character "S".
[2] Argon can be replaced by Helium up to 95 %.

3.3.4 Gas Shielded Metal Arc Welding with flux-cored Wires

The principle of the process is basically comparable with gas-shielded welding using solid wire electrodes. Although solid wire electrodes always display a similar metal deposition efficiency depending on the welding parameters selected, the welding characteristics and deposition efficiency, positional welding capability plus mechanical property values are greatly influenced by the powder core when using flux-cored wires.

As is the case for the coating of stick electrodes, the core controls de-oxidation, slag formation and stabilisation of the arc. In addition the quantity of flux and the cross-sectional area of the flux-cored tube are largely responsible for the level of deposition efficiency as well as current-carrying capacity and in turn productivity.

With regard to this BÖHLER flux-cored electrodes exhibit particularly beneficial efficiency parameters for the user.

Advantages of MAG welding with flux-cored wire compared with MAG solid wire:

- Higher deposit efficiency due to higher current density.
- Greater fabrication safety. The risk of lack-of-fusion defects is appreciably lower due to the flux-cored wire's broader arc and the improved penetration profile.
- Easier handling, easier parameter setting, large tolerance range of possible welding parameters in the low-spatter spray arc.
- Better accessibility with reduced weld preparation angle due to longer wire stickout of 15 to 25 mm.
- Smooth welds, good wetting of weld edges plus lowest possible spatter formation lead to a very low post-weld machining time.
- With high-alloy, slag-promoting flux-cored wires there are also considerable pickling savings since the weld surfaces are only slightly oxidised. In addition it is also possible to make use of the advantages gained due to the ability to use higher welding speeds by inputting less heat input resulting in less distortion.

Fields of Application for Non and Low Alloy BÖHLER Flux Cored Wires

Böhler product	type of filling	recommended fields of application
Ti 52-FD Ti 52 W-FD (mild steel)	rutile slag system	out-of-position welding up to an apmerage of 240 A (Ø 1.2 mm) for welding position vertical up mild steels
HL 51-FD (mild steel) HL 53-FD (0,9 % Ni)	metal powder without slag metal powder without slag	flat and horizontal position (PA, PB), fillet welds mechanised welding mild steels
Kb 52-FD (0.8 % Ni)	basic slag system	for all welding positions, for heavier walled or all welding positions, for heavier walled best mechanical property values-mild steels
DMO Kb-FD (0.5 % Mo)	basisches basic slag system	for all welding positions, for heavier walled components best mechanical property values high temperature steels, e.g. grade P265GH
DMO Ti-FD (0.5 % Mo)	rutile slag system	for all welding positions high temperature steels, e.g. grade P265GH

Additional products for production welds in high-temperature cast steel or for high-tensile welds are available on request.

Fields of Application for High Alloy BÖHLER Flux Cored Wires

for flat / horizontal welding positions	for out-of-position welding	recommended fields of application
BÖHLER E 308 H-FD	BÖHLER E 308 H PW-FD	CrNi-steels, 1.4948, 1.4878, AISI 304, 304H, 321, 321H, 347H
BÖHLER EAS 2-FD	BÖHLER EAS 2 PW-FD	CrNi-steels, e.g. 1.4301, 1.4306, 1.4308, 1.4541, 1.4550
BÖHLER SAS 2-FD	BÖHLER SAS 2 PW-FD	CrNi(Nb)-steels, e.g. 1.4541, 1.4546, 1.4550, 1.4552
BÖHLER EAS 4 M-FD	BÖHLER EAS 4 PW-FD	CrNiMo-steels, e.g. 1.4401, 1.4435, 1.4571
BÖHLER SAS 4-FD	BÖHLER SAS 4 PW-FD	CrNiMo(Nb)-steels, e.g. 1.4571, 1.4580, 1.4581, 1.4583
BÖHLER CN 22/9 N-FD	BÖHLER CN 22/9 PW-FD	Duplex-steels, e.g. 1.4462, 1.4362
BÖHLER A7-FD	BÖHLER A 7 PW-FD	for fabrication, repair and maintenance
BÖHLER CN 23/12-FD	BÖHLER CN 23/12 PW-FD	dissimilar welds, claddings without Mo
BÖHLER CN 23/12 Mo-FD	BÖHLER CN 23/12 Mo PW-FD	dissimilar welds, claddings with Mo
BÖHLER E 317L-FD	BÖHLER E 317 L PW-FD	CrNiMo-steels with 3-4 % Mo, e.g. 1.4438, 317L

Practical Tips for Welding Flux-cored Wires
The constant-voltage power source should be adequately dimensioned. Water-cooled torches and wire feed units with 4 smooth drive rollers are advisable for effective utilisation of the deposit efficiency advantages.

Welding is performed with direct current positive pole. The basic flux-cored wires and BÖHLER HL 53-FD are the only ones designed for negative pole.
Torch manipulation for slag-promoting wires is trailing. Metal powder wires may be keyhole welded like solid wires.

Care must also be taken in comparison to solid wires when setting higher wire feed speeds. The wire stickout for spray arc is 15 - 25 mm.

Suitable shielding gases are argon + 15-25 % CO_2 (15-18 l/min). Böhler Ti 52-FD may also be welded well using 100 % CO_2.

3.3.5 Recommendations for Submerged Arc Welding using Solid Wires

Submerged-arc welding requires a metallic filler metal (wire) and a non-metallic consumable, the welding flux.

The welding flux has a very large effect on the welding result. It has a significant effect on weld appearance and slag detachability as a result of the melting characteristics and various physical properties such as viscosity, surface tension, density, thermal expansion and electrical conductivity.

There is also a significant effect on the chemical composition of the weld metal and in turn on its mechanical property values resulting from the metallurgical reaction of the welding flux.
Depending on the type of manufacture it is possible to differentiate between:

Fused flux, code letter F *(fused),* e.g. BÖHLER BF 16.
Manufactured by melting in the arc kiln; homogeneous, not susceptible to moisture, abrasion-proof, but very limited metallurgical reaction, high apparent density and poorer slag detachability.

Agglomerated flux, code letter A *(agglomerated),* e.g. BÖHLER BB 24.
Manufactured by agglomeration and subsequent drying in the rotary kiln; very good metallurgical reaction, low apparent density, good slag detachabi lity, possibility of addition by alloying but susceptible to moisture and abrasion.

The welding fluxes are divided into acid, neutral and basic according to the degree of basicity. The degree of basicity is calculated from

$$B = \frac{\text{Basic constituents } (CaO,\ CaF_2,\ MgO,\ MnO)}{\text{Acid constituents } (SiO_2,\ TiO_2,\ ZrO_2)}$$

If B is less than 1 one speaks of an acid welding flux (acid constituents predominate), with a value between 1 and 1.2 it is a neutral welding flux, above this a basic welding flux, and above 2 a highly-basic welding flux.

According to the predominant main constituents they may be termed:

as manganese silicate types (MS), predominantly MnO and SiO_2.
as calcium silicate types (CS), predominantly CaO, MgO and SiO_2.
as aluminate-rutile types (AR), predominantly Al_2O_3 and TiO_2.
as aluminate-basic (AB), predominantly Al_2O_3, CaO and MgO
and as fluoride-basic (FB) with the main constituents CaO, MgO, MnO and CaF_2.

Each type of flux has different specific properties that must be taken into consideration when selecting them for practical use.

3.4. Material based Selection of Consumables

Overview

The most important problem in selecting filler metals is correctly assessing the metallurgical behaviour of the metals to be welded. The whole welding technology, pre-heating and any post-weld heat treatments correspond with this.

This section attempts to discuss the most important welding-engineering aspects of different types of material groups in brief individual chapters. As far as possible a broad outline of the required welding technology is provided.

The last chapter of this section deals with the much more complex problems surrounding mixed-metal joints. Since a detailed treatment of this topic would take up a whole book, this chapter only contains brief references as to how various combinations of typical groups of materials should be dealt with.

Content

3.4.1 Weldability of Steels

On one hand the weldability of steels depends essentially on their tendency to hardening and the formation of brittle microstructures in the transition zones of welds as well as on their ability to absorb stresses on the other. Where steels with limited weldability are concerned, particularly those susceptible to stresses and/or a tendency to hardening, it is still possible in many cases to fabricate perfect welds by using an appropriate welding procedure (control of temperature, heat treatment).

Weldability of Mild Steels
With regard to the content of phosphorus and sulphur, weldability of non-alloy steels will usually be classified according to carbon content. Areas of the parent metal in the weld transition zones will be austenitised as a result of the heat generated during welding. Localised increases in hardness may occur inside these heat-affected zones as a consequence of rapid cooling. Therefore as a rule it is possible to weld non-alloy steels with carbon contents up to approx. 0.22 % without problems; with higher carbon contents it is necessary to preheat the parent metal or care must be taken to ensure correct control of heat in the welded sections so as to reduce the cooling rate during austenite transformation. However, it is not only carbon that determines the weldability of non-alloy steels. Problems during welding may also arise due to higher contents of hydrogen, nitrogen and oxygen and the presence of segregations. The wall thickness also plays an important role.

Weldability of Alloy Steels

Low-alloy Steels
Low-alloy steels often require proper control of heat prior to, during and after welding in order to achieve welds with the properties required. The chemical composition with regard to the type and quantity of alloying constituents and the microstructure has a significant effect. It is possible to improve the strength and ductility of high-tensile low-alloy steels by quenching and tempering. The total alloy content does not usually exceed 5 %. As a rule the carbon content lies between 0.2 and 0.6 %. Important alloying elements are chrome, nickel and molybdenum, as well as manganese, silicon and vanadium.

Their inclination towards the formation of martensite leads to greater stresses inside the component on cooling of the weld. The critical cooling rate is low and therefore it is possible for a hard microstructure to occur even on cooling in ambient air thus unfavourably changing the ductility of the weld. There is a high risk of hardness cracks in transition zones. Areas of pronounced softening may appear in the case of steels with limited resistance to tempering.

High-alloy Steels
High-alloy steels contain over 5 % of alloying elements. Stainless steels containing chrome and those containing both chrome and nickel as characteristic alloying elements represent a significant section of these steels.

Chromium steels are mainly divided into two grades with a ferritic or martensitic microstructure which exhibits limited weldability. The reason for this is the tendency towards grain growth in ferritic chrome steels and a tendency towards hardness increase in the heat-affected zones of chrome-based martensitic steels.

By contrast the austenitic chromium-nickel (molybdenum) steels are classified as having good weldability. However, the corrosion resistance, hot crack resistance and ductility of these steels may deteriorate if fabricated unprofessionally. Consequently it is necessary to observe certain basic rules when welding stainless steels.

3.4.2 Mild Steels

These steels which conform to EN 10025 (DIN 17100) are determined by components which will be utilised essentially at ambient temperatures.

According to the regulations of EN 10027, Part 1 (Classification of Steels) the code letter

1. S - Steels for general steel construction, or
2. E - Machine-construction Steels

is set in front of the abbreviated designation followed by a number which refers to the minimum yield strength in N/mm2 given the lowest thickness manufactured. The yield strength ranges lie between 185 and 355 N/mm^2 (~27 and 51 ksi) for steels classified "S" and between 295 and 360 N/mm2 (~43 and 52 ksi) for steels classified "E".

The ability to specify a specific maximum value of carbon equivalent (CET) on purchase orders may be considered an advantage from the weldability point of view. However, this applies only to steel grades "S 235" to "S 355". All other steels of this standard exhibit limited qualifications for welding. Steel grades such as these must be classified primarily as possessing "limited weldability", the fabrication process for which is left up to the manufacturer where the chemical composition is not defined at all.

Welding of Mild Steels
The weldability of steels diminishes as the carbon content rises due to the increase in hardness. Therefore steels with no guarantee of weldability must be treated specifically in order to avoid unacceptably high hardness. The ability to predict the tendency towards hardening, e.g. by calculation of the carbon equivalent, etc., is well known. As a rule of thumb it may be said that hardness increase in the transition zone should not exceed 350 Vickers units for non-alloy constructional steels and 400 Vickers units for alloy constructional steels.

Welding Technology for Mild Steels

- Filler metals must be selected with respect to the minimum requirements for the mechanical properties of the parent metals.
- Steels with “guaranteed weldability“ and wall thicknesses exceeding 30 mm (13/16“) or 20 mm (3/4“) must be preheated to 100 - 150 °C (210 - 300 °F) and basic-type filler metals must be used.
- Steels with “limited weldability“ must be preheated in accordance with the carbon equivalent; only rebaked basic filler metals are to be used.
- For rimmed steels avoid melting of segregation zones as far as possible and use basic filler metals as well.

Filler metals
The following section lists examples of suitable filler metals.

base material (example)	BÖHLER-product
S235J2G3 to S355J2G3	FOX OHV, FOX ETI, FOX EV 50, EMK6, EMS2/BF16, HL 51-FD

Dependency of Welding Procedure on Material Thickness
In addition, reference must be made to the fact that as the thickness of the component increases three-dimensional stresses caused by localised heating and cooling may reach the yield strength or may even exceed it when superimposed with operating loads. These stresses then lead to cold deformation, ageing and embrittlement. Therefore even steels with guaranteed weldability require preheating above certain wall thicknesses.

Typical wall thicknesses for good weldability are:

tensile strength [N/mm²]	thickness limit [mm]
up to 360	30
> 360 - 540	20

Larger wall thicknesses call for preheating to 100 - 150 °C (210 - 300 °F) in all cases.

Weldability of Rimmed Steels
According to EN 10025 and DIN 17100 respectively rimmed steels may also be welded. These steels show a pure and ductile shell zone ("bacon rind") which causes no problems during welding but contains a core rich in segregation with poor weldability. The core often exhibits significantly higher contents of carbon, phosphorus, sulphur, oxygen and manganese than the shell zone due to liquefaction phenomena on solidification (segregation in the ingot). One is confronted with a number of negative influences in respect of the segregated zone, such as increased tendency towards hardening, risk of brittle fracture, tendency to hot cracking and embrittlement by ageing.

Given these facts the segregated zone exhibits lower ductility and poor weldability compared with the pure shell zone. The primary rule for welding rimmed steels is therefore not to fuse segregated zones if possible, which is a point that should be taken into account at the design stage. Rimmed steels with segregation will be welded in practice using basic-coated electrodes or using a combination of rutile and basic-coated electrodes (basic coated electrodes for the segregated zone, rutile type electrodes for root and cap layer).

Free-cutting Steels
Free-cutting steels are characterised by good machinability and good chip brittleness that are essentially achieved by means of higher sulphur contents coupled in part with lead and other elements. They allow high edge lives of the cutting tools at high cutting speeds during cutting on automatic high-speed machines and as a result produce finished parts with a very clean smooth surface.

The microstructure of free-cutting steels differs from that of other steels only due to the sulphidic inclusions introduced on purpose.

Welding of Free-cutting Steels
Similar considerations to those for the welding of unkilled steels apply to the welding of low-carbon free-cutting steels and consequently welding is possible to a limited extent. On the other hand the welding of higher-carbon steels must be considered difficult. In this case the tendency towards hot cracking is extremely high due to the higher contents of carbon and sulphur. Particular attention must be paid to poor penetration and stress-free welding.

The suitability of free-cutting steels for welding is very limited indeed. Free-cutting steels containing lead should not be welded due to the health hazards caused by leaded welding fume.

3.4.3 Coated Plates

Coating with Anti-corrosive Paints
Structures made of non-alloy steels may undergo substantial reductions in cross-section as a result of rusting. Material loss such as this may be counteracted by painting with effective anti-corrosion paint, which to some extent is carried out immediately after descaling (prefabrication priming) on hot-rolled products for economic reasons. Iron oxide-rich paints are most commonly used. This brings to light the problems associated with the weldability of plates coated with such paints.

Iron oxide-rich paints are readily weldable with regard to the TLV (threshold limit values in the workshop environment) and are not susceptible to porosity whereas zinc dust-rich paints may cause problems with the TLV as well as porosity. Butt welds are less prone to porosity than fillet welds. Whilst rutile coated electrodes such as BÖHLER FOX OHV will generally deposit welds free of porosity, it is not always possible to guarantee this when using basic coated types. Wires with increased silicon content and fluxes with high MnO contents should be used for submerged-arc welding. Inert-gas welding using CO^2 as the shielding gas often leads to problems; this can be improved by adding a few percent of oxygen to the shielding gas.

Galvanised Plates
Hot galvanizing offers very effective protection of the steel surface against corrosive media.

When welding galvanized plates and sheet metal there is intense generation of fume depending on the type of electrode used due to the evaporation of zinc. Medium-thick rutile-coated electrodes, such as the FOX MSU type, may be used. These will not affect the mechanical properties. For double fillet welds with wall thicknesses above 10 mm (3/8”) on all-round galvanized sheet metal it is necessary to maintain a gap of at least 1 mm (3/64”) between the flange and web to avoid zinc-induced cracking.

3.4.4 Reinforcing Steels

Concrete, the traditional material used for building, possesses high compressive strength but only low tensile strength. This means that a fracture in the structure is highly likely after applying only a relatively low load if a structure made purely of concrete is loaded for bend.

Steel rods are inserted in the concrete to increase the tensile strength of this construction material producing a composite structure which utilises both the excellent compressive strength of the concrete and the high tensile strength of the steel.

The various types of reinforcing steels differ from each other either due to their external form (varying surface shape) or processed form (e.g. as welded wire meshes) or both. The reinforcing steels, also known as armouring, are subdivided into the following types:

Rods of

1. hot-rolled round steel
2. hot-rolled ribbed steel
3. hot-rolled and then cold-twisted ribbed steel
4. cold-formed ribbed steel

as well as welded reinforcing meshes of

5. flat wires
6. shaped wires
7. ribbed wires.

Welding of Reinforcing Steels
All steels of the DIN 488 or EN 10080 referred to are suitable for resistance flash-butt welding and oxyacetylene pressure welding. Suitability for electric arc welding using coated stick electrodes or the gas-shielded arc process is considered to have been demonstrated if the base metal ultimate strength is achieved in the tensile test and it is possible to bend butt welds around a required mandrel.

Welds may be classified according to their intended use or the welding process employed. The principal distinction is between load-bearing and non-load-bearing welds.

Welding Technology

- The steel surface in the area of the weld must be cleaned of dirt, grease, rust, etc. and there must be adequate access to the welding area.
- The weld area must exhibit a temperature of at least +5 °C and must be protected against cooling down too quickly after welding to reduce the risk of hardness increase in the transition zone.

Filler Metals
The following overview shows suitable Böhler filler metals:

Reinforcing Steel grade		BÖHLER-product
DIN	EN	
BSt 420 S	B420N	FOX SPE, FOX OHV, FOX MSU, EMK 6
BSt 500 S	B500H	FOX SPE, FOX OHV, FOX MSU, EMK 6
BSt 500 N	B500N	FOX EV 50, EMK 6

Pre-stressed Reinforcing Steels
A high offset yield stress and apparent yield point plus high tensile strength are required of pre-stressed reinforcing steels to ensure there is little or no decrease in the pre-stressing of the concrete. Non-alloy C-Mn steel with 0.6 to 0.9 % C or steel similar to spring steel is used as a suitable material.

Welding of pre-stressed reinforcing steels is not permitted.

3.4.5 Case-hardening and Nitriding Steels

Case hardening is understood to be hardening following prior carburisation of the skin of a workpiece. Carburising and also nitrogenising in solid, liquid or gaseous media is performed at temperatures between 850 - 930 °C following forming and machining after which hardening takes place. The carburised layer assumes a content of 0.7 to 1 % C and a surface hardness of 59 to 67 HRC. Case hardening is used where the aim is to achieve a hard surface resistant to wear and fatigue (higher fatigue strength), but where the transition and the low-lying core should have good ductility and high notch impact strength with improved strength.

Nitration is understood to be the treatment of steel surfaces in media giving off nitrogen at temperatures below the Ac1 point to achieve a surface enriched with nitrogen. Nitriding steels are steels that are particularly suitable for nitration due to the nitride formers contained within them. Chromium-containing steels that are alloyed with aluminium for increased special nitride formation are primarily considered as materials. To some extent they also exhibit molybdenum and nickel. The nitrided surface layers (approx 0.05 to 0.5 mm) are very hard even without quenching (approx. 750 to 900 HV) and wear-resistant, i.e. they provide resistance to sliding abrasion that is better than in case-hardened parts.

Welding of Case-hardened and Nitriding Steels
For welds in the surface area of case-hardened or nitrided parts it is first necessary to remove a sufficiently large area of the carburised or nitrided layer by grinding. However, it seems advisable to weld prior to case hardening or nitration.

Filler metals similar in alloy composition to the parent metal must be used if the welds are also intended to be nitridable. Otherwise filler metals corresponding to the mechanical properties of the parent metal not subjected to surface treatment should be used. Basic electrodes are to be preferred.

The preheat temperature must be matched to the steel's hardenability.

3.4.6 Welding of Pipelines

Crude oil and natural gas are currently the most important energy carriers. Vast transport pipelines already exist or in the planning stages throughout the world. The development of new higher-strength pipe steels is thus making greater and greater demands on welding technology. Thanks to our specially developed electrodes that are optimally matched to the individual steels, we are able to completely satisfy these increased requirements as well as the strict safety conditions.

The circumferential pipe seams are mainly performed as vertical-down welds using cellulose-coated stick electrodes whereby construction progress is essentially determined by the speed with which these welds can be manufactured. This method renders it possible to weld with a larger electrode diameter, higher current intensities and higher welding speeds. This results in considerable economic advantages compared with otherwise conventional vertical-up welding using rutile or basic-coated stick electrodes.

Welding with basic-coated stick electrodes is dealt with following the section "Welding with cellulose-coated stick electrodes" for both the vertical-up and vertical-down position. Böhler Welding also has a complete range of qualities expressly designed for low-temperature loading.
Please make separate enquiries regarding wires for gas-shielded and submerged-arc welding.

Welding with Cellulosic-coated Stick Electrodes

BÖHLER product name	AWS classification A 5.1-91 A 5.5-96	recommended for pipeline steels acc. API Spec. 5L
FOX CEL	E6010	A, B, X 42, X 46, X 52, X 56, X60, X 65, X 70, X 80
FOX CEL 75	E7010-P1	X 52, X 56, X 60
FOX CEL Mo	E7010-A1	X 52, X 56, X 60
FOX CEL 85	E8010-P1	X 56, X 60, X 65, X 70
FOX CEL 90	E9010-G	X 65, X 70, X 80

Particular mention must be made regarding the special suitability of the BÖHLER FOX CEL electrodes for root welding even in higher-strength steels. The welding technology developed by Böhler Welding by using the BÖHLER FOX CEL for the root and if need be also for the hot pass in the form of so-called “combination welding“ provides the greatest security against cracks.

Careful weld preparation is very important for achieving perfect welds. It is not usually possible to comply with tolerances with torch-cut edges. In practice the pipe ends are generally prepared by metal cutting. To prevent pores and fusion defects the weld edges must be free from foreign matter such as oil, lubricant, scale and dirt. In the same way grooves and notches also disrupt handling of the electrode. The BÖHLER FOX CEL 2.5 mm Δ electrode is recommended for pipes with smaller diameters (up to 300 mm) and 3.2 mm Δ for the root pass.

Preheating and Interpass Temperature
Preheating the parent metal encourages and accelerates the diffusion of hydrogen and therefore inhibits underbead cracking. Furthermore, it is possible to reduce the hardness increase in the heat-affected zone depending on the temperature level and the chemical composition of the steel.

150 °C has been found to be adequate for preheating. Regardless of the carbon content preheating should always be performed for wall thicknesses over 20 mm and in the case of high-carbon steels susceptible to hardness increase it is advisable to increase the temperature to approx. 200 °C. It is also necessary to take the external temperature into account!

For thin pipe materials unsusceptible to hardening increase it is beneficial to heat the pipe ends slightly to at least 50 °C to remove condensation water. According to the various specifications different carbon contents are permissible. If the carbon content is above 0.20 % we recommend consulting the electrode and steel manufacturer about the choice of preheat temperature.

The interpass temperature affects the metallurgical processes which take place during solidification and cooling and thus has an effect on the mechanical properties of the weld metal. It also affects the diffusion speed of hydrogen. It is therefore recommended that the interpass temperature should be maintained at no less than 80 °C during welding. An interpass temperature of at least 140 °C is recommended if cellulose-coated stick electrodes with tensile strengths above 620 N/mm^2 (e.g. BÖHLER FOX CEL 90) are used.

Welding with Basic-coated Stick Electrodes

In some countries the use of basic-coated stick electrodes for pipeline construction is preferred over the use of cellulose-coated stick electrodes for various reasons. Generally speaking the use of basic electrodes is recommended for welding very thick steels over 25 mm susceptible to hardness increase. The reason for this is the very low hydrogen content of these types of electrodes.

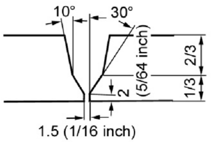
The high dissipation of welding heat in higher wall thicknesses and the simultaneous presence of higher hydrogen contents increases the risk of hydrogen-induced underbead cracks when using cellulose-coated stick electrodes. To prevent this it is only worthwhile using basic-coated stick electrodes if the root pass is also welded using the same type of electrode.

In vertical-up welding using basic-coated stick electrodes the time required above all for root welding is relatively high. Naturally this is also linked to a certain loss of economic viability. As a result basic-coated vertical-down electrodes have been developed which may be used for both root welding and also filler and cover pass welding.

Vertical-up Welding

Depending on the pipe material's chemical composition and its tendency towards hardness increase, preheating to 150 200 °C should be carried out for thick plates even when using basic-coated stick electrodes.

The preference in this case is to use basic-coated electrodes of the FOX EV 50 (E7018-1), FOX EV 55 (E7018-1), FOX EV 60 (E8018-G) and above all the FOX EV PIPE (E7016) type specially optimised for pipe welding. Care must be taken to protect the electrodes against moisture. Electrodes from boxes that are already open must be re-dried before use for 2 hours at 300 – 350 °C according to the specifications.



The root pass is usually applied using electrodes with a 2.5 mm Δ in order to achieve perfect root fusion. Welding is performed in the vertical-up position with a root gap of approx. 2.5 - 3 mm. At times a special weld shape is used to save weld metal (see sketch).

Welding of the filler and cover passes is usually performed using electrodes with 3.2 und 4 mm Δ whereby the welding area must be protected against wind, rain, etc. to prevent pores.

Vertical-down Welding

BÖHLER product name	AWS-classification A 5.5-96	recommended for pipeline steels acc. API Spec. 5L
FOX BVD RP	E8018-G	A, B, X 42 - X 100
FOX BVD 85	E8018-G	A, B, X 42 - X 65
FOX BVD 90	E9018-G	X 70, X 80
FOX BVD 100	E10018-G	X 80
FOX BVD 110	E11018-G	X 100
FOX BVD 120	E12018-G	X 110

Executing the Welding of Pipelines

Weld preparation: Weld preparation is carried out by metal cutting. The permissible dimensional tolerances of the pipes are listed in the standards API Spec. 5 LX and DIN 17122.

Preheating: The risk of underbead cracks due to hydrogen when welding with basic-coated stick electrodes is lower than when welding with cellulose-coated stick electrodes due to their relatively low hydrogen content. Nevertheless preheating to 150 °C is recommended above all when welding thick-walled pipe materials that are susceptible to hardness increase. The following diagram illustrates when preheating is recommended.

Alignment of pipes: Alignment of the pipes is performed with hydraulically operated internal align ment clamps as when welding with cellulose-coated stick electrodes. Due to the relati vely strong root bead formation and the low hydrogen content on the part of the basic-coated root electrode it is possible to release the internal alignment clamp when the root weld is complete as long as the edge misalignment is not too great.

Welding at Low External Temperatures or in Wet Weather

Under unfavourable weather conditions especially at air temperatures below 0 °C, welding work may only be carried out on pipelines if the welding and working conditions render perfect weld execution possible. This means that although welding at low external temperatures is not prohibited, it is necessary to observe certain safety precautions.

The following rules have been tried and tested in practical use:

1. Remove ice, frost and rain by warming up (preheat to hand-hot).
2. Speedy welding without longish pause; if necessary employ several welders for one weld seam.
3. Use electrodes as thick as possible.
4. The welder himself must be adequately protected against the cold (provide tents, windbreak or infrared radiator).

There are no generally applicable rules or restrictive specifications regarding the execution of welding work whilst raining or on wet workpieces. Nevertheless it is obvious that the welding area and its surroundings must be shielded from rain and other weather effects. The welding area must be free from water in all cases.

Rebaked basic stick electrodes have very little hydrogen in the weld metal from the start and therefore provide a higher level of safety against hydrogen-induced cracks under unfavourable conditions. However, even the basic weld metal may exhibit substantial hydrogen contents during welding in a steam-saturated atmosphere.

3.4.7 High-strength Fine-grain Constructional Steels

The micro-alloy steels may be divided into three main groups depending on their manufacture:

1. normalised fine-grain constructional steels
2. quenched and tempered fine-grain constructional steels
3. thermomechanically treated fine-grain constructional steels

A fine-grain ferritic-pearlitic structure is achieved with the conventionally rolled, normalised fine-grain constructional steels essentially by the elimination of finely dispersed carbonitrides and carbides from the austenitic area during air cooling. Fine-grain constructional steels with yield points up to 500 N/mm^2 are manufactured by this method.

The finest grain is achieved by water quenching in the quenched and tempered fine-grain constructional steels whereby micro-alloying elements such as B, V, Nb and Ti as well as to some extent the alloying elements Cr and Ni are of significant importance. With water quenching it is possible to achieve yield points between 450 and 960 N/mm^2. The special properties of the two steel groups initially mentioned are achieved by a heat treatment carried out after rolling.

In the thermodynamically treated steels a targeted heat treatment is included in the rolling process as a result of which it is possible to manufacture high-tensile steels with very low carbon contents. It was possible to significantly increase the mechanical properties of constructional steels and their weldability with the help of the micro-alloying elements and appropriate production methods.

Welding of Fine-grain Constructional Steels
Generally speaking special precautions are required for processing steels with increasing minimum yield strength values where the design of weldments and load analysis are essential. However, the instructions for processing these steels cannot deal with and control every possible problem. Thus in special cases it is useful to consult the steel manufacturer or to carry out in-house tests which may be necessary when first using fine-grained constructional steels.

The risk of hot cracking in these steels is low. On the other hand attention must be drawn to the possibility of lamellar tearing and cold cracking which require appropriate design and/or welding technology measures such as reducing stresses, avoiding excessive hardness increase and internal stresses and aiming for low hydrogen contents in the weld metal.

The preheat temperature for joint welding and tack welding lies between 50 and 250 °C (120 and 480 °F). It depends upon material thickness, chemical compositions of parent material and weld metal, energy input during welding, as well as on predicted residual stresses. As the thickness increases it is necessary to aim for the upper temperature limit. The following table presents figures for thickness limits taking preheat as a function of the minimum yield strength of the parent material.

minimum for yield strength [N/mm^2]	thickness limit [mm]
≤ 355	30
>355 to 420	20
>420 to 590	12
> 590	8

The development of temperature and time during welding is of crucial importance to mechanical properties of high-strength welded joints. This development is significantly influenced by plate thickness, geometry of edge preparation, energy input, preheat temperature and sequence of passes.

The cooling time $t_{8/5}$ is generally used to define the development of temperature and time during welding. This is the period of time during which a weld passes through the temperature range from 800 to 500 °C (1470 to 930 °F) when cooling. The maximum hardness in the heat affected zone drops as the cooling time $t_{8/5}$ increases.

If a specific maximum hardness may not be exceeded in a particular steel then it is necessary to set the welding parameters in such a manner that the cooling time $t_{8/5}$ does not fall below a defined value. On the other hand increasing values for the cooling time $t_{8/5}$ cause a reduction in the impact strength and an increase in the transition temperature of impact strength within the heat affected zone.

If it is necessary to meet a specific minimum impact strength for a particular steel, then the welding parameters must be set in such a way that the cooling time $t_{8/5}$ is kept below a defined value. The cooling time $t_{8/5}$ to be applied in a particular case depends on the collective requirements for mechanical properties including characteristic strength values of the actual weld joint in the post-weld heat-treated condition.

Selection of a suitable filler metal is of prime importance before welding a specific fine-grained constructional steel. In this case allowance must be made for the fact that the weld metal must meet the mechanical and technological properties of the base metal despite dilution.

Welding Procedure

- When selecting filler metals the weld metal must satisfy the mechanical properties of the base metal despite dilution by the latter. Use only re-dried basic-coated electrodes.
- Preheat and interpass temperature should be between 80 and 250 °C (180 and 480 °F) depending on wall thickness, chemical compositions of base metal and weld metal, energy input and existing state of residual stresses.
- Thickness limits must be considered when determining preheating as a function of the base metal's yield strength. Aim for the upper limit of the temperature range as wall thickness increases.
- The temperature/time curve ($t_{8/5}$) is very significant for the mechanical properties of heat-affected zones. Comply with the recommendations of steel manufacturers regarding energy input at all times.

Filler metals
The following table shows suitable BÖHLER consumables.

base material (example)	BÖHLER-product
S355NL	FOX EV 50, EMK 6, EMS 2//BB 25 resp. BB 24
S500QL	FOX EV 65, NiMo 1-IG, 3 NiMo 1-UP//BB 24
S690QL	FOX EV 85, X70-IG, 3 NiCrMo 2.5-UP//BB 24

3.4.8. Cryogenic Steels

The large-scale use of oxygen in the steel industry, nitrogen in the chemical industry and natural petroleum gases in industrial supply and also in the chemical industry has increased significantly in recent years. With the increase in the use of these gases transporting and storing them economically has become more and more important. The gases pass over into the liquid state when cooled to very low temperatures and at the same time their volume decreases considerably. This behaviour is utilised for storage and transport.

However, it is only possible to utilise this behaviour if suitable base metals and filler metals, which posses adequate mechanical properties and toughness at the low temperatures of the liquid gases, are available for construction of the transport and storage tanks required.

Non-alloy, low-alloy or high-alloy steels that are still tough at low temperatures (below approx -50 °C) are known as cryogenic steels. Non-alloy and low-alloy steels may be used in all cases for temperatures up to -50 °C as long as they are killed.

The steel groups may be differentiated as follows:

1. Non-alloy and low-alloy cryogenic and fine-grain constructional steels for operating tempera tures up to approx. -50 °C in the normalised condition and down to approx. -60 °C in the quenched and tempered condition.
2. Nickel-alloy tempering steels with 1.5 to 9 % nickel for operating temperatures from -80 °C to approx. 200 °C.
3. Austenitic chrome nickel steels for operating temperatures down to approx. -269 °C.

Welding of Cryogenic Steels
The characteristic properties of filler metals for welding cryogenic materials is their deformability at low temperatures which is tested as a rule using the notched bar impact test. Conclusions regarding the propensity to brittle fracture and employability down to a specific temperature are drawn from the impact energy value. The notch shape of the notched bar test specimens is a noteworthy influential variable on the test results. U-notch specimens according to DVM result in higher impact energy and lower service temperatures than the V-notch specimens according to ISO, more commonly known as Charpy-V-notch specimens.

The value 27 is frequently taken as the minimum value of impact energy with the Charpy-V-notch specimen at the lowest service temperature in each case.

Care must be taken to control the heat input when welding cryogenic and fine-grain constructional steels to keep the heat affected zone as narrow as possible and still prevent hardness peaks. Basic-coated non-alloy and low-alloy stick electrodes according to EN 499 and EN 757 are suitable. The hydrogen content in the welded joint should be as low as possible to prevent cold cracks, i.e. rebaking of the electrodes immediately prior to welding is recommended. This statement also applies to the flux powder in submerged-arc welding. The problem of excessively high hydrogen contents does not normally exist for gas-shielded arc welding. Particular attention should be paid to the low-temperature toughness and strength required when selecting wire and flux combinations or wire and shielding gas combinations.

Filler metals of the same or similar composition as the parent metal with 2.0 to 3.5 % Ni are used when welding nickel-alloy tempering steels. Filler metals of the same composition as the parent metal are to be preferred if it is necessary to guarantee the mechanical and technological (strength, toughness) and physical (heat expansion coefficient) properties of the parent metal in the weld metal in addition to satisfying the minimum temperature required.

Filler metals with higher nickel contents have a tendency towards increased hot cracking. For this reason the 5 % nickel steel is preferably welded with austenitic filler metals on the basis of “A7” or “ASN 5“ and nickel-base types. Heat treatment of the weld must not take place out of regard for the austenitic weld metal (embrittlement, carbon diffusion).

9 % Ni-steel is mainly joined using completely austenitic filler metals with a high nickel content of the “NIBAS 625“ type, or „FOX NIBAS 60/15“. This nickel-based type has advantages over conventional austenites due to a higher yield point and the possibility of heat treating welds. It may also be used for steels with a low nickel content. Crack resistance and adequate cold toughness down to -200 °C are ensured if dilution with the parent metal is limited.

Austenitic chrome nickel steels are welded in the same manner. The unstabilised weld metal is slightly superior to the stabilised weld metal in impact energy at low temperatures.

3.4.9. High-temperature Steels

The mechanical strength properties of the non-alloy constructional steels undergo a significant reduction at increased operating temperatures; therefore, they are only suitable for use up to a threshold temperature of 350 °C. Under stress creep and flow processes occur in the steel at increased temperatures as a result of which the permissible load becomes time dependent. Thus all calculation values for strength now have a time added to them from which it can be seen how long the material can bear a specific stress up to fracture or up to a specific permanent elongation. In this context one talks about the creep rupture strength or creep strain limit.

Thus first and foremost high temperature steels have adequate mechanical strength at high operating temperatures. In addition to this they must also exhibit a certain resistance to corrosion and in the event of hot aggressive gases increased scale resistance as well which is only achievable with high-alloy steels. With the addition of specific alloying elements such as Cr, Mo, V, W, Ti and Nb it is possible to increase the high-temperature strength properties and the creep resistance. The slip planes are blocked due to the formation of special carbides and special nitrides (anti-slip effect).

For a temperature load up to 550 °C small additions of Mo, V, and Cr are sufficient although Mo has the greatest effect on increasing the high-temperature strength. Above 550 °C increased scale resistance is also required. In this case the 9 to 12 % Cr-steels with additions of Mo, V and Nb are considered. Above 600 °C the behaviour under long period stressing drops off so much in heat treatable steels that special Cr-Ni steels (basic type: 16 % Cr, 13 % Ni) have to be used. The creep resistant steels are standardised in EN 10028, EN 10222-2, DIN 17155, DIN 17175 and DIN 17460.

Welding of High Temperature Steels
Creep-resistant steels may be divided into three main groups:

Ferritic-Pearlitic Steels
(e.g. P295GH, P355GH and 16Mo3)
These are normalised steels. Basically these steels are not susceptible to hardness increase in the heat-affected zone. However above a certain wall thickness preheating to 150 °C is advisable (P295GH = 25 mm; 16Mo3 = 10mm.)

Bainitic (Martensitic) Ferritic Steels
(e.g. 13CrMo4-5, 10CrMo9-10, 14MoV6-3).
These steels are quenched and tempered and air-hardening and special account must be taken of this when welding. Hard and brittle zones may develop simultaneously, both in the heat affected zones (HAZ) and the weld metal itself, due to the formation of martensite which contributes towards the danger of underbead cracking. Stress cracking after completion of welding is also possible.

Therefore, depending on the steel grade it is advisable to carry out preheating to 100 - 300 °C prior to welding and a specific interpass temperature must be controlled. As the preheat and interpass temperature is lower than the M_s temperature (M_s = 480 °C), annealing and tempering at 640 - 740 °C but below A_{c3} in any case is necessary after welding is complete.

Consequently the temperature should not significantly exceed approx. 450 °C and the energy input must be limited to 7 - 24 kJ/cm. At a preheat temperature not exceeding 300 °C it is not completely possible to prevent the formation of martensite (Ms = 480 °C) in the heat affected zone but its formation will be minimized to approx. 30 - 50 %. Therefore, depending on the type of steel, it is necessary to perform annealing and stress-relieving at 640 - 740 °C after welding is complete.

Martensitic Steels – Alloying Type 12 % Chromium
(e.g. 12 %Cr-Stähle X20CrMo12-1. X22CrMoV12-1 und X22CrMoWV12-1).

These steels are also quenched and tempered. The predominantly martensitic structure calls for a very special heat control procedure during welding. Two different technological procedures are used which are known in practice by the terms "martensitic and austenitic welding techniques".

The difference between these methods is determined by preheat and interpass temperatures above M_s-temperature (400 - 450 °C) in "austenitic" welding and below M_s-temperature (200 - 250 °C) in "martensitic" mode. After completion of welding, cooling is carried out to 120 - 80 °C to complete the martensite transformation, followed by final annealing in the temperature range between 720 - 780 °C.

Martensitic Steels – Alloying Type 9 % Chromium
(e.g. 10CrMoVNb9-1, X12CrMoWNiVNbN10-11 and E911/NF 616).

There has been another material available since the beginning of the 80's that guarantees outstanding high-temperature strength properties due to its modified alloy base. This material is the grade P91 steel standardised to ASTM A335. Furthermore, there are efforts underway to find successor generations for the P91 materials. These cognate but as yet not standardised materials (NF 616, P911 und HCM12) are supposed primarily to guarantee appreciably higher long-term creep strength values resulting from the addition of tungsten by alloying.

Unlike the 12 % chrome types, the 9 % chrome types exhibit a lower tendency towards hardness increase during welding due primarily to the lower carbon content which results in a reduced risk of cold crack formation and the occurrence of stress corrosion cracking. However, a preheat and interpass temperature ranging between 200 to 300 °C must be taken into account.

The use of the multi-pass technique is recommended since the welding technology has a considerable effect on the toughness properties achievable, i.e. thinner passes, in order to obtain a high proportion of annealed weld metal structure and thus an improved level of toughness.

Interim cooling to ambient temperature is necessary prior to the required postweld tempering (740-775 °C) to achieve complete martensitic transformation.

Choice of Filler Metal
Essentially the filler metals used are those of the same composition as the base. Only under this condition is it possible to expect a creep rupture strength from the weld that corresponds to the base metal. In the case of stick electrodes there are basic and rutile coated types available although the latter are only used for steels not exceeding 5 % Cr and up to 12 mm wall thickness due to poorer mechanical properties and the higher hydrogen content. Rutile-coated stick electrodes are used mainly for root welding.

GTA welding is widely used for the root pass in pipes whilst the GMAW and submerged-arc processes are increasingly gaining in importance. The use of gas fusion welding is restricted to thin-walled joints in steels not exceeding 2.5 % Cr.

Welding Technology

- Use only filler metals with the same alloy composition as the base metal.
- Above certain wall thicknesses normalised steels such as 16Mo3 must be preheated to 150 °C.
- Tempered steels such as 13CrMo4-5 must be preheated to 100 to 300 °C depending on type and must be postweld annealed in the range between 640 and 740 °C.
- With martensitic Cr steels on the basis of X20CrMoV12-1 care must be taken to ensure special heat input, i.e. preheating to 200-250 °C or 400-450 °C, then cooling down to 80-120 °C and finally annealing at 720 to 780 °C.
- Martensitic Cr steels on the basis of 10CrMo9-10 must be preheated to 200 to 300 °C and may be cooled down to ambient temperature following welding. Then tempering treatment must be carried out at 750 °C.

Filler Metals
The following table provides examples of different BÖHLER filler metals for welding high temperature steels:

base material	BÖHLER product
16Mo3	FOX DMO Kb, DMO-IG, EMS 2 Mo/BB24, DMO Kb-FD, DMO Ti-FD
13CrMo4-5	FOX DCMS Kb, DCMS-IG, EMS 2 CrMo/BB 24,
10CrMo9-10	FOX CM 2-Kb, CM 2-IG, CM 2-UP/BB 24
X10CrMoVNb9-1	FOX C 9 MV, C 9 MV-IG, C 9 MV-MC, C 9 MV-UP/BB 910
HCM2S	FOX P 23, P 23-IG, P 23-UP/BB 430
7CrMoVTiB10-10	FOX P 24, P 24-IG, P 24-UP/BB 430
X12CrMoWVNbN10-1-1	FOX C 9 MVW, C 9 MVW-IG, C 9 MVW-UP/BB 910
P 92, NF 616	FOX P 92, P 92-IG, P 92-UP/BB 910
X20CrMoWV12-1	FOX 20 MVW, 20 MVW-IG, 20 MVW-UP/BB 24

3.4.10 Low-alloyed Tempered Steels

These steels are mainly used in the construction of machinery and equipment, in boilers, in the construction of piping and chemical plants, in the petrochemical industry, in cryogenics and in the automobile and aircraft industry. They are used in the quenched and tempered condition, as a result of which constructional steels such as this are termed tempering steels. Their special property is hardenability which depends principally on the type and proportions of the alloying elements they contain.

Due to a special alloying technique the critical cooling speed is reduced increasing in turn the temperability and creep resistance. Depending on the alloy composition it is possible to differentiate between Mn, Mn-Si, Mn-V steels; Cr, Cr-Mo, Cr-Mo-V, Cr-Ni-Mo steels; Ni, Ni-Cr steels and others.

Targeted lowering of the critical cooling speed for the purpose of good temperability worsens the steel's weldability. Structural components between bainite and martensite occur in the heat affected zone of the base metal which cause local hardness increases. The higher the carbon content in the steel, the harder the martensite becomes and the lower the martensite formation temperature lies (M_s).

Knowing the martensite formation temperature is of major significance for determining the preheat temperature of steels with poor weldability. In addition to the familiar methods of determining the preheat temperature such as the carbon equivalent, TTT curve, weld TTT curve and hardness testing of practical welds, it is also possible to calculate the M_s or M_f point according to the following formula:

M_s point (start of martensite formation):
M_s(°C)=561-474(% C)-33(% Mn)-17(% Ni)-17(% Cr)-21(% Mo).

M_f-point (end of martensite formation):
M_f (°C) = M_s-215±15

The two formulae are applicable for steels with approximately the following chemical composition:

% C	% Si	% Mn	% Ni	% Cr	% Mo
0.1 - 0.55	0.1 - 0.35	0.2 - 1.7	0 - 5	0 - 3.5	0 - 1

The following table shows the hardness, tensile strength and notch impact energy of the martensite in alloy steels with varying carbon contents (following heating to 200 °C according to Thorneycroft).

carbon [%]	tensile strength [N/mm²]	impact work [J]	hardness [HV 10]
0.14	1370	85	420
0.20	1480	60	440
0.26	1650	41	470
0.40	1860	24	560
0.61	2200*)	7	700

*) brittle crack

Alloying elements such as manganese, nickel, chrome and molybdenum promote the γ-α transformation in the martensitic stage. As a result low-alloy steels have a greater tendency towards hardness increase than non-alloy steels with the same carbon content.

Welding of Low-alloy Tempering Steels

It is hardly possible to find a filler metal of the same composition as the base for welding a specific tempering steel that usually contains above 0.25 % C. Nor is this sensible because for welding engineering reasons the carbon content in the weld metal is reduced and attempts are made to achieve the desired strength and tempering qualities by means of a suitable combination of alloys. However, in many cases it is not expected that the weld will achieve the strength of the base metal or it is not designed with high load ranges in mind. The filler metals then used are non-alloy basic electrodes or austenitic electrodes. In both cases the high weld metal ductility has a favourable effect with regard to at least a partial reduction of stress.

Filler metals for joint welding of tempering steels have not been standardised as yet.

Welding Technology

Proceed as follows to prevent cracks in the weld interfaces:

1. Use non-alloy or low-alloy electrodes with low hydrogen content which are adequately re-dried prior to welding. In certain cases austenitic electrodes may also be used. Gas metal-arc wel ding using argon or mixed gases may also be used.
2. Preheat to prevent or delay martensite formation. The possibilities for determining the preheat temperature have already been outlined.
3. Weld with thick electrodes and high heat input per unit length of weld. As a result cooling pro gresses more slowly.

Postweld heat treatment at approx. 600 °C and above, preferably without interim cooling, is recommended to reduce the residual welding stresses and to temper the hardened zone if there is a fear of cracking, especially in air-hardening steels.

Consideration should also be given to isothermic welding, i.e. maintaining the interpass temperature up to the formation of harmless structures.

Austenitic filler metals of the "A 7" type (18 % Cr, 8 % Ni, 6 % Mn alloy type), whose weld metal cannot of course be tempered, are often chosen for air-hardening steels (e.g. armoured steel with higher carbon content of the 30 CrNiMo 8 type). They are particularly suitable because the low yield point and high plastic ductility of the alloy make it possible to reduce stress peaks by means of lower deformation without the danger of cracking.

3.4.11 Compressed Hydrogen-resistant Steels

Steels that are only slightly susceptible to decarburisation by hydrogen at high pressures and high temperatures and to the embrittlement and intercrystalline failure associated with this are considered to be compressed hydrogen-resistant steels. These properties are achieved by alloying with elements that form highly resistant, barely decomposable carbides at the operating temperature. Chrome is one such element. The following for example are compressed hydrogen-resistant steels 25CrMo4, 20CrMo9, 17CrMoV10, X20CrMoV121, X8CrNiMoVNb1613 in accordance with SteelMaterial Specification 590.

At high pressures hydrogen penetrates the steel and reacts with the carbon in the iron carbide or pearlite forming methane at the same time. High pressures which lead to disaggregation and finally to intercrystalline cracks occur inside the steel since the methane molecules have only a very low diffusability due to their size.

Welding of Compressed Hydrogen-resistant Steels
Compressed hydrogen-resistant steels are weldable if the necessary precautions are taken. However, their weldability declines as the carbon content increases. These steels must be preheated to 200 to 400 °C depending on the type of steel and this temperature must be maintained during welding.

After welding cooling must be slow and even. Postweld heat treatment must be carried out as specified. The filler metals must also result in a compressed hydrogen-resistant weld metal. Steels X20CrMoV12-1 and X8CrNiMoVNb16-13 require a very specialised welding technology.

3.4.12 Stainless Steels

The group of stainless steels contains a large number of very different alloy variations all of which are commonly characterised by a chrome content of at least 12 %. This guarantees that extremely thin, stable oxide layers form on the surface of the steel under oxidising conditions and the steel passes from the active (soluble) to the passive (insoluble) condition. In the passive condition there is increased resistance to oxidising media. However, in the case of a reducing atmosphere, i.e. decreased oxygen supply, the formerly passive steel may pass over into the active condition. The chrome content of at least 12 % necessary for a certain chemical resistance of the steel is very often referred to as the “parting limit”.

The alloying element chrome and subsequently nickel represent the basic elements for stainless steels. However, their effect with regard to the crystalline structure in the steel is very varied.
With increasing nickel content the gamma area is extended whilst with increasing chrome content the gamma area is confined and above approximately 12 % only ferrite (= body-centred cubic mixed crystal) continues to prevail. Above a certain nickel content the microstructure is made up only of austenite (= face-centred cubic mixed crystal) from solidification to ambient temperature.

All other alloying elements which are added to the steel to improve specific properties may be assigned to either the chrome or nickel in their effect on the crystalline structure. This means that it is possible to differentiate as follows between ferrite-forming and austenite-forming elements.
Ferrite-forming elements: chrome, silicon, aluminium, molybdenum, niobium, titanium, tungsten and vanadium.

Austenite-forming elements: nickel, manganese, carbon, cobalt, copper and nitrogen.

If one adds sufficient quantities of nickel to a ferritic iron-chrome alloy then it passes over into the austenitic condition.

The following table lists the most important groups of stainless steels classified according to the microstructure.

micro structure		typical steel
pearlitic-martensitic		X30Cr13
half ferritic-ferritic		X8Cr17
soft-martensitic		X5CrNi13-4
ferritic-austenitic		X2CrNiMoN22-5
austenitic	austenite with ferrite	X5CrNi18-9
	austenite without ferrite	X8CrNiNb16-13

These groups of steels differ from each other from both the metallurgical and physical point of view and allowance must be made for the peculiarities in each case by taking appropriate measures when fabricating welds.

3.4.13 Martensitic Chromium Steels

Some characteristic martensitic Cr steels and their weldabilty:

material designation according EN 10088-1	% C	% Cr	% Mo	weldability
X12Cr13	0.15	13.0	-	limited
X20Cr13	0.20	13.0	-	strongly limited
X39CrMo17-1	0.42	16.5	1.2	none

Basically speaking this group of steels must be classified as having only limited weldability since the risk of cold cracking increases as the carbon content rises and joint welds should be avoided where possible.

As already mentioned, the most important alloying element is chrome which lends the steels its passivity and thus its corrosion resistance in oxidising media if it accounts for approximately 12 % of the content. Chrome as a ferrite-forming element has the effect of narrowing the iron's austenitic zone and this is constricted completely with approx. 13 % chrome. Steels with chrome contents higher than 13 % with very low carbon contents (< 0.1 %) undergo no transformation during cooling from solidification to ambient temperature. These are the ferritic chrome steels.

The group of hardenable steels starts with chrome contents above 12 % and carbon contents of approx. 0.1 to 1.2 %. These are the martensitic chrome steels. The austenitic zone is widened by the higher carbon content creating the opportunity for hardening.

Welding of Martensitic Chromium Steels
The austenitic fraction in the heat affected zone of the base metal will always transform into martensite during air cooling as the formation of pearlite and bainite progresses with a significant time delay due to the high chrome content.

Due to the steel's high chrome content the beginning of pearlite transformation, during which δ ferrite and carbide are precipitated out of the ?-mixed crystals, takes a long time so that the weld metal and the heat-affected zone (HAZ) practically always transform to the martensitic stage unless the martensitic transformation temperature is exceeded on heating. The unfavourable and inadequate weldability of such steels is easy to understand if one looks at the hardness increment as a function of the carbon content.

Hardness increment with different carbon contents:

carbon content	hardness
0.10 % C	app. 40 HRC
0.15 % C	app. 46 HRC
0.20 % C	app. 50 HRC
0.25 % C	app. 53 HRC
0.40 % C	app. 56 HRC
0.70 % C	app. 58 HRC
1.00 % C	app. 60 HRC

At the same time it becomes understandable why only martensitic Cr steels with less than 0.15 % carbon are usually used in practice for welded structures.

Hydrogen also represents a further unfavourable factor when welding. Somewhat higher hydrogen contents may cause a strong tendency towards hydrogen-induced cold cracks in the weld particularly in the presence of brittle martensite.

13 % Cr steels are always tempered and 17 % Cr steels are always tempered or soft-annealed since the martensite is relatively hard, brittle and at the same time susceptible to corrosion.

This group of steels is welded using filler metals of both the same and different composition to the base. Please consult later sections for recommendations regarding the appropriate welding technology and filler metals. The weld metal in the welded condition consists of martensite and δ-ferrite with small proportions of residual austenite when using filler metals of the same or similar composition to the base. For this reason only very low elongation and impact energy values are present and annealing is almost always carried out at 700 to 750 °C.

Welding Technology

for steels with carbon contents below 0.15 %

- Coated stick electrodes and submerged arc flux powders must be re-dried in accordance with the manufacturer's instructions.
- Only use filler metals of the same composition as the base if there are requirements for the same colour, comparable strength or alternating strength. Otherwise use austenitic filler metals.
- A preheat and interpass temperature of 200 - 300 °C is to be recommended in any case.
- Carry out postweld tempering at 700 - 750 °C. Beware when using austenitic filler metals due to the risk of embrittlement.

Suitable BÖHLER filler metals are:

microstructure	BÖHLER product
equal	FOX KW 10, FOX SKWAM, SKWAM-IG
different	FOX A7 (IG/UP/FD), FOX EAS 2 (IG/UP/FD), FOX CN23/12 (IG/UP/FD)

3.4.14 Ferritic Chromium Steels

The following table contains the chemical composition and weldability of some ferritic Cr steels whose characteristic feature is a low carbon content. As a result these steels are predominantly ferritic from the commencement of solidification to ambient temperature, and thus in the main are not subject to transformation and are therefore also not hardenable. Mo, Ti or Nb are sometimes added as alloying elements to improve the chemical properties.

material designation according EN 10088-1	% C	% Cr	% Mo	weldability
X6Cr13	<0.08	13.0	-	limited
X6Cr17	<0.08	17.0	-	limited
X6CrMo17-1	<0.08	17.0	1.1	limited

The prerequisite for adequate technological values, particularly regarding elongation, is a fine-grain structure. This is achieved if the final forming stages are carried out below 800 °C and there is then heat treatment up to 800 °C with subsequent rapid cooling in air or water. This group of materials is very susceptible to overheating, i.e. on exposure to a temperature above 1000 °C it has a tendency towards grain coarsening which may bring about considerable embrittlement in conjunction with the precipitation of carbides. For this reason ferritic Cr steels are not used in the construction of pressure vessels.

Furthermore, as the Cr content increases the ferritic Cr and Cr-Mo steels have a tend ency towards time-related precipitation hardening in the temperature range between 400 - 525 °C known as 475 °C embrittlement. Here this means segregation of the ferrite into a chromium-rich and an iron-rich phase.

Welding of Ferritic Cr Steels

Primarily with steels with a higher Cr content there is grain growth in the super-heated part of the transition zone due to the input of thermal energy during welding that cannot be remedied by subsequent heat treatment. In addition to this, carbides that cause an even further reduction in ductility are precipitated on the grain boundaries. For these reasons ferritic Cr steels should be classed as having only “limited weldability”. Similarly unfavourable conditions are to be expected in the weld metal if filler metals of the same composition as the base are used.

The loss of ductility represents an absolute weakening of the welded joint. It is therefore recommended that austenitic filler metals are used for welding ferritic Cr steels. To a certain extent the austenitic weld metal is able to function as an expansion element due to its considerably better ductility properties. The austenitic weld metal also exhibits advantages from a corrosion point of view. However, there is one disadvantage in the formation of a different colour between the base metal and the weld deposit. Filler metals with the same alloy composition as the base must be used where there is a requirement for the same colour. In practical use where highly sulphurous or carburizing gases are present the austenitic weld metal may be prone to attack (e.g. due to the formation of nickel sulphide). In this case the procedure followed should be to fill the joint austenitically and only use a ferritic filler metal for depositing the final layers on the side exposed to the aggressive medium.

Welding should be carried out with preheating to 200 to 300 °C in order to keep thermal stresses as low as possible. Attention must also be paid to low input of thermal energy in order to minimise coarse grain formation. Postweld annealing in the range between 700 to 750 °C is beneficial. As a result of this the carbides precipitated coagulate and stress reduction is achieved at the same time. Both factors lead within certain limits to an improvement in ductility (see Fig. 4). However, it is no longer possible to get rid of the coarse grain in the heat-affected zone. When using austenitic filler metals consideration must be given to its tendency to precipitate intermetallic phases (embrittlement) in the 600 to 900 °C temperature range.

Welding Technology

for ferritic Cr steels with carbon contents less than 0.12 %

- Coated stick electrodes and submerged arc flux must be re-dried according to the manu facturer's instructions.
- Only use filler metals of the same composition as the base if there is a requirement for colour matching, or if the component will come into contact with sulphurous or carburising gases.
- Preheat and interpass temperature between 200 - 300 °C is advisable.
- Keep heat input per unit length of weld as low as possible.
- Postweld annealing and tempering at 700 - 750 °C is recommended. Caution when using austenitic filler metals due to risk of embrittlement.

The following table shows BÖHLER filler metals with same composition or different composition to base suitable for welding:

microstructure	BÖHLER-product
equal	FOX SKWA, SKWA-IG, SKWA-UP
different	FOX SAS 2, SAS 2-IG, SAS 2-UP, SAS 2-FD, SAS 2 PW-FD FOX EAS 2, EAS 2-IG, EAS 2-UP, EAS 2-FD, EAS 2 PW-FD FOX CN 23/12, CN 23/12-IG, CN 23/12-UP, CN 23/12-FD, CN 23/12 PW-FD

3.4.15 Soft-martensitic Chromium Nickel Steels

Steels with soft martensitic microstructure are used in a wide range of applications with the steel containing 12 % chrome and 4 % nickel being considered as the most important representative of this group. The following table contains information on their chemical composition and weldability.

material designation according EN 10088-1	% C	% Cr	% Mo	% Ni	weldability
X5CrNi13-1	<0.05	13.0	0-0.4	1-2.0	good
X5CrNi13-4	<0.05	13.0	0.4	4.0	good
X5CrNi13-6	<0.05	13.0	0.4	6.0	good
X5CrNi16-6	<0.05	16.0	-	6.0	good/limited
X5CrNiMo16-5-1	<0.05	16.0	1.5	5.0	good/limited
X5CrNi17-4	<0.05	17.0	-	4.0	good/limited

The mechanical properties of such materials lie within a very broad range depending on their chemical composition and above all on the type of heat treatment performed although consideration is only paid to type X5CrNi13-4 in the following section.

The basic precept of development was primarily to lower the carbon content to increase the ductility of the martensitic structure and to reduce the tendency towards cold cracking plus to achieve a structure as free as possible from δ-ferrite by alloying with 4 to 6 % nickel. Thus at “ambient temperature“ the structure consists of “soft“ martensite with small amounts of undercooled δ-ferrite and austenite. Tempering further increases the ductility and reduces the hardness or strength. The low carbon content and the addition by alloying of approx. 0.5 % molybdenum simultaneously improve corrosion resistance.

One major advantage of the soft-martensitic Cr-Ni steels compared with pure Cr steels is their excellent weldability.

Weldability of the soft-martensitic steels is essentially typified by three characteristics which are:

1. Formation of low-carbon, ductile martensite in the HAZ and in the weld metal which greatly reduces the tendency towards cold cracking.
2. Low δ-ferrite contents. This largely eliminates the tendency towards coarse grain formation during welding.
3. Hydrogen sensitivity of the martensitic structure. Hydrogen-induced cold cracks may arise with contents of diffusible hydrogen of HDM > 5 ml/100 g.

Welding of Soft-martensitic Cr-Ni Steels
The type of heat treatment represents a major influencing factor on the mechanical properties of these materials. Soft martensites in nickel contents above 3.5 % exhibit a metallographic peculiarity, namely the formation of finely dispersed austenite at tempering temperatures above 580 °C. This effect leads to a rise in the impact energy values in the 13/4 weld metal whereby highest values are achieved between 600 und 620 °C. At higher tempering temperatures the impact energy drops off again due to transformation of the tempering austenite into martensite on cooling.

The choice of interpass temperature is particularly important in preventing cold cracks in welded joints. Practical experience gained in connection with soft martensitic materials show that sudden “conversion“ of large weld areas into martensite should be prevented during postweld cooling. Otherwise conditions of extreme transformation and residual stress are to be anticipated in the weld metal which may in turn trigger cold cracks. Therefore interpass temperatures within the Ms temperature range must be considered critical.

It is recommended that the interpass temperature for X5CrNi13-1 weld metal is held between 120 and 220 °C and for X5CrNi13-4 and X5CrNi13-6 weld metals between 100 and 160 °C. This means that for each weld bead the martensitic transformation will be approximately 50 % which should be the aim from both a metallographic and stress engineering point of view. At all events it is necessary to adhere strictly to the interpass temperature mentioned if subsequent heat treatment cannot be performed.

Welding Technology
In accordance with the properties encountered during welding of soft-martensitic steels it is therefore advisable to adhere to the welding technology described below. The notes apply to the most important soft-martensitic steel containing 13 % Cr and 4 % Ni.

- Use only filler metals of the same alloy composition as the base for welding.
- Coated stick electrodes and submerged arc flux powders must be re-dried in accordance with the manufacturer’s instructions to comply with a hydrogen content in the weld metal of < 5 ml/100 g.
- Thick-walled components should be pre-heated to 100 °C and welded with an interpass temperature ranging between 100 and 160 °C.
- Postweld tempering or at least postweld quenching is necessary to increase ductility.

3.4.16 Austenitic Cr-Ni(-Mo)-Steels

Where stainless materials are concerned by far the greatest importance is attached to the group of austenitic chrome-nickel-(molybdenum) steels. Basically these chemically resistant steels may be classified as "very readily weldable". They are not quench-hardenable as a result of which there is no occurrence of hardness increase and essentially no grain coarsening in the heat-affected zone. However, three problems may possibly arise in both the base metal and in the weld metal as a result of inexpert fabrication. These are:

- Sensitisation, i.e. reduction in the resistance to corrosion due to the formation of chrome carbide.
- Hot cracking, i.e. intergranular separations during solidification or in the high temperature sections of the heat-affected zone with rigid restraint of the weld area.
- Embrittlement, i.e. precipitation of intermetallic phases such as σ-phase due to application of high temperature or annealing.

When welding fully austenitic steels it is also necessary to take into consideration their constitutional tendency toward the formation of hot cracks.

Notes on the welding technology of austenitic Cr-Ni-(Mo) standard steels, weld dressing and information on filler metals may all be found in the appropriate sections.

Welding Technology

- Only qualities corresponding to the respective base metal with weld deposits exhibiting δ-ferrite contents ranging from 5 - 15 FN (ferrite number) should be used for welding. This ensures adequate resistance to hot cracking. Filler metals of the same composition as the base, which result in fully austenitic weld metal, are available for highly corrosion-resistant special steels.
- Care should be taken to ensure that austenitic steels are only fabricated with a clean and dry surface.
- The arc should be kept as short as possible to prevent absorption of nitrogen from the air. When performing gas-shielded welding care must be taken to ensure perfect gas shielding and, with the exception of flux-cored welding, only shielding gases with a low CO_2 content should be used to keep carburisation of the weld deposit as low as possible.
- Preheating to 100 - 150 °C is only advisable for a thick base metal but is not necessary on principle.
- An interpass temperature of 150 °C should not be exceeded.
- The recommended current intensity ranges must be complied with.
- If re-welding of the root is not possible during gas-shielded welding then there must be pro vision of gas shielding from the underside when welding the root bead (e.g. with forming gas or pure argon).
- Dilution with the base metal should be less than 35 % if possible. If it is greater than this due to the welding procedure used, the ferrite content in a test bead should be determined by means of a calibrated ferrite gauge or should be estimated by calculation from the che mical composition e.g. with the help of the WRC-92 diagram. The ferrite content or the FN should not lie below the minimum value referred to above.

- Postweld annealing treatments should be avoided whenever practicable. If this is not possible then allowance must be made for a possible reduction in corrosion resistance and/or ductility. In this case it is advisable to consult the manufacturer of the steel and the filler metal.

- It is not generally possible to use unstabilised, low-carbon filler metals for stabilised steels and vice versa although the respective maximum temperature of intergranular corrosion resistance should be observed.

- Greater distortion than when welding ferritic steels must be taken into account and allowance must be made for appropriate corrective measures such as the weld shape, increa sed tacking, pre-tensioning, back-welding, etc.

- Flame straightening should not be carried out if possible as it can adversely affect corrosion resistance. In connection with this it is also particularly important to point out the damaging effect of arc strikes outside the welding groove.

- Only de-slagging hammers and brushes of stainless Cr or Cr-Ni steel may be used for clea ning austenitic weld joints.

Weld Dressing
A completely bare metallic surface must be mentioned as the prerequisite for achieving optimum corrosion resistance. Not only must every trace of welding scale, slag and all spatter be removed but all bloom as well.

Weld dressing may be performed by means of grinding, pickling, sandblasting, brushing and/or polishing. The finer the surface the greater the corrosion resistance (e.g. coarse grinding – finish-grinding – polishing).

Pickling is the most often used method. There are various pickling solutions or pickling pastes commercially available for this purpose that are applied to the surface and rinsed off thoroughly with water after the recommended reaction time.

The removal of so-called "bloom“ on welds sometimes causes a problem. It is also possible to remove this bloom by washing with silica sand or brushing.

If the pickled component is rapidly subjected to corrosion, as is usually the case with repairs for example, then passivation is recommended subsequent to the pickling treatment. The appropriate manufacturers also offer suitable agents for this. The component must be rinsed thoroughly again after passivation treatment.

It must be expressly mentioned in connection with the use of pickling agents that these are highly caustic substances and it is therefore imperative that protective items such as rubber gloves, rubber aprons, protective goggles and possibly breathing equipment are worn when handling them. Local environmental regulations must also be observed.

Sandblasting is used when grinding or pickling cannot be considered. This procedure may only be performed with steel grit made from rust and acid-resistant steel or silica sand. Although the surface obtained is bare metal it is somewhat rougher. Passivation should also be performed after sandblasting.

Filler Metals
The following table shows various BÖHLER filler metals suitable for welding the materials listed:

base material	BÖHLER-product
X5CrNi18-9	FOX EAS 2-A (IG/UP/FD)
X2CrNi18-9	FOX EAS 2-A (IG/UP/FD)
X5CrNiMo18-12	FOX EAS 4 M-A (IG/UP/FD)
X2CrNiMo18-10	FOX EAS 4 M-A (IG/UP/FD)
X10CrNiNb18-9	FOX SAS 2-A (IG/UP/FD)
X10CrNiMoNb18-10	FOX SAS 4-A (IG/UP/FD)

3.4.17 Ferrite Determination in Weld Deposit

The austenitic chemically resistant Cr-Ni steels generally exhibit very good weldability. However, the special physical properties of these steels – low thermal conductivity and high coefficient of thermal expansion – must be taken into account when welding with regard to input of welding heat. Special significance is accorded to the type of primary solidification which subsequently has a crucial effect on hot cracking behaviour.

For the practical welder the presence of specific ferrite fractions in the weld metal is an indirect indication of adequate resistance to hot cracking. Generally speaking ferrite in the weld metal is an advantage in welds that do not have the ability to expand freely, those with large weld cross-sections and if cracks have previously impaired their suitability for use. Ferrite increases the weld metal strength but has the opposite effect on corrosion resistance in certain media. Furthermore, it is also a disadvantage in low-temperature applications and in the high-temperature range where transformation to the brittle σ-phase is possible.

The ferrite content may be determined magnetically in addition to metallurgical estimation. The scale used is not absolute with the result that there will probably be differences in the results of measurements obtained from different laboratories (e.g. variations between 3.5 and 8.0 % in a specimen with approximately 5 % δ-ferrite). The measured values are usually shown in FN (ferrite numbers). The ferrite number may be equated with the percentage of ferrite up to approx. 10 FN.

According to the Welding Research Council (WRC) it is not possible at present to determine the absolute ferrite content in austenitic-ferritic weld metal deposits. Variations resulting from differences in the welding and measuring conditions are to be anticipated even in specimens with pure weld metal deposit. The usual standardisation assumes a 2-sigma variation which means a variation of ±2.2 FN for 8 FN.

Greater variations are to be anticipated if the welding procedure permits higher absorption of nitrogen from the ambient air. High nitrogen absorption may lead to a weld metal with 8 FN falling to 0 FN in the ferrite content. Absorption of 0.10 % nitrogen typically reduces the ferrite content by 8 FN. In weld metal deposits dilution with the base metal leads to further ferrite reductions since base metals with the same composition usually have lower ferrite contents than the pure weld metal.

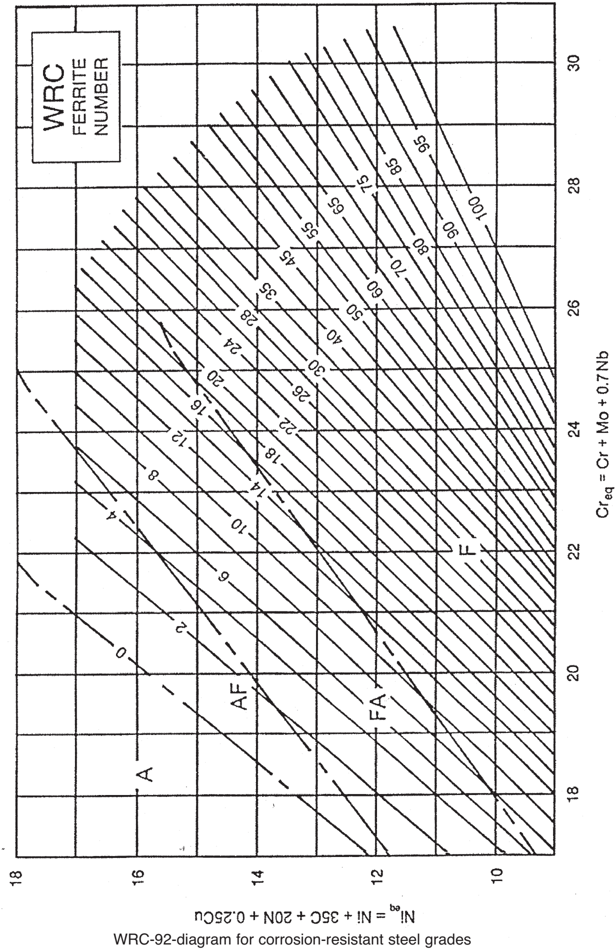
In addition to measurement, it is also possible to calculate the ferrite content from the chemical composition of the pure weld metal. Various structural diagrams may be referred to for this purpose. They are the WRC-92 diagram, the Schaeffler diagram, the DeLong diagram and the Espy diagram. There may be very great variations between the results of the individual diagrams as they were prepared on the basis of series examinations for different groups of materials.

The WRC-92 diagram provides a prediction of the ferrite content in FN. It is the most recent of the diagrams mentioned and exhibits better concurrence between the measured and the calculated ferrite contents than when using the DeLong diagram. It should be noted that the WRC92 diagram does not take account of the silicon and manganese content which restricts the weldability of weld metals with high-silicon and high-manganese contents (over 8 %). Furthermore, its use should be restricted with nitrogen contents over 0.2 %.

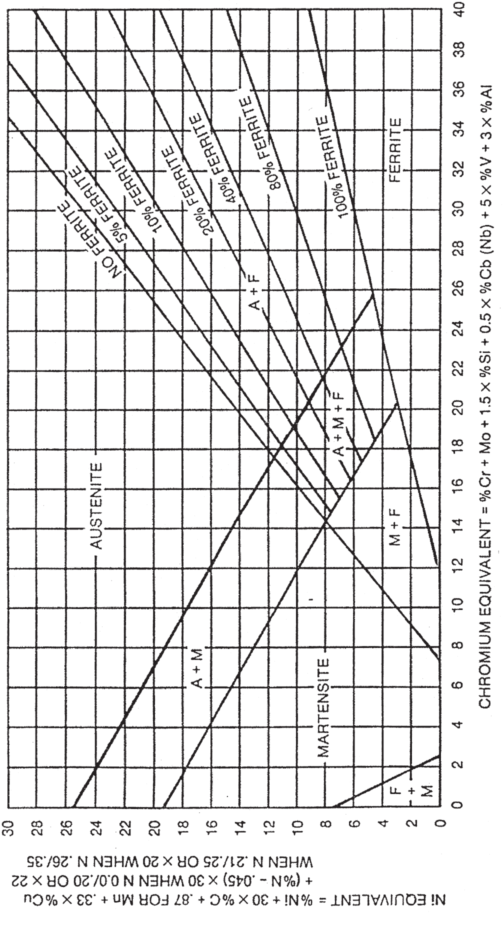
The Schaeffler diagram is the oldest of the diagrams referred to and until now has been widely used for calculation of the ferrite content. It has a broad scope of application but does not allow for the highly austenitising effect of nitrogen.

The Espy diagram attempts to compensate for these weaknesses. Like the Schaeffler diagram it calculates the ferrite content in percent but also allows for manganese contents up to 15 % and nitrogen contents up to approximately 0.35 %.

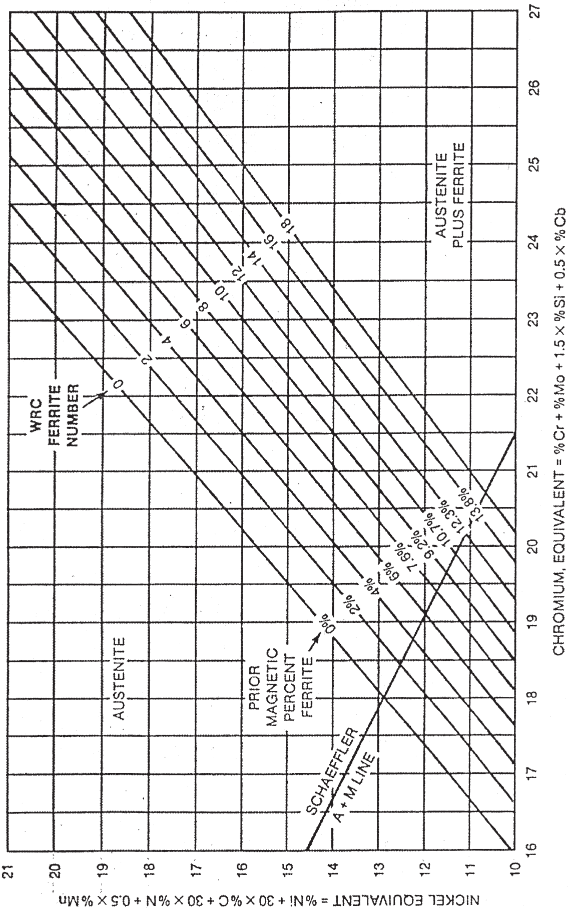
The DeLong diagram is a modification of the Schaeffler diagram which shows the ferrite content in ferrite numbers up to about 18 FN. The diagram allows for the nitrogen content in calculation and exhibits better concurrence between measurement and calculation than the Schaeffler diagram. It overlaps approximately with the WRC-92 diagram in its applicability.



WRC-92-diagram for corrosion-resistant steel grades



Espy-diagram for ferrite determination of corrosion-resistant steel grades



DeLong-diagram for ferrite determination of corrosion-resistant steel grades

If the nitrogen content is not known for determining the nickel equivalent then it is possible to assume a content of 0.06 % for TIG welding and manual electrode welding and a content of 0.08 % for gas-shielded welding with solid wire electrodes. Using the WRC-92 diagram it is possible to predict the ferrite number within a range of ± 3 FN in approximately 90 % of the measurements assuming an accurate chemical composition.

Effect of δ-Ferrite
The following overview provides a summary of the advantages and disadvantages of δ-ferrite in the austenitic weld metal. In principle the statements apply to the steel material as well.

Depending on the practical conditions of use the δ-ferrite is sometimes undesirable, in most cases beneficial and in some cases even necessary. The reasons for these requirements, which on first sight appear contradictory, are shown in the overview. The consequences of deviations are also highlighted.

Reasons		Consequences of too much or to little δ-ferrite	
δ-ferrite fraction is undesirable			
requirement for non-magnetic weld metal	FN=0	magnetisation	
special corrosion stresses	FN<0.5	selective corrosion	
use at very low temperatures	FN<0.5	loss of ductility	
use at high temperatures	FN<0.5	phase precipitation	
low δ-ferrite fraction is beneficial			
high resistance to hot cracking	FN=5-15	danger of hot crack formation	FN<5
even in thick-walled components		loss of ductility	FN>15
service temperatures between		phase precipitation	FN>15
–100 and +400°C		selective corrosion	FN>15
no unusual chemical stresses			
high δ-ferrite content is necessary			
resistance to stress corrosion cracking	FN=30-75	reduced resistance to stress corrosion cracking	FN<30
increase of strength properties	FN=30-75	reduced ductility properties	FN<75
compensation for dilution in		reduced strength properties	FN<30
dissimilar welds	FN=15-25	danger of hot cracks as a result of dilution	FN<15

3.4.18 Heat-resistant Steels

Steels that stand out for their special resistance to the oxidising effect of gases at temperatures above approximately 600 °C are deemed to be creep-resistant. A steel is classified as creep-resistant if it does not exceed 1 g/m²*h on average at the temperature x the weight of metal oxidised and does not exceed 2 g/m²*h at the temperature (x + 50 °C) for a stress duration of 120 h with four interpass cooling processes.

Information and references to scale resistance or highest working temperatures such as those contained in SEW 470 for example should only be used as a reference point. The temperature ranges for use are lower under unfavourable conditions, e.g. in sulphurous or reducing gases, especially with high steam content or with possible settling of corrosive dust. It is also necessary to allow for possible σ-phase precipitation.

The following table shows the most important creep-resistant steel groups classified according to the crystalline structure.

microstructure	typical steel grade
ferritic	X10CrAl7, X10CrAl13, X10CrAl24
ferritic-austenitic	X20CrNiSi25-4
austenitic	X12CrNiTi18-9, X15CrNiSi25-20, X12NiCrSi36-16

Welding of Heat-resistant Steels

The ferritic chromium steels are joined using predominantly austenitic filler metals or with the same alloy composition as the base depending on the conditions of practical use. A preheat and interpass temperature ranging between 200 and 300 °C is recommended for thicker cross-sections. It is subsequently possible to improve the ductility properties reduced by the formation of coarse grain and carbide precipitations by performing a heat treatment of 700 to 750 °C.

Steels with ferritic-austenitic microstructure are usually welded with filler metals of the same composition as the base without preheating or postweld heat treatment.

Allowance must be made for the constitutional tendency towards hot cracking exhibited by fully austenitic chrome-nickel steels and filler metals. In the temperature range between 600 and 900 °C care must be taken with possible embrittlement due to the precipitation of intercrystalline phases. Filler metals of the same alloy composition as the base are used sometimes although nickel-based filler metals are also used.

3.4.19 Welding of Dissimilar Joints

The subject of welding technology is both extensive and complex if one takes into consideration all the mixed metal welds possible between the most varied types of steels. It is practically impossible to cover every individual combination of materials. This is undoubtedly one of the main reasons why there are hardly any appropriate standards and codes for dissimilar metal welds.

As a result of the situation described the enquiries received in practice by the customer service department for welding technology are very often related to the problems surrounding mixed metal welds. As a consequence of this, basic general rules were drawn up in the form of rough guidelines which contain notes, recommendations and precautions for the selection of filler metals and the compilation of a welding technology. However, basic rules such as these can only be considered valuable if they can be translated into practice with adequate expertise and a basic knowledge of metallurgy.

Generally speaking it should be noted that in many cases when joining different materials it is not possible to select the best possible filler metals and welding conditions for each individual partner material. It is therefore necessary to find suitable compromises.

Selection of the filler metal must be considered as an essential criterion in the fabrication of mixed metal welds. This selection must be made so that where possible the weld metal arising should not be too hard, brittle and susceptible to cracks allowing for dilution with the different materials. In very simple terms, no new and thus indefinable accidental alloy that might consequently require additional considerations may come into being when the weld metal melts on the component. The weld metal properties which exist in the pure weld metal must be retained in principle despite dilution with the different base metals.

The following section highlights in very broad outlines guidelines for the selection of filler metals and suitable welding technology when fabricating mixed metal welds. In this case the structure is only rough since it only deals with groups of materials with examples of type of steels.

Basic Rules for the Selection of Filler Metals for Dissimilar Welds
General basic rules can only be considered valuable if they can be translated into practice with adequate expertise and a basic knowledge of metallurgy. The large selection of differently alloyed steels within the individual alloy groups and the mixed metal welds possible between steels from different alloy groups make it practically impossible to consider every individual combination of materials in the following section.

For this reason it is only possible to specify filler metals for the various material combinations in the form of a rough structure, i.e. only by narrowing down to types steel or groups of steel. The drawback to this method is a certain degree of inaccuracy as it is not possible to take account in each case of different influencing factors that are important in the selection of suitable filler metals.
Therefore the recommendation of a filler metal does not claim to be exhaustive. In case of doubt it is recommended that you consult the manufacturer.

Mild Steel – Mild Steel
(e.g. S235JR with S355J2G3)

In practice non-alloy steels of different strengths are joined relatively often. Essentially, in the case of mixed metal welds such as these, only the mechanical property data of the base metals are in the forefront of considerations. Normally filler metals that correspond to the strength properties of the softer base metal are used. However, it should be noted in this case that non-alloy weld metal deposits barely fall below yield point values of 400 N/mm^2 and tensile strength values of 500 N/mm^2 due to the fine-grain microstructure.

Naturally the choice of coating, flux and powder type must be made depending on the welding procedure to be used allowing for the wall thickness and component stiffness. With increased stiffness and application of stress to a component it is advisable to use basic filler metals and consumables whose metallurgically pure weld metal together with low hydrogen contents ensures high resistance to cracking.

Mild Steel – High Temperature Steel
(e.g. P235G1TH with 13CrMo4-5)

Depending on the material combination, non-alloy filler metals or high-temperature resistant filler metals should be used whereby the latter have a lower alloy content than the high-temperature resistant material of the combination.

With a few exceptions high-temperature resistant steels are air-hardening and therefore require special heat input during welding or subsequent postweld heat treatment. The recommendation regarding this contained in VdTÜV code of practice 451-82/1 should be taken into consideration.

Mild Steel – High Strength Steel
(e.g. S235JR with S460N)

The filler metal is usually matched to the softer base metal.

In the case of great discrepancies between the strength properties of the two materials (e.g. S235JR with S690Q) a filler metal whose strength is between the values of the two base metals should be considered.

Mild Steel – Cryogenic Steel
(e.g. S235JR with 14Ni6)

If a cryogenic steel exhibits up to 3.5 % Ni, it is possible to use both non-alloy filler metals and filler metals of the same or similar composition to the base.

With Ni contents between 5 and 9 % austenitic or nickel-based filler metals should be used. If one of the materials is an austenitic Cr-Ni steel then mainly fully austenitic filler metals of similar composition to the base should be used.

Mild Steel – Tempering Steel
(e.g. S235JR with 42CrMo4)

Tempering steels have only limited weldability, and types with a higher C content should not be used in welded structures. They require special heat input during welding and postweld heat treatment.

Depending on the material combination, non-alloy or low-alloy filler metals should be considered the weld metal of which undergoes an increase in strength due to carburisation from the base metal.

In exceptional cases where postweld heat treatment is not possible, it may be beneficial to use austenitic Cr-Ni filler metals.

Mild Steel – Chromium Steel
(e.g. S235JR with X12Cr13)

Both ferritic and martensitic Cr steels require special heat input during welding and subsequent annealing. As a result the use of nickel-based alloys should be considered (depending on the conditions of use).

Austenitic over-alloy filler metals may also be used if subsequent annealing is not possible and the temperature during use is limited to max. 300 °C.

Mild Steel – Austenitic Steel
(e.g. S235JR with X4CrNi18-10)

When joining steels with very different chemical compositions there is a complex metallurgical problem which it appears can essentially only be solved by compromise. Over-alloy austenitic filler metals should be used.

The most crucial criterion of mixed-metal joints such as these is the choice of filler metal. It must be made allowing for dilution with the different base metals so that the weld metal produced is neither martensitic nor fully austenitic. However, the latter is unavoidable when using nickel-based filler metals. In very simple terms no new and therefore indefinable random alloy may arise on fusing the weld metal to the component that would of necessity give rise to additional considerations being taken into account. The weld metal properties as are present in the pure weld metal deposit must be retained in spite of dilution with the base metal. The main function of filler metals is to enable fabrication of a crack- free and ductile weld between the ferritic constructional steel and the austenitic material. The Schaeffler diagram serves as the most important aid in the selection of filler metals.

For the purposes of weld metal properties care should be taken to keep dilution as low as possible. The use of nickel-based filler metals is necessary in the case of postweld heat treatments or operating temperatures above 300 °C otherwise embrittlement or carbon diffusion must be reckoned with.

High Strength Steel – High Strength Steel
(e.g. S355N with S460N)

In the case of mixed-metal welds between normalised and annealed high-tensile fine-grained constructional steels one should again orient oneself to the softer steel grade with regard to strength when choosing the filler metal.

In the case of partner materials with very different strength properties (e.g. S355N with S690Q) consideration should be given to a filler metal whose strength lies between the two base metals. Otherwise a high jump in strength directly in the weld area could represent an additional weak spot in the component depending on the stress conditions in practical use.

Special requirements, e.g. with regard to low-temperature ductility, must also be taken into account when choosing the filler metal. Due to the huge number of steel grades in existence it is barely possible to provide a concrete assignment of filler metals allowing for all the material combinations possible. Furthermore, this method of proceeding would severely compromise clarity.

High Strength Steel – Austenitic Steel
(e.g. S460N with X4CrNi18-10)

Over-alloy austenitic filler metals should be used.

Nickel-based filler metals should be used in the case of operating temperatures over 300 °C and postweld annealing.

High Temperature Steel – High Temperature Steel
(e.g. 13CrMo4-5 with 11CrMo9-10)

Each combination of materials must be considered separately with regard to choice of filler metal and heat treatment.

Generally speaking a filler metal corresponding to the partner material with the lower alloy is chosen.

Unless there is an overlapping annealing range, the postweld heat treatment represents a compromise between the optimum annealing temperatures of the materials concerned. The recommendations contained in VdTÜV Code of Practice 451-82/1 must be taken into account.

High Temperature Steel – Austenitic Steel
(e.g. 13CrMo4-5 with X4CrNi18-10)

Only use over-alloy austenitic filler metals under certain conditions.

Nickel-based filler metals should be used in the case of operating temperatures over 300 °C and postweld annealing. With the exception of the non-alloy grades and 16Mo3, high-temperature steels are air-hardening. In certain cases this necessitates postweld annealing in addition to suitable heat input during welding and therefore the use of nickel-based filler metals.

Annealing treatments may adversely affect the properties of austenitic steels. Therefore, where possible the welding edges of the high-temperature material should be clad and subsequently annealed; only then should the joint be welded.

Cryogenic Steel – Cryogenic Steel
(e.g. S225NL with 14Ni6)

Filler metals must be specified allowing for the required level of low-temperature ductility. Normally for mixed-metal joints with steels up to 3.5 % Ni a filler metal that corresponds to one of the two partner metals is adequate.

Austenitic (possibly also nickel-based) filler metals should be considered for nickel contents of 5 and 9 % respectively.

Material combinations with austenitic Cr-Ni steels are joined using fully austenitic filler metals with a similar alloy composition to the base or nickel-based filler metals.

Cryogenic Steel – Austenitic Steel
(z. B. 14Ni6 mit X4CrNi18-10)

Filler metals must be specified allowing for the required level of low-temperature ductility.

Consideration should be given to predominantly over-alloy fully austenitic filler metals.

Tempering Steel – Tempering Steel
(e.g. 25CrMo4 with 42CrMo4)

Tempering steels are only weldable to a limited extent; weldability deteriorates as the C content or alloy content increases. They require special heat input during welding as well as postweld annealing. There are hardly any filler metals with the same alloy composition as the base. Selection is made according to the specified strength properties taking into account the heat treatment necessary. In many cases the practical conditions of use allow the employment of softer filler metals as a result of which it is mainly nickel-based types that are used.

The use of austenitic Cr-Ni filler metals may only be taken into consideration on condition that it is not possible to perform postweld heat treatment.

Tempering Steel – Austenitic Steel
(e.g. 42CrMo4 with X4CrNi18-10)

Limited weldability and necessary postweld heat treatment require the use of nickel-based filler metals, with the result that the procedure of cladding the edges, annealing and only welding thereafter is to be preferred where possible.

Austenitic over-alloy filler metals may also be used but only where it is not possible to perform annealing and in this case an operating temperature of max. 300 °C may not be exceeded.

Austenitic Steel – Austenitic Steel
(e.g. X4CrNi18-10 with X6CrNiMoTi17-12-2)

It is recommended that the filler metal be chosen in line with the chemical composition of the partner material with the higher alloy.

Austenitic Steel – Chromium Steel
(e.g. X4CrNi18-10 with X12Cr13)

Only use over-alloy austenitic filler metals under certain conditions.

Both ferritic and martensitic Cr steels have only limited weldability. They require special heat input during welding and postweld heat treatment.

The specification of austenitic filler metals must therefore be made allowing for their tendency towards embrittlement and in certain cases may necessitate the use of nickel-based filler metals.

Annealing treatments may also adversely affect the properties of austenitic steels. The weld edges of the chrome steel should therefore be clad with two layers and then annealed; the joint should only be welded thereafter.

Austenitic Steel – Heat Resistant Steel
(e.g. X4CrNi18-10 with X12CrNi25-21)

Mainly filler metals that correspond in respect of the alloy to the high-temperature resistant partner material should be used.

Nickel Base Alloy – Nickel Base Alloy
(e.g. Alloy C 625 with Alloy C 22)

Each combination of materials must be considered separately with regard to the choice of filler metal.

The filler metal should correspond in respect of the alloy to the partner material with the better ductility properties. For higher corrosion stress conditions the filler metal should be matched to the higher Mo-alloy base metal or should be over-alloy welded if necessary.

Nickel Base Alloy – Mild Steel /High Temperature Steel / High Strength Steel /Cryogenic Steel / Tempering Steel
(e.g. C 276 with S235JR /13CrMo4-5 /S460N /14Ni6 /42CrMo4)

There is a whole series of nickel-based filler metals with different alloys available for mixed-metal joints such as those referred to above. In many cases a filler metal of the same or similar composition to the nickel-based parent metal is used.

Nickel Base Alloy – Chromium Steel / Austenitic Steel / Heat Resistant Steel
(e.g. C 276 with X12Cr13 /X4CrNi18-10 /X12CrNi25-21)

The conditions of use should be taken into consideration when choosing the filler metal. Normally a filler metal corresponding to or of similar composition to the nickel-based alloy is used.

Manganese Steel – Mild Steel
(e.g. X120Mn12 with S235JR)

The use of austenitic Cr-Ni filler metals with increased Mn content or over-alloy types is recommended.

Manganese Steel – Austenitic Steel
(e.g. X120Mn12 with X4CrNi18-10)

Austenitic filler metals with increased Mn content or over-alloy types are recommended.

Grey Cast Iron – Mild Steel
(e.g. GGG-40 with S235JR)

Only cold cast iron welding may be taken into consideration. The filler metals are of different composition to the base metal and are Ni-Fe-based.

Grey Cast Iron – Austenitic Steel
(e.g. GGG-40 with X4CrNi18-10)

Only cold cast iron welding may be employed. Either Ni-Fe-based types or Cr-Ni-based types with increased Mn content are used.

3.5. Welding Technology Details

Overview

A correct welding technology is the essential prerequisite for the fabrication of welds which meet requirements. This section does not go into all the possible facets in detail but highlights several points that have often been the subject of enquiries made by welding-engineering staff. More extensive treatment of this subject would far outstrip the bounds of this manual.

Contents

3.5.1 Tips for Preheating

Hardness Increase During Welding
Due to the fact that during welding the base metal is always heated to above Ac1 or Ac3 respectively in specific areas of the heat-affected zone, there is always a danger with hardenable steels of hardness increase and as a result crack formation. The tendency towards hardness increase with non-alloy and alloy steels depends in particular on the carbon content but also on the content of other alloys. During welding the speed of cooling from the austenitic range may be so great that it corresponds approximately to hardening in water.

The cooling speed becomes greater

- the less heat is inputted during welding,
- the thicker the material is,
- the colder the material is.

If the critical cooling speed is reached, one must reckon with the formation of hardened microstructures , e.g. martensite. The level of the hardness values is largely determined by the carbon content.

The hardness increases linear to the rise in carbon content up to approximately 0.45 % C to a value of around 650 HV. The impact energy in the hardened steel lies above 78 Joule up to 0.12 % and above this drops off sharply. Above 0.2 % C it lies below 32 Joule. From this one can see that the value of 0.2 % C approximately represents the limit up to which steels can be welded without preheating and without the need for special precautions.

If the filler and cover passes are then welded over this root pass, the zones lying below them are normalised or tempered and the hardness peaks next to the root weld are reduced. However, if cracks have already occurred beforehand in the transition zone due to postweld hardness increase, then they also remain after applying the cover passes to the weld and may possible lead to fracture of the welded component.

In zones hardened in this way high stresses are set up due to the effect of welding shrinkage because the material is prevented from reducing them by means of plastic deformation. Over and above this a multi-axis stress condition is set up in this area particularly in the case of thick cross-sections which is promoted still further due to martensite formation taking place with increase of volume. Cracks occur in the transition area if the stresses reach the cohesion strength.

Hydrogen may also be significantly involved in the occurrence of these underbead cracks. If possible a hardness value of 350 HV should not be exceeded in order to prevent these underbead cracks with some degree of certainty.

Accurate knowledge of the hardening processes in the heat-affected zone of the steel is especially important to prevent underbead cracks and for the safety of a welded structure for the reasons mentioned above. It also appears to be very important prior to welding to be able to predict a possible hardness increase for a specific steel with a known chemical composition.

Preheating the Material
The preheat temperature is the temperature up to which the workpiece must be brought in the region around the current welding area prior to laying the first bead.

Reasons for Preheating
The heat inputted into the workpiece during welding and thus the highest temperature drop that occurs in the zone between the weld metal and the unaffected base metal may lead to changes in the material (danger of crack formation). Preheating reduces the temperature drop and ensures slow cooling. This means that the critical cooling speed which can lead to adverse structural changes is not reached (low or no hardness increase – no danger of cracking).

Furthermore, there is less shrinkage due to the smaller temperature drop and as a result less distortions occur. The residual welding stresses are reduced and the hydrogen has more time available at higher temperatures for post-alloy diffusion (lower hydrogen contents).

Steel should always be preheated for welding if critical structural changes are to be anticipated. This also applies to tack welding. The necessity for preheating is the result of the described tendency towards hardness increase of certain steels in the heat-affected zone. After any interruption of the welding process it is necessary to re-attain the preheat temperature before starting welding again. However, the rule applicable is that above all critical welds should be welded in one pass that is without interruption.

Level of Preheat Temperature
The optimum preheat temperature depends on numerous factors. These are for example the chemical composition of the base metal, the welding procedure, the diameter and type of filler metal, the welding speed, the workpiece thickness, the position of the weld joint on the component, the possibility of heat dissipation, the type of construction, external temperature, etc. Therefore, it is hardly possible to specify values that are generally applicable. In this case “optimum preheat temperature” is understood to be the temperature that is just high enough so that the critical cooling temperature is not reached. A temperature that is too low increases the risk of cracking, temperatures that are too high are uneconomical and may have an adverse effect on certain steel grades (e.g. high-tensile fine-grained constructional steels).

Performing Preheating
Once the correct preheat temperature has been determined, the welding area in question must be preheated correspondingly. Allowance must also be made for the fact that the heat migrates into the cold metal. The heat supply must be great enough for the specified temperature to be reached over the entire cross-section that is both front and back.

With relatively short welds preheating is usually done using the welding torch. Special torches with air intake or fuel gas/compressed air torches are also used. In addition to preheating in the oven there is also the possibility of inductive preheating.

The base metal should exhibit the preheat temperature at a distance of 75 mm in each direction.

Checking the Preheat Temperature
Checking the specified preheat temperature is important since it has been shown time and again in practice that the welder relies more on his instincts. For a large number of cases measuring with thermo crayons (temperature indicating crayons) is adequate. However, for critical welds accurate temperature measurement is necessary usually with recording of the temperature curve. In addition to the thermo crayons there are also adhesive thermometers and contact thermometers as well as devices with which one can measure the preheat temperature without contact and record its progress.

3.5.2 Tips for Tack Welding

Tack welds should not be thinner than specified for the root weld and should be subject to the same quality requirements for welding as are also applicable for the root weld. The length of the tack weld should not be less than four times the thickness of the thicker of the parts to be joined. For workpiece thicknesses over 50 mm or for high-tensile materials consideration should be given to increasing the length and thickness of tack welds. This may also include a two-pass weld. Attention should also be paid to the use of lower-tensile filler metals when welding higher-alloy steels.

For joints that are supposed to be welded using automated or fully-mechanised processes, it is necessary to include the conditions for fabricating the tack welds in the welding procedure.

If a tack weld is to be included in a welded joint, then the shape and quality of the tack should be suitable for incorporation into the final weld. It should be fabricated by qualified welders. The tack welds should be free from cracks and prior to final welding should be cleaned thoroughly. Tack welds that exhibit cracks should be grooved out. However, crater cracks may also be removed by grinding. All tack welds that are not to be included in the final weld should be removed.

Any necessary aids that are temporarily attached for the construction or assembly of parts with fillet welds should be designed so that are can easily be removed again. The surface of the component must carefully be ground smooth again if the aid is removed by cutting or chiselling. It is possible to demonstrate by means of a dye penetrant test that the metal is not cracked in the area of the temporary weld.

3.5.3 Tips for Avoiding Welding Defects

Defects in welds are an unpleasant phenomenon since to some extent they are the cause of extremely cost-intensive weld dressing. In many cases defects and damage may be prevented by taking simple precautions. Measures such as these may be implemented at various stages of planning and fabrication. They may range from choosing the best possible filler metal to mastery of the welding procedure and regular maintenance of the power source.

This subsection does not provide a complete overview of possible welding defects but limits itself to types of defects that can be prevented by relatively simple measures. In addition to a description of the defects and its causes, the following tables also contain possible countermeasures that may have a favourable effect. Refer to standards, welding guidelines (e.g. of the DVS) and other literature for more detailed information.

Occurrence and Prevention of Defects
The following list provides explanations for possible unfavourable phenomena when welding steels and presents measures to prevent these defects. Basically speaking most of the phenomena listed can be reduced by optimising the chemical composition of steel and filler metal.

The list is not ranked according to the importance of the defects described.

Defects and Causes	**Countermeasures**
HYDROGEN-INDUCED CRACKS	
During welding atomic hydrogen diffuses into the weld metal and into the heat-affected zone. During and after cooling this may lead to crack formation especially in areas of higher internal stresses and high dislocation density (e.g. at grain boundaries in martensite).	Use filler metals that lead to a very low hydrogen content in the weld metal. Re-dry the filler metal. Prevent the application of high stress. Preheat the joint. Use low-hydrogen postweld annealing. Reduce hardness increases in the weld metal and the heat-affected zone.
DUCTILITY TOO LOW	
Generally speaking the ductility of specific parts of the heat-affected zone compared with the base metal is adversely affected by coarse grain formation or hardness increase.	Select the optimum welding temperature cycle.
SOLIDIFICATION CRACKS	
Solidification cracks are mainly linked with trace elements such as sulphur and phosphorous. These may be precipitated in the centre of the bead during solidification. They are the result of the formation of low fusion films around the grain boundaries. These films reduce the deformability of the weld metal and longitudinal cracks may form due to shrinkage stresses on solidification of the weld metal.	Modify the welding parameters so that the individual beads become broader and flatter, i.e. reduce the depth to width ratio of a bead. Reduce dilution with the base metal. Reduce the welding speed. Note: solidification cracks rarely occur in steels with low proportions of sulphur and phosphorous.

Defects and Causes	Countermeasures
TERRACE FRACTURES	
If no special measures are taken during steel production, it is possible for the ductility of flat products or sections to be distinctly smaller in the direction of thickness than in the longitudinal direction. This is determined by the presence of non-metallic inclusions that are elongated by rolling. Shrinkage stresses in the weld metal that act in the direction of thickness may be the reason why these inclusions open up and as a result fractures occur parallel to the surface of the sheet metal. Highly stressed tee butt welds and cross butt welds have a tendency towards this..	Use steels with specified properties in the thickness Avoid sensitive arrangements of welds. Optimise the sequence of weld beads Use filler metal with the lowest permissible strength.
CRACKS DUE TO STRESS-RELIEVE ANNEALING	
Carbide or nitride precipitations may occur during stress-relief annealing if the stress-relief annealing and/or the steel composition are unfavourable. This may reduce the steel's deformability to such an extent that the stress reduction leads not only to plastic deformations but also to the formation of cracks.	Reduce the stress concentration by grinding the bead transitions. Reduce the proportion of coarse-grain in the heat-affected zone by a correct sequence of weld beads. Use an optimum procedure for heat treatment.
CORROSION – GENERAL ATTACK	
Differences in the chemical composition, grain size and degree of stress between the weld and the base metal may lead to different rates of corrosion. In most cases the weld and the heat-affected zone are attacked in preference.	Choose a suitable filler metal (sometimes with a higher alloy than the base metal) Reduce residual welding stresses Proper dressing of welds (e.g. pickling).
STRESS CORROSION CRACKS	
A critical combination of stress, microstructure and surrounding medium may lead to this form of corrosion as a result of which all three influencing factors must always be present at the same time.	Prevent stress concentrations. Reduce stress in all welds.

Occurrence and Prevention of Pores
Unlike the phenomena mentioned above, it is only possible to influence pores during welding to a limited extent by means of the chemical composition of the base metal and the weld metal. Basically there are two possible types of pore formation:

In the liquid condition steel dissolves gases such as hydrogen, nitrogen and oxygen. In metallurgical pore formation dissolved gases are precipitated as gas bubbles (H_2, N_2, CO, O_2) during the solidification process due to the jump in solubility from the liquid to the solid phase. If the solidification speed is greater than the speed at which the gas bubbles up, then the bubbles are entrained ("frozen") and are left behind in the weld as predominantly spherical pores. Depending on the amount of gas available, these pores may also be present in an elongated form. Gas bubbles occur at the phase boundary between liquid and solid and in slag particles floating in the molten weld pool.

Mechanical pore formation occurs if gaps or voids filled with gases, e.g. air, are welded over. If gases that expand due to welding heat are unable to escape completely in another direction, a pressure builds up that is reduced by the formation of bubbles in the liquid weld pool.

This effect may be intensified still further by gas-forming substances in the gaps and voids (moisture, greases and oils, components of coating materials, metallic coatings). As a rule mechanically formed pores are linked to the voids that led to their formation.

defects and causes	**countermeasures**
METALLURGICAL PORES	
High nitrogen contents in the base metal and the filler metal	Use filler metals matched to the base metal with an increased solvent power for nitrogen (e.g. increased Cr and Mn contents in austenitic alloys)
Increase in nitrogen content due to plasma cuts	Grind the cut edge
Inadequate shielding of the arc area against the atmosphere due to: - arc being too long - wrong angle of electrode inclination - damaged electrode coating - arc blow effect	Weld with short arc Weld with steep inclination Take care to use undamaged and centric electrode coating Take care to ensure symmetrical material connection, weld with alternating current if possible
Shielding gas flow rate too low due to: - setting being too low - leaking line - capillary hole too small - preliminary pressure too low for pressure regulator	Correct setting accordingly Look for and remedy leaks Correct assignment of capillaries and pressure regulators Cylinder and line pressure must correspond to required preliminary pressure of pressure regulator.
Inadequate gas shielding due to: - draft from open windows, doors, etc. - insufficient gas flow at beginning or end of welding - gas nozzle gap too large - eccentric exit of wire electrode - wrong shape of gas nozzle - wrong position of gas nozzle	Prevent drafts, position extraction system differently Allow gas to pre-flow or post-flow longer as appropriate Reduce gas nozzle gap Align wire electrode better, arrange contact tube centrically Match gas nozzle shape to weld preparation If possible arrange gas nozzle downstream of torch seen in direction of welding.
Turbulence due to: - shielding gas flow rate being too high - spatter on gas nozzle or contact tube - turbulent arc	Reduce gas flow rate Clean gas nozzle and contact tube during welding breaks Remedy problems with wire feed, increase voltage with stuttering wire electrode, ensure good current transition in contact tube, perfect bonding to earth, remove slag from beads welded previously.

defects and causes	**countermeasures**
Thermal up-current or chimney effect due to: - weld pool temperature being too high - workpiece temperature being too high - unimpeded draft in pipelines	Reduce size of weld pool Reduce preheat or interpass temperature (if possible metallurgically) Seal pipes
Moisture due to: - moist electrode coating (increased H contents) - condensation on wire electrode - moisture on base metal - leaking water-cooled torch - condensation on shielding gas nozzle	Re-dry electrodes according to manufacturer's instructions Equalize temperature of filler metal, store in a dry place Dry weld area by skin-drying or preheating Look for leaks and remedy, dry wire transport hose in case water has got in Check torch cooling for excess capacity Weld over arc strikes
Incorrect handling of basic electrodes	Use basic electrode with higher Mn content
Rounding of segregation zones	Reduce penetration by decreasing the arc power or increasing the welding speed.
Rusty and scaly surfaces	Clean weld area prior to welding
MECHANICAL PORES	
Inclusion of air in the area immediately surrounding the weld	Create opportunities for entrained air to escape e.g. increase welding gap, use butt welds instead of fillet or lap welds
Moisture in welding gap, possibly chemically bonded to rust	Remove moisture by preheating, remove rust or layers of scale, use butt welds instead of fillet or lap welds
Layers of grease in welding gap, present either as contamination or to prevent corrosion or applied intentionally for lubrication purposes	Remove grease using solvents, increase welding gap and dry well, use butt welds instead of fillet or lap welds
Metallic coatings (e.g. tin, zinc)	Comply with recommended layer thicknesses, remove metal coatings if necessary, increase welding gap, use butt welds instead of fillet or lap welds
Coating materials (e.g. production coatings)	Choose favourable coating material, comply with prescribed coating thickness, remove any layers that are too thick if necessary, ensure good degasification in the gap, use butt welds to replace fillet or lap welds

4 Efficiency and Calculation Guide

◆ Overview

It is in the nature of a competitive economy that every trader involved works at achieving the best possible ratio between the profits of his production output and the expenditure it requires. Reduction of costs is a complex task that affects the most varied areas of the company.
This section attempts to provide an overview in a very brief form of the factors that affect the economic viability of a weld and offers a simple calculation formula that makes it possible to make a rough estimate of the filler metal requirements and the welding time.

◆ Contents

4.1. Economic Aspects of Welding

4.1.1 Efficient Production of Welded Joints

Consideration must be given to the most varied criteria in component design to achieve low-cost production of a component. Above all these include designing the component with a view to function, stress, material and production. If the component needs to be designed as a welded structure, there are additional factors, which have an impact on the efficiency audit such as the material and finishing costs of the individual parts and welding costs.

It is not possible to give any generally applicable instructions and solutions for low-cost construction of welded components although one can define a series of individual basic rules that make the work easier and save costs. The following list details such rules although the sequence does not necessarily correspond to the importance of these rules.

- *Dimension fillet welds correctly*
  - Keep fillet welds as thin as possible
  - Take note of fillet weld formation, use deeper penetration
  - Provide for thin and long fillet welds
  - Provide for double fillet welds where possible
- *Ensure accessibility*
- *Use economic weld shapes on butt weld*
  - Deposit as little weld metal as possible
  - Take notice of welding procedure
  - Check weld preparation angle for MAG welding
  - Check effect of material on weld shape
  - Allow for back welds
- *Utilise potential cost reductions in production*
  - Specify standard operating times
  - Analyse times and look for possible ways to make savings
- *Reduce the actual welding time*
  - Use more current with same electrode diameter
  - Use thicker electrodes
  - Use other types of electrodes
  - Use other welding consumables
  - Use procedures with higher output
- *Choose more favourable welding position*
- *Mechanise Production*
  - Partial mechanisation of the welding procedure used
  - Replace the existing procedure with a mechanised welding procedure
  - Use special welding machines
  - Adapt weld preparations
- *Use weld pool backings*

- *Do not deposit more weld metal than necessary*
  - Assemble to exact size
  - Produce more accurate flame cuts
  - Monitor weld thicknesses and weld reinforcements
- *Reduce downtimes*
  - More efficient organisation of production
  - More efficient organisation of the workplace
  - Better information provided for welders
- *Use jigs*
- *Prevent or reduce distortion*
  - Plan allowance for distortion, pre-bend
  - Pre-tension
  - Draw up welding sequence schedule
  - Check weld shape and weight of weld
  - Use procedures with less distortion
  - Weld from both sides simultaneously
  - Use thicker sheet metal
- *Reduce process-dependent interruptions and weld dressing*
  - Shorten process-dependent interruptions
  - Make slag removal easier
  - Reduce spatter formation by choosing correct type of electrode
  - Reduce spatter formation by choosing correct shielding gas
  - Prevent spatter by using pulsed arc technique with mixed gas shielding
  - Set up central gas supply
- *Reduce malfunctions in units*
  - Purchase quality products
  - Operative preventive maintenance
  - Maintain and care for unit regularly
  - Take notice of operating instructions
- *Save energy costs*
  - Reduce cable losses
  - Switch off units during breaks
  - Use energy-saving procedures
  - Buy energy-saving power sources
- *Train and motivate welders*
  - Improve qualifications
  - Set up performance-related wage system as motivation
  - Get rid of noxious environmental influences
- *Take note of costs and quality*
  - Do not demand higher quality than necessary
  - Do not produce higher quality than needed
  - Save unnecessary costs by working conscientiously
  - Take notice of the effect of defects during weld preparation on the weld quality
- *Design with a view to testing and examination*

4.1.2 Checklist for Cost Reduction

1. Reduce the quantity of weld metal
- a) Reduce the number of welds
- b) Dimension weld cross-sections more accurately
- c) Dimensions weld lengths more accurately
- d) Weld interrupted welds (check permissibility)
- e) Restrict tolerances of fillet weld dimensions
- f) Use deeper penetration
- g) Assemble to more correct size
- h) Weld butt welds from both sides (double-vee weld instead of vee weld)
- j) Reduce weld preparation angle (depending on procedure)
- k) Change groove shape (U-groove butt weld or square-edge butt weld instead of vee weld)
- l) Produce more accurate flame cuts, reduce flame cutting distortion
- m) Reduce sheet metal thicknesses by higher weld quality (weld strength factor)

2. Reduce welding times
- a) All measures listed in point 1
- b) Work with higher deposition efficiency (more current, thicker electrode, high-performance electrode, other shielding gas
- c) Use other welding procedure with higher output
- d) Weld in more favourable positions (if necessary use jigs or positioning devices)
- e) Use weld pool backing (provide for structurally or use as production aid)
- f) Mechanise
- g) Improve dissipation of welding heat (e.g. in fully automated thin-sheet welding)
- h) Train and motivate welders

3. Reduce downtimes and refit times
- a) Organise production more efficiently (shorten absences and waiting times)
- b) Organise welder’s workplace more efficiently
- c) Inform the welder more effectively
- d) Ensure good access to the weld
- e) Get rid of noxious or performance-impeding environmental influences
- f) Use jigs and fixtures
- g) Mechanise
- h) Prevent or reduce distortion (pre-bend, pre-tension, draw up welding sequence schedule, use procedures with less distortion, weld both sides simultaneously)
- i) Reduce process-dependent interruptions and weld dressing (make slag removal easier, reduce spatter formation, reduce adhesion of spatter, set up central gas supply)
- k) Reduce malfunction times (purchase quality, operate preventive maintenance, maintain and care for unit regularly, take notice of operating instructions, train and motivate welders)

4. Do not waste energy and consumables
- a) Save energy (reduce cable losses, switch off unit during breaks, used energy-saving procedures and units)
- b) Be economical with consumables (do not leave electrode stumps too long, prevent gas losses, watch consumption of spare and wear parts)

5. Monitor quality
- a) Avoid excessive requirements
- b) Prevent defects and quality deficiencies

4.2. Consumable Consumption and Welding Time

4.2.1 Calculation of Electrode Consumption

Calculation Formula
For the practical welder it is important to be able to estimate the requirement for stick electrodes or other filler metals quickly, easily and accurately enough. For users who use a PC for their daily work Böhler Welding's WELCOME software program (Welding Consumables and Materials Expertise) is the simplest solution as it permits flexible calculation of the weight of weld metal for around 50 different weld shapes depending on the welding procedure and quality requirements.

Since not every user has a PC or laptop at his disposal the following pages illustrate a simplified method which is intended above all to make an initial estimate possible. An accurate calculation is not possible using generally applicable tables as the tables would become too complicated and therefore unmanageable.

The following approach may be used as the calculation formula:

	Weight of weld without weld reinforcement
x	Factor for the effect of the welding position (weld reinforcement)
x	Allowance for back welding (if necessary)
=	**Reference value for the total weight of the weld**
/	0.01894 kg/pcs. = weight of core metal rod deposited (ø3.2/350, stub 50 mm, metal recovery 100%)
x	Factor for divergent electrode dimension
x	Factor for divergent metal recovery
x	Factor for divergent stub length
=	**Reference value for the number of electrodes required**

The individual lines of the calculation formula are explained in a little more detail in the following sections and are provided with summaries in the form of tables. The method of proceeding is demonstrated briefly at the end of the section using a practical example.

Weight of Weld
The following tables provide an overview of the weight of the weld for different welding procedures with different types of welds. The weld shapes correspond to the specifications of the standard. Recommended diameters for rods and electrodes should only be considered as reference values. The data will be too high above all in the out-of-position welds. The weights of weld metals correspond as they only relate to the cross-section to be filled.

reference values for gas welding of flat-position joints (one side, without backing)

thickness mm	edge preparation	air gap mm	rod diameter mm	deposition rate kg/h	weight of joint kg/m	welding time min/m
0.8	I	0	1.5	0.17	**0.024**	8.5
1.0	I	0	2.0	0.19	**0.024**	7.6

thickness mm	edge preparation	air gap mm	rod diameter mm	deposition rate kg/h	weight of joint kg/m	welding time min/m
1.5	I	1.5	2.0	0.25	**0.042**	10.0
2.0	I	2.0	2.0	0.25	**0.048**	11.5
3.0	I	2.5	2.5	0.36	**0.074**	12.3
4.0	I	3.0	3.2	0.70	**0.17**	14.5
5.0	I	4.0	3.2	0.74	**0.265**	21.5
6.0	V 60°	3.0	3.2	0.80	**0.35**	25.5

reference values for shielded manual arc welding of butt welds (without backing, flat)

thickness mm	air gap mm	number of layers	electrode dimension mm	deposition rate kg/h	weight of joint kg/m	welding time per layer min/m
1.5	0	1	2.5/250	0.5	**0.03**	3.6
2.0	0	1	2.5/250	0.61	**0.036**	3.5
3.0	2	1	3.2/350	0.53	**0.064**	7.25

For double-vee welds it is possible to find a usable reference value for back welding on the root side of the weld by doubling the corresponding vee weld values of half the sheet thickness and adding the weight of the weld. Back welding on the root side of the weld is assessed with approximately half the weight of the root for sheet thicknesses under 8 mm and the simple weight of the root for thicker sheets.

reference values for shielded manual arc welding of fillet welds (one side, horizontal)

thickness a mm	number of layers	electrode dimension mm	deposition rate kg/h	weight of joint kg/m	welding time per layer min/m
3.0	1	3.2/350	1.19	**0.085**	4.3
4.0	1	5.0/450	1.75	**0.145**	5.0
5.0	1	6.0/450	2.14	**0.21**	5.9
6.0	3	4.0/450+ 3.2/350	1.+2.l: 1.38 3.l: 0.88	1.+2.l: **0.19** 3.l: **0.11**	1.+2.: 8.3 3.: 7.5
7.0	3	4.0/450	1.+2.l: 1.38 3.l: 1.25	1.+2.l: **0.31** 3.l: **0.11**	1.+2.: 13.5 3.: 6.8
8.0	3	4.0/450	1.+2.l: 1.38 3.l: 1.25	1.+2.l: **0.37** 3.l: **0.18**	1.+2.l: 16.1 3.l: 8.6
10.0	3	4.0/450	1.42	1.l: **0.29** 2.l: **0.31** 3.l: **0.25**	1.l: 12.2 2.l: 13.1 3.l: 10.5

l … layer

reference values for shielded manual arc welding of flat vee-welds of plates

thickness mm	ace/gap mm	number of layers	electrode dimension mm	deposition rate kg/h	weight of joint kg/m	welding time per layer min/m
4.0	2/1	2	r 2.5/250 c 3.2/350	r 0.43 c 1.2	r **0.08** c **0.09**	r 11.2 c 4.5
5.0	2/1	2	r 2.5/250 c 4.0/450	r 0.48 c 1.41	r **0.085** c **0.105**	r 10.6 c 4.5
6.0	2/1	3	r 2.5/250 f,c 3.2/350	r 0.52 f,c 1.24	r **0.08** f+c **0.14**	r 9.2 f+c 6.8
7.0	2.5/1.5	3	r 3.2/350 f,c 4.0/450	r 0.75 f,c 1.38	r **0.14** f+c **0.22**	r 11.2 f+c 9.2

reference values for shielded manual arc welding of flat vee-welds of plates

thickness mm	face/gap mm	number of layers	electrode dimension mm	deposition rate kg/h	weight of joint kg/m	welding time per layer min/m
8.0	3/2	3	r 3.2/350 f 4.0/450 c 5.0/450	r 0.75 f 1.42 c 1.75	r **0.16** f **0.13** c **0.14**	r 12.8 f 5.5 c 4.8
9.0	3/2	3	r 3.2/350 2f,c 5.0/450	r 0.75 f,c 1.88	r **0.14** f+c **0.37**	r 11.2 f+c 11.8
10.0	3/2	4	r 3.2/350 3f,c 5.0/450	r 0.75 f,c 1.88	r **0.15** f+c **0.47**	r 12.0 f+c 15.0
12.0	3.5/2	5	r 3.2/350 3f,c 5.0/450	r 0.75 f,c 1.93	r **0.17** f+c **0.74**	r 13.6 f+c 23.0
15.0	3.5/2	5	r 3.2/350 3f,c 5.0/450	r 0.81 f,c 2.1	r **0.15** f+c **0.91**	r 11.1 f+c 26.0

r .. root pass, f .. filler layer, c .. cap layer

For double-vee welds it is possible to find a usable reference value for back welding on the root side of the weld by doubling the corresponding vee weld values of half the sheet thickness and adding the weight of the weld. Back welding on the root side of the weld is assessed with approximately half the weight of the root for sheet thicknesses under 8 mm and the simple weight of the root for thicker sheets.

Effect of the Welding Position

The welding position has different effects on the execution of a weld. It is not possible to disregard the welding position for calculating quantities as in affects the weld reinforcement. When estimating time effects are to be anticipated due to higher downtimes such as cleaning, electrode replacement, lower current intensities, etc.
The following tables provide rough reference values in the form of multipliers which may be used to adapt the weight of the weld for horizontal position from the first determination.

factors for divergent welding positions - weight						
	PB	PA	PG	PE	PF	PC
vee-weld	**1.0**	**1.0**	**1.0**	**1.1**	**1.15**	**1.15**
fillet weld	**1.0**	**0.95**	**1.0**	**1.1**	**1.05**	**1.0**

factors for divergent welding positions - welding time						
	PB	PA	PG	PE	PF	PC
vee-weld	**1.0**	**1.0**	**1.1**	**1.87**	**1.5**	**1.2**
fillet weld	**1.0**	**0.95**	**1.15**	**1.65**	**1.43**	**1.1**

The values highlighted correspond to the reference calculation.

Proportion of Weld Metal for Back Welds

When deciding on a specific weld preparation one should not forget back welding if it is necessary for quality reasons. There are certain reference points for the consumption of filler metal and the work time required for back welding. The following list is based on practical values that were gained from experience in the grooving out of weld roots without major defective parts of the weld.
The additional consumption is specified as a multiplier for the weight of the weld without back welding. The angle information refers to the weld preparation angle or the angle of bevel preparation for U-groove welds.

thickness mm	vee-weld α 50°	60°	90°	double-vee-weld α 50°	60°	90°	U-groove weld β 8°	10°	15°
6…11	1.32	1.27	1.15						
11…16	1.24	1.19	1.11						
16…20	1.21	1.18	1.10						
21…30	1.18	1.14	1.08						
20				1.26	1.21	1.12	1.18	1.17	1.16
30				1.17	1.14	1.08			
40				1.15	1.12	1.07	1.10	1.09	1.08
60				1.10	1.08		1.06	1.05	1.04
80							1.05	1.04	1.04
90				1.07	1.055				
100							1.035	1.03	1.025
120				1.04	1.03				

Allowance for Divergent Electrode Dimensions
Naturally the core metal rod deposited per electrode changes if other electrode dimensions are used for performing a weld, i.e. a considerably higher number of thinner electrodes will be required than of thicker electrodes to fill the same weld volume.
A stub loss of 50 mm was taken into account for the following table and this applies to all dimensions. The metal recovery is 100 % for all dimensions.

diameter mm	length mm	allowance factor
1.5	250	6,83
2.0	250	3,84
2.0	300	3,07
2.5	250	2,46
2.5	300	1,97
3.2	300	1,20
3.2	350	1,00*
3.2	450	0,75
4.0	350	0,64
4.0	450	0,48
5.0	450	0,31
6.0	450	0,21

* reference for the approach used

Allowance for Divergent Metal Recovery
The metal recovery of a stick electrode is the ratio of the weight of weld metal deposited to the weight of core rod deposited. It depends on the type of electrode (e.g. contribution of metal flux powder from the electrode coating), the diameter of the electrode (usually somewhat higher with larger diameters), the welding current (increasing or decreasing slightly with the current depending on the type of coating) and the welding position (different spatter and burn-off losses).
In practical use it is sufficient to calculate using the multipliers in the following table. The table allows for standard classification in accordance with EN and the type of coating if greater deviations are to be reckoned with.

code acc. EN	type of coating	allowance factor
1 and 2	C	**1.25**
	R, RC	**1.11**
	RR	**1.05**
	B	**1.0****
3 and 4	R	**0.91**
	B	**0.87**
5 and 6	RA, RR, B	**0.71***
7 and 8	RA, RR, B	**0.56***

* With high-performance types Böhler Welding's brand designation provides a reference to the actual metal recovery. The multiplier should be corrected accordingly (e.g. 0.62 for FOX HL 160 Ti).

** Reference for the approach used

Allowance for Divergent Stump Losses

When determining the number of electrodes from the required weight of weld metal, allowance must also be made for the electrode stubs in addition to the losses included in metal recovery. The following table shows that with regard to the electrode requirement for a specific quantity of weld metal, the varying stub losses for which the welder is responsible have a greater effect on the calculation than variations in the metal recovery of a specific type of electrode.

In the case of stub lengths allowance must be made for the fact that the welder is not always wholly able to influence them. For example restricted access to the weld may easily lead to stub lengths over 80 mm. In this case the designer is responsible for ensuring good access. Out-of-position welds also result in longer stubs than welds in the gravity position.

diameter	length	allowance factor for different stub length values in mm				
mm	mm	40	50	60	70	80
1.5	250	**0.95**	**1.00**	**1.05**	**1.11**	**1.18**
2.0	250	**0.95**	**1.00**	**1.05**	**1.11**	**1.18**
2.0	300	**0.96**	**1.00**	**1.04**	**1.09**	**1.14**
2.5	250	**0.95**	**1.00**	**1.05**	**1.11**	**1.18**
2.5	300	**0.96**	**1.00**	**1.04**	**1.09**	**1.14**
3.2	300	**0.96**	**1.00**	**1.04**	**1.09**	**1.14**
3.2	350	**0.97**	**1.00**	**1.03**	**1.07**	**1.11**
3.2	450	**0.98**	**1.00**	**1.03**	**1.05**	**1.08**
4.0	350	**0.97**	**1.00**	**1.03**	**1.07**	**1.11**
4.0	450	**0.98**	**1.00**	**1.03**	**1.05**	**1.08**
5.0	450	**0.98**	**1.00**	**1.03**	**1.05**	**1.08**
6.0	450	**0.98**	**1.00**	**1.03**	**1.05**	**1.08**

Example for Calculation

A metal sheet with a thickness of 15 mm is to be joined in the horizontal-vertical position. Let the weld length be 10 m.

A vee weld with a preparation angle of 60 ° is chosen as the weld preparation. For quality assurance reasons the root will be back welded. A basic stick electrode will be used (the metal recovery code according to EN is 4). An electrode with ø 3.2 mm will be used for the root and an electrode with ø 4.0 mm will be used for the filler and cover passes. The stub length is assumed to be 70 mm.

	influencing factor		calculated values
	weight of weld without weld reinforcement	r f+c	0.15x10 = 1.5 kg 0.91x10 = 9.1 kg
x	factor for the effect of the welding position (weld reinforcement)		1.15
x	allowance for back welding (if necessary)		1.19
	reference value for the total weight of the weld	r f+c	**2.05 kg** **12.45 kg**
/	0.01894 kg/pcs. = weight of core metal rod deposited (ø3.2/350, stub 50 mm, metal recovery 100%)		0.01894
x	factor for divergent electrode dimension	r f+c	1.0 0.48
x	factor for divergent metal recovery		0.87
x	factor for divergent stub length	r f+c	1.07 1.05
	reference value for the number of electrodes required	r f+c	**101 Stk.** **289 Stk.**

r .. root pass, f .. filler layer, c .. cap layer

Explanations
The weight of the weld may be taken from the table "Reference Values for Manual Metal Arc Welding of Horizontal Vee Welds in Sheet Metal". This table is already divided into root, filler and cover passes for assistance. The factor for the influence of the welding position may be found in the appropriate section. The same applies to back welding of the root in which case the value is chosen depending on the thickness of the sheet, the shape of the weld and the weld preparation angle.

From this information the total weight of the weld should be determined divided into areas for different electrode dimensions.

The next line produces the number of electrodes if only one electrode with ø 3.2/350 with 50 mm stub and 100 % metal recovery were to be used. As a thicker electrode is used for the filler and cover passes, allowance must be made for the altered electrode dimension. Let the metal recovery be 115 %, which would result in a factor of 1/1.15 = 0.87. The altered stub length results in different effects depending on the electrode length.

The number of electrodes required as a result of division and multiplication is only a reference value to which a factor must be added for any waste due to bent, contaminated or incompletely used electrodes.

4.2.2 Estimation of Standard Welding Time

Actual Welding Time
Reduction of the costs by reducing the actual welding time is one of the most important tasks of production monitoring. In this case the actual welding time may be estimated within certain limits. However, a second factor that has just as great a significance for reduction of the overall costs is increasing the proportion of actual welding time in the overall time.

The approach shown here uses part of the calculation for the requirement of filler metal and the deposition rate of the individual electrodes.

=	**reference values for total weight of joint in kg**
/	deposition rate of consumable in kg/(h*A)
/	chosen amperage in A
x	60 min/h
=	**reference values for welding time in minutes**

The deposition rate is not shown for every single brand as the divergence resulting from the different welding conditions does not justify this level of detail. The following table presents a summary of deposition rates for different types of coating. In the case of ranges of values the lower value in each case should be assigned to the lower current intensity limit for this electrode.

type of stick electrode	deposition rate [kg/(h*A)] ø 1.5 mm	ø 2.0 mm	ø 2.5 mm	ø 3.2 mm	ø 4.0 mm	ø 5.0 mm	ø 6.0 mm
medium coated (rutile)							
R	0.01	0.009	0.009-0.015	0.009			
RC		0.01	0.010-0.011		0.009	0.009	
thick coated (rutile)							
RR		0.008	0.008	0.009	0.009	0.01	0.01
RC	0.009	0.009-0.0091	0.009	0.009	0.01	0.01	
AR			0.01-0.011	0.011	0.011	0.011	0.011
RB		0.008	0.008-0.009	0.008-0.009	0.009	0.009	
thick coated (basic)							
B			0.009-0.010	0.01	0.01	0.011	0.011
R(B)			0.009	0.01	0.01	0.011	
metal powder type							
RR (160 %)				0.012	0.013	0.014	0.015
RR (180 %)				0.014	0.015	0.016	0.016
RR (200 %)				0.016	0.017	0.018	
RR (240 %)					0.02	0.021	
AR (120 %)			0.012-0.014	0.011	0.011		

Example for Calculation

A metal sheet with a thickness of 15 mm is to be joined in the horizontal-vertical position. Let the weld length be 10 m.

A vee weld with a preparation angle of 60 ° is chosen as the weld preparation. For quality assurance reasons the root will be back welded. A basic stick electrode will be used (the metal recovery code according to EN is 4). An electrode with ø 3.2 mm will be used for the root and an electrode with ø 4.0 mm will be used for the filler and cover passes. The stub length is assumed to be 70 mm.

Thus the example is identical to the example for estimating the electrode requirement. The electrode is specified more particularly as BÖHLER FOX EV 50 to obtain a calculation variable.

	influencing factor	calculated values	
	weight of weld without weld reinforcement	r	0.15x10 = 1.5 kg
		f+c	0.91x10 = 9.1 kg
x	factor for the effect of the welding position (weld reinforcement)		1.15
x	allowance for back welding (if necessary)		1.19
	reference value for the total weight of the weld	r	2.05 kg
		f+c	12.45 kg
/	deposition rate of consumable in kg/(h*A)		0.010
/	chosen amperage in A	r	110
		f+c	160
x	60 min/h		60
	reference values for welding time in minutes	r	112 min
		f+c	467 min

r .. root pass, f .. filler layer, c .. cap layer

Duty Cycle

The proportion of actual welding time is often referred to as the “duty cycle”. This value specified in percent does not make any statement as an absolute variable about the efficiency of a method of working since with high-performance procedures where it is not possible to reduce the downtimes to the same extent as the actual welding time for example, the duty cycle may actually drop in percentage despite the total welding time being lower.

The downtimes that reduce the duty cycle may be dependent on the procedure, component, operating environment and the welder himself. The individual aspects are not dealt with in greater detail here. In any case an accurate analysis is required to find reference points for reducing the downtimes.

For the calculation of standard times attempts have been made time and again to specify reference values for the duty cycle. Values of this type range for example from 5 % for tack welds in assembly to over 30 % for individual production of machine casings and 55 % for series production of machine casings up to 70 % for series production of components in turn-over jigs. One may not overlook in this case that these figures have to be checked individually for each company or have to be compared with in-house statistics since investigations of different sizes of company in different sectors showed divergences in the average duty cycle between 30 and 75 %.

With statistically well-covered duty cycle values the standard time is calculated as follows:

Standard time = actual welding time / duty cycle x 100

5 Comparison Table for Hardness

Rm	Tensile Strength in N/mm²
HV	Vickers-Hardness
HB	Brinell-Hardness
HRC	Rockwell-C-Hardness

R_m	HV	HB	HRC	R_m	HV	HB	HRC	R_m	HV	HB	HRC
200	63	60	--	545	170	162	--	890	278	264	
210	65	62	--	550	172	163	--	900	280	266	27
220	69	66	--	560	175	166	--	910	283	269	
225	70	67	--	570	178	169	--	915	285	271	
230	72	68	--	575	180	171	--	920	287	273	28
240	75	71	--	580	181	172	--	930	290	276	
250	79	75	--	590	184	175	--	940	293	278	29
255	80	76	--	595	185	176	--	950	295	280	
260	82	78	--	600	187	178	--	960	299	284	
270	85	81	--	610	190	181	--	965	300	285	
280	88	84	--	620	193	184	--	970	302	287	30
285	90	86	--	625	195	185	--	980	305	290	
290	91	87	--	630	197	187	--	990	308	293	
300	94	89	--	640	200	190	--	995	310	295	31
305	95	90	--	650	203	193	--	1000	311	296	
310	97	92	--	660	205	195	--	1010	314	299	
320	100	95	--	670	208	198	--	1020	317	301	32
330	103	98	--	675	210	199	--	1030	320	304	
335	105	100	--	680	212	201	--	1040	323	307	
340	107	102	--	690	215	204	--	1050	327	311	33
350	110	105	--	700	219	208	--	1060	330	314	
360	113	107	--	705	220	209	--	1070	333	316	
370	115	109	--	710	222	211	--	1080	336	319	34
380	119	113	--	720	225	214	--	1090	339	322	
385	120	114	--	730	228	216	--	1095	340	323	
390	122	116	--	740	230	219	--	1100	342	325	
400	125	119	--	750	233	221	--	1110	345	328	35
410	128	122	--	755	235	223	--	1120	349	332	
415	130	124	--	760	237	225	--	1125	350	333	
420	132	125	--	770	240	228	--	1130	352	334	
430	135	128	--	780	243	231	21	1140	355	337	36
440	138	131	--	785	245	233		1150	358	340	
450	140	133	--	790	247	235		1155	360	342	
460	143	136	--	800	250	238	22	1160	361	343	
465	145	138	--	810	253	240		1170	364	346	37
470	147	140	--	820	255	242	23	1180	367	349	
480	150	143	--	830	258	245		1190	370	352	
490	153	145	--	835	260	247	24	1200	373	354	38
495	155	147	--	840	262	249		1210	376	357	
500	157	149	--	850	265	252		1220	380	361	
510	160	152	--	860	268	255	25	1230	382	363	39
520	163	155	--	865	270	257		1240	385	366	
530	165	157	--	870	272	258	26	1250	388	369	
540	168	160	--	880	275	261		1255	390	371	

Rm Tensile Strength in N/mm²
HV Vickers-Hardness
HB Brinell-Hardness
HRC Rockwell-C-Hardness

R_m	HV	HB	HRC
1260	392	372	40
1270	394	374	
1280	397	377	
1290	400	380	
1300	403	383	41
1310	407	387	
1320	410	390	
1330	413	393	42
1340	417	396	
1350	420	399	
1360	423	402	43
1370	426	405	
1380	430	409	
1390	431	410	
1400	434	413	44
1410	437	415	
1420	440	418	
1430	443	421	45
1440	446	424	
1450	449	427	
1455	450	428	
1460	452	429	
1470	455	432	
1480	458	435	46
1485	460	437	
1490	461	438	
1500	464	441	
1510	467	444	
1520	470	447	
1530	473	449	47
1540	476	452	
1550	479	455	
1555	480	456	
1560	481		
1570	484		48
1580	486		
1590	489		
1595	490		
1600	491		
1610	494		
1620	497		49
1630	500		
1640	503		

R_m	HV	HB	HRC
1650	506		
1660	509		
1665	510		
1670	511		
1680	514		50
1690	517		
1700	520		
1710	522		
1720	525		
1730	527		51
1740	530		
1750	533		
1760	536		
1770	539		
1775	540		
1780	541		
1790	544		52
1800	547		
1810	550		
1820	553		
1830	556		
1840	559		
1845	560		53
1850	561		
1860	564		
1870	567		
1880	570		
1890	572		
1900	575		
1910	578		54
1920	580		
1930	583		
1940	586		
1950	589		
1955	590		
1960	591		
1970	594		
1980	596		55
1990	599		
1995	600		
2000	602		
2010	605		
2020	607		

R_m	HV	HB	HRC
2030	610		
2040	613		
2050	615		56
2060	618		
2070	620		
2080	623		
2090	626		
2100	629		
2105	630		
2110	631		
2120	634		
2130	636		
2140	639		57
2145	640		
2150	641		
2160	644		
2170	647		
2180	650		
2190	653		
2200	655		58
	675		59
	698		60
	720		61
	745		62
	773		63
	800		64
	829		65
	864		66
	900		67
	940		68

5.1. Material Comparison Chart EN - DIN

As many users are still not familiar with the EN designation, this section of the manual contains recoding from the EN to the former DIN designation. Materials for which no direct recoding is possible are not listed. Designations based on the chemical composition are also excluded since the multipliers between DIN and EN standards have remained the same.

W-No.	EN-Classification	DIN-Classification	W-No.	EN-Classification	DIN-Classification
1.0468	**C14GAl**	15 Mn 3 Al	1.1151	**C22E**	Ck 22
1.0481	**P295GH**	17 Mn 4	1.1158	**C25E**	Ck 25
1.0482	**P310GH**	19 Mn 5	1.1178	**C30E**	Ck 30
1.0473	**P355GH**	19 Mn 6	1.1181	**C35E**	Ck 35
1.8980	**S500QGL**	5 CuNi 12 3	1.1005	**C3E**	Ck 4
1.0647	**C85**	85 Mn 3	1.1186	**C40E**	Ck 40
1.0428	**B420N**	BSt 420 S	1.1191	**C45E**	Ck 45
1.0464	**B500G1**	BSt 500 G	1.1195	**C45EPb**	Ck 45 Pb
1.0466	**B500G3**	BSt 500 M	1.1198	**C48EMn**	Ck 48 Mn
1.0465	**B500G2**	BSt 500 P	1.1010	**C5E**	Ck 5
1.0438	**B500N**	BSt 500 S	1.1206	**C50E**	Ck 50
1.0302	**C10GPb**	C 10 Pb	1.1210	**C53E**	Ck 53
1.1545	**C105U**	C 105 W1	1.1203	**C55E**	Ck 55
1.1554	**C110U**	C 110 W	1.1107	**C6E**	Ck 6
1.1563	**C125U**	C 125 W	1.1221	**C60E**	Ck 60
1.1573	**C135U**	C 135 W	1.1231	**C67E**	Ck 67
1.0403	**C15GPb**	C 15 Pb	1.1234	**C68E**	Ck 68
1.0402	**C22**	C 22	1.1009	**C7E**	Ck 7
1.0404	**C22GPb**	C 22 Pb	1.1248	**C75E**	Ck 75
1.0427	**C22G1**	C 22.3	1.1269	**C85E**	Ck 85
1.0460	**C22G2**	C 22.8	1.1140	**C15R**	Cm 15
1.0406	**C25**	C 25	1.1149	**C22R**	Cm 22
1.0528	**C30**	C 30	1.1163	**C25R**	Cm 25
1.0501	**C35**	C 35	1.1179	**C30R**	Cm 30
1.0502	**C35GPb**	C 35 Pb	1.1180	**C35R**	Cm 35
1.0511	**C40**	C 40	1.1189	**C40R**	Cm 40
1.0503	**C45**	C 45	1.1201	**C45R**	Cm 45
1.0504	**C45GPb**	C 45 Pb	1.1241	**C50R**	Cm 50
1.1730	**C45U**	C 45 W	1.1205	**C53R**	Cm 53
1.0540	**C50**	C 50	1.1209	**C55R**	Cm 55
1.0535	**C55**	C 55	1.1223	**C60R**	Cm 60
1.0537	**C55GPb**	C 55 Pb	1.3991	**CoNiCr26-20**	CoNiCr 26 20
1.0601	**C60**	C 60	1.1122	**C10C**	Cq 10
1.0602	**C60GPb**	C 60 Pb	1.1132	**C15C**	Cq 15
1.1740	**C60U**	C 60 W	1.1152	**C22C**	Cq 22
1.0627	**C68**	C 68	1.1172	**C35C**	Cq 35
1.1520	**C70U**	C 70 W	1.1192	**C45C**	Cq 45
1.1525	**C80U**	C 80 W1	1.0310	**C10D**	D 10-2
1.1830	**C85U**	C 85 W	1.0413	**C15D**	D 15-2
1.1183	**C35G**	Cf 35	1.0414	**C20D**	D 20-2
1.1193	**C45G**	Cf 45	1.0415	**C26D**	D 25-2
1.1213	**C53G**	Cf 53	1.0530	**C32D**	D 30-2
1.1219	**C54G**	Cf 54	1.0516	**C38D**	D 35-2
1.1249	**C70G**	Cf 70	1.0541	**C42D**	D 40-2
1.1121	**C10E**	Ck 10	1.0517	**C48D**	D 45-2
1.1274	**C101E**	Ck 101	1.0586	**C50D**	D 50-2
1.1130	**C12E**	Ck 12	1.0588	**C52D**	D 53-2
1.1141	**C15E**	Ck 15	1.1202	**C52D2**	D 53-3
1.1135	**C16EAl**	Ck 16 Al	1.0518	**C56D**	D 55-2
1.1134	**C19E**	Ck 19	1.1220	**C56D2**	D 55-3

W-No.	EN-Classification	DIN-Classification
1.0609	**C58D**	D 58-2
1.1212	**C58D2**	D 58-3
1.0610	**C60D**	D 60-2
1.1228	**C60D2**	D 60-3
1.0611	**C62D**	D 63-2
1.1222	**C62D2**	D 63-3
1.0612	**C66D**	D 65-2
1.1236	**C66D2**	D 65-3
1.0613	**C68D**	D 68-2
1.1232	**C68D2**	D 68-3
1.0615	**C70D**	D 70-2
1.0617	**C72D**	D 73-2
1.1242	**C72D2**	D 73-3
1.0614	**C76D**	D 75-2
1.1253	**C76D2**	D 75-3
1.0620	**C78D**	D 78-2
1.1252	**C78D2**	D 78-3
1.0622	**C80D**	D 80-2
1.1255	**C80D2**	D 80-3
1.0313	**C7D**	D 8-2
1.0626	**C82D**	D 83-2
1.1262	**C82D2**	D 83-3
1.0616	**C86D**	D 85-2
1.1265	**C86D2**	D 85-3
1.0628	**C88D**	D 88-2
1.1272	**C88D2**	D 88-3
1.0010	**C8D**	D 9
1.0618	**C92D**	D 95-2
1.1282	**C92D2**	D 95-3
1.0373	**T550**	DR 550
1.0374	**T620**	DR 620
1.0376	**T660**	DR 660
1.0393	**DC13ED**	ED 3
1.0394	**DC04ED**	ED 4
1.0391	**DC12EK**	EK 2
1.0392	**DC04EK**	EK 4
1.1103	**S255NL1**	EStE 255
1.1104	**P275NL2**	EStE 285
1.1105	**S315NL1**	EStE 315
1.1106	**P355NL2**	EStE 355
1.8911	**S380NL1**	EStE 380
1.8913	**S420NL1**	EStE 420
1.8918	**P460NL2**	EStE 460
1.8919	**S500NL1**	EStE 500
1.8984	**S500QL1**	EStE 500 V
1.8986	**S550QL1**	EStE 550 V
1.8944	**S550G1QL1**	EStE 550 V A
1.8987	**S620QL1**	EStE 620 V
1.8954	**S620G1QL1**	EStE 620 V A
1.8988	**S690QL1**	EStE 690 V
1.8964	**S690G1QL1**	EStE 690 V A
1.8939	**S790QL1**	EStE 790 V
1.8925	**S890QL1**	EStE 890 V
1.1230	**C65S1**	Federstahldraht FD
1.1250	**C65S2**	Federstahldraht VD
1.0829	**M1000-65A**	FeV 1000-65 HA
1.0555	**S355GO1**	FStE 355 OS 1
1.0559	**S355GO2**	FStE 355 OS 2
1.0591	**S355GO3**	FStE 355 OS 3
1.1102	**S355GO4**	FStE 355 OS 4
1.8858	**S355GO5**	FStE 355 OS 4 A
1.8822	**S355G1M**	FStE 355 TM
1.8854	**S420GO1**	FStE 420 OS 1
1.8855	**S420GO2**	FStE 420 OS 2
1.8856	**S420GO3**	FStE 420 OS 3
2.4778	**CoCr28**	G-CoCr 28
2.4779	**CoCr28Nb**	G-CoCr 28 Nb
1.0440	**S235JRS1**	GL-A
1.0441	**S235JRS2**	GL-A
1.0513	**S315G1S**	GL-A 32
1.0583	**S355G1S**	GL-A 36
1.0532	**S390G1S**	GL-A 40
1.0442	**S235J0S**	GL-B
1.0475	**S235J2S1**	GL-D
1.0474	**S235J2S2**	GL-D
1.0514	**S315G2S**	GL-D 32
1.0584	**S355G2S**	GL-D 36
1.0534	**S390G2S**	GL-D 40
1.0476	**S235J4S**	GL-E
1.0515	**S315G3S**	GL-E 32
1.0589	**S355G3S**	GL-E 36
1.0560	**S390G3S**	GL-E 40
1.8840	**S315G4S**	GL-F 32
1.8841	**S355G4S**	GL-F 36
1.8842	**S390G4S**	GL-F 40
1.0345	**P235GH**	H I
1.0425	**P265GH**	H II
1.0435	**P285NH**	H III
1.0445	**P295NH**	H IV
1.0873	**DC06**	IF 18
1.0120	**S235JRC**	K.Q.Z St 37-2
1.0118	**S235J2G3C**	K.Q.Z St 37-3 N
1.0115	**S235J0C**	K.Q.Z St 37-3 U
1.0128	**S275JRC**	K.Q.Z St 44-2
1.0141	**S275J2G3C**	K.Q.Z St 44-3 N
1.0140	**S275J0C**	K.Q.Z St 44-3 U
1.0569	**S355J2G3C**	K.Q.Z St 52-3 N
1.0554	**S355J0C**	K.Q.Z St 52-3 U
1.1004	**C2E**	Mk 3
1.1291	**C97E**	Mk 97
2.4661	**EL-NiCr29Mo5W**	NiCr22Fe20Mo6AlCuTi
1.0538	**E295GF**	PSt 50-2
1.0572	**S355J2G3F**	PSt 52-3
1.0303	**C4C**	QSt 32-3
1.0213	**C7C**	QSt 34-3
1.0214	**C11C**	QSt 36-3
1.0587	**S355J2G3CuC**	QSt 52-3 Cu 3
1.0971	**S260NC**	QStE 260 N
1.0970	**S260MC**	QStE 260 TM
1.0973	**S315NC**	QStE 300 N
1.0972	**S315MC**	QStE 300 TM
1.0975	**S340NC**	QStE 340 N
1.0974	**S340MC**	QStE 340 TM
1.0977	**S355NC**	QStE 360 N
1.0976	**S355MC**	QStE 360 TM
1.0979	**S380NC**	QStE 380 N
1.0978	**S380MC**	QStE 380 TM
1.0981	**S420NC**	QStE 420 N
1.0980	**S420MC**	QStE 420 TM
1.0983	**S460NC**	QStE 460 N
1.0982	**S460MC**	QStE 460 TM
1.0985	**S500NC**	QStE 500 N
1.0984	**S500MC**	QStE 500 TM
1.0987	**S550NC**	QStE 550 N

W-No.	EN-Classification	DIN-Classification	W-No.	EN-Classification	DIN-Classification
1.0986	**S550MC**	QStE 550 TM	1.0305	**P235G1TH**	St 35.8
1.8976	**S650MC**	QStE 650 TM	1.0254	**P235T1**	St 37.0
1.0703	**C10RG2**	R 10 S 10	1.0255	**P235T2**	St 37.4
1.0709	**C7RG2**	R 7 S 6	1.0315	**P235G2TH**	St 37.8
1.0337	**DC04GT**	RoSt 4	1.0037	**S235JR**	St 37-2
1.0149	**S275J0H**	RoSt 44-2	1.0169	**S235JRCu+CR**	St 37-2 Cu 3 G
1.0138	**S275J2H**	RoSt 44-3	1.0037	**S235JR+CR**	St 37-2 G
1.0576	**S355J2H**	RoSt 52-3	1.0116	**S235J2G3**	St 37-3
1.0122	**S235JRG2C**	RQSt 37-2	1.0166	**S235J2G3Cu**	St 37-3 Cu 3
1.0170	**S235JRG2CuC**	RQSt 37-2 Cu 3	1.0116	**S235J2G3+CR**	St 37-3 G
1.0351	**C10W**	RRSD 10	1.0114	**S235J0**	St 37-3 U
1.0347	**DC03**	RRSt 3, RRSt 13	1.0338	**DC04**	St 4, St 14
1.0319	**L210GA**	RRStE 210.7	1.0498	**P255G2TH**	St 42.8
1.0459	**L240GA**	RRStE 240.7	1.0256	**P275T1**	St 44.0
1.0398	**DD12**	RRStW 23	1.0257	**P275T2**	St 44.4
1.0339	**C10WSi**	RSD 10 Si	1.0044	**S275JR**	St 44-2
1.1115	**C10EW**	RSD 11	1.0179	**S275JRCu**	St 44-2 Cu 3
1.0324	**C8G2W**	RSD 7	1.0144	**S275J2G3**	St 44-3
1.0326	**S180G2T**	RSt 28	1.0144	**S275J2G3+CR**	St 44-3 G
1.0034	**S205G2T**	RSt 34-2	1.0143	**S275J0**	St 44-3 U
1.0208	**C10G2**	RSt 35-2	1.0408	**S255GT**	St 45
1.0205	**C11G2**	RSt 36	1.0405	**P255G1TH**	St 45.8
1.0038	**S235JRG2**	RSt 37-2	1.0050	**E295**	St 50-2
1.0167	**S235JRG2Cu**	RSt 37-2 Cu 3	1.0050	**E295+CR**	St 50-2 G
1.0223	**C14G2**	RSt 38	1.0580	**S355GT**	St 52
1.3207	**HS10-4-3-10**	S 10-4-3-10	1.0421	**P355T1**	St 52.0
1.3318	**HS12-1-2**	S 12-1-2	1.0581	**P355T2**	St 52.4
1.3302	**HS12-1-4**	S 12-1-4	1.0570	**S355J2G3**	St 52-3
1.3202	**HS12-1-4-5**	S 12-1-4-5	1.0585	**S355J2G3Cu**	St 52-3 Cu 3
1.3355	**HS18-0-1**	S 18-0-1	1.0585	**S355J2G3Cu+CR**	St 52-3 Cu 3 G
1.3265	**HS18-1-2-10**	S 18-1-2-10	1.0570	**S355J2G3+CR**	St 52-3 G
1.3257	**HS18-1-2-15**	S 18-1-2-15	1.0553	**S355J0**	St 52-3 U
1.3255	**HS18-1-2-5**	S 18-1-2-5	1.0060	**E335**	St 60-2
1.3247	**HS2-10-1-8**	S 2-10-1-8	1.0060	**E335+CR**	St 60-2 G
1.3346	**HS2-9-1**	S 2-9-1	1.0070	**E360**	St 70-2
1.3348	**HS2-9-2**	S 2-9-2	1.0070	**E360+CR**	St 70-2 G
1.3249	**HS2-9-2-8**	S 2-9-2-8	1.0307	**L210**	StE 210.7
1.3333	**HS3-3-2**	S 3-3-2	1.0457	**L245NB**	StE 240.7
1.3343	**HS6-5-2**	S 6-5-2	1.0242	**S250GD**	StE 250 Z
1.3341	**HS6-5-2S**	S 6-5-2 S	1.0461	**S255N**	StE 255
1.3243	**HS6-5-2-5**	S 6-5-2-5	1.0244	**S280GD**	StE 280 Z
1.3245	**HS6-5-2-5S**	S 6-5-2-5 S	1.0486	**P275N**	StE 285
1.3344	**HS6-5-3**	S 6-5-3	1.0490	**S275N**	StE 285
1.3246	**HS7-4-2-5**	S 7-4-2-5	1.0493	**S275NH**	StE 285
1.3342	**HS6-5-2C**	SC 6-5-2	1.0484	**L290NB**	StE 290.7
1.3340	**HS6-5-2CS**	SC 6-5-2 S	1.0429	**L290MB**	StE 290.7 TM
2.4623	**EL-NiCr23Mo7Cu**	SG-NiCr23Mo7Cu	1.0505	**P315N**	StE 315
1.1237	**C70D3**	SKD 70	1.0250	**S320GD**	StE 320 Z
1.1238	**C80D3**	SKD 80	1.0409	**L320**	StE 320.7
1.0226	**DX51D**	St 02 Z	1.0430	**L320M**	StE 320.7 TM
1.0350	**DX52D**	St 03 Z	1.0529	**S350GD**	StE 350 Z
1.0355	**DX53D**	St 05 Z	1.0562	**P355N**	StE 355
1.0306	**DX54D**	St 06 Z	1.0545	**S355N**	StE 355
1.0344	**DC01Cu**	St 12 Cu 3	1.0539	**S355NH**	StE 355
1.0354	**DC04Cu**	St 14 Cu 3	1.8823	**S355M**	StE 355 TM
1.0312	**DC05**	St 15	1.0582	**L360NB**	StE 360.7
1.0318	**S180GT**	St 28	1.0578	**L360MB**	StE 360.7 TM
1.0212	**S215GAlT**	St 30 Al	1.8900	**S380N**	StE 380
1.0211	**S215GSiT**	St 30 Si	1.8970	**L385N**	StE 385.7
1.0035	**S185**	St 33	1.8971	**L385M**	StE 385.7 TM
1.0032	**S205GT**	St 34-2	1.8972	**L415NB**	StE 415.7
1.0308	**S235G2T**	St 35	1.8973	**L415MB**	StE 415.7 TM

W-No.	EN-Classification	DIN-Classification
1.8902	**S420N**	StE 420
1.8825	**S420M**	StE 420 TM
1.8975	**L450MB**	StE 445.7 TM
1.8905	**P460N**	StE 460
1.8901	**S460N**	StE 460
1.8953	**S460NH**	StE 460
1.8827	**S460M**	StE 460 TM
1.8977	**L485MB**	StE 480.7 TM
1.8907	**S500N**	StE 500
1.8924	**S500Q**	StE 500 V
1.8904	**S550Q**	StE 550 V
1.8978	**L555MB**	StE 550.7 TM
1.8914	**S620Q**	StE 620 V
1.8931	**S690Q**	StE 690 V
1.8979	**L690M**	StE 690.7 TM
1.0915	**R1100Cr**	StSch 1100
1.0631	**R1200**	StSch 1200
1.0422	**R0550**	StSch 550
1.0544	**R0600**	StSch 600
1.0521	**R0700**	StSch 700
1.0524	**R0800**	StSch 800
1.0623	**R0900**	StSch 900 A
1.0624	**R0900Mn**	StSch 900 B
1.0341	**R0290**	StSchStr
1.0021	**S240GP**	StSp 37
1.0023	**S270GP**	StSp 45
1.0083	**S355GP**	StSp S
1.0332	**DD11**	StW 22
1.0335	**DD13**	StW 24
1.0371	**TH50**	T 50
1.0372	**TH52**	T 52
1.0375	**TH57**	T 57
1.0377	**TH61**	T 61
1.0378	**TH65**	T 65
1.0463	**S255NL**	TStE 255
1.0488	**P275NL1**	TStE 285
1.0491	**S275NL**	TStE 285
1.0497	**S275NLH**	TStE 285
1.0508	**P315NL**	TStE 315
1.0566	**P355NL1**	TStE 355
1.0546	**S355NL**	TStE 355
1.0549	**S355NLH**	TStE 355
1.8834	**S355ML**	TStE 355 TM
1.8910	**S380NL**	TStE 380
1.8912	**S420NL**	TStE 420
1.8836	**S420ML**	TStE 420 TM
1.8915	**P460NL1**	TStE 460
1.8903	**S460NL**	TStE 460
1.8956	**S460NLH**	TStE 460
1.8838	**S460ML**	TStE 460 TM
1.8906	**S460QL**	TStE 460 V
1.8917	**S500NL**	TStE 500
1.8909	**S500QL**	TStE 500 V
1.8926	**S550QL**	TStE 550 V
1.8923	**S590QL**	TStE 590 V
1.8927	**S620QL**	TStE 620 V
1.8928	**S690QL**	TStE 690 V
1.8920	**S690G1QL**	TStE 690 V A
1.8921	**S690G2QL**	TStE 690 V B
1.8922	**S690G4QL**	TStE 690 V C
1.8929	**S690G3QL**	TStE 690 V D
1.8938	**S770QL**	TStE 770 V
1.8983	**S890QL**	TStE 890 V
1.8933	**S960QL**	TStE 960 V
1.1101	**S225NL**	TTSt 35
1.0702	**C10RG1**	U 10 S 10
1.0708	**C7RG1**	U 7 S 6
1.0348	**P195GH**	UH I
1.0160	**S235JRG1F**	UPSt 37-2
1.0204	**C11G1C**	UQSt 36
1.0121	**S235JRG1C**	UQSt 37-2
1.0164	**S235JRG1CuC**	UQSt 37-2 Cu 3
1.0224	**C14G1C**	UQSt 38
1.1112	**C8E1W**	USD 5
1.1116	**C8E2W**	USD 6
1.0323	**C8G1W**	USD 7
1.0357	**S180G1T**	USt 28
1.0333	**DC03G1**	USt 3, USt 13
1.0028	**S205G1T**	USt 34-2
1.0207	**C10G1**	USt 35-2
1.0203	**C11G1**	USt 36
1.0253	**P235G1T1**	USt 37.0
1.0036	**S235JRG1**	USt 37-2
1.0036	**S235JRG1+CR**	USt 37-2 G
1.0217	**C14G1**	USt 38
1.0336	**DC04G1**	USt 4, USt 14
1.0334	**DD12G1**	UStW 23
1.0834	**M<35A**	V < 35 A
1.0833	**M>65A**	V > 65 A
1.0832	**M>65ASi**	V > 65 A Si
1.0805	**M>350-35A**	V >350-35 A
1.0830	**M1070-65A**	V 1070-65 A
1.0818	**M1450-50A**	V 1450-50 A
1.0831	**M1590-65A**	V 1590-65 A
1.0800	**M250-35A**	V 250-35 A
1.0801	**M270-35A**	V 270-35 A
1.0806	**M270-50A**	V 270-50 A
1.0807	**M290-50A**	V 290-50 A
1.0803	**M300-35A**	V 300-35 A
1.0808	**M310-50A**	V 310-50 A
1.0804	**M330-35A**	V 330-35 A
1.0809	**M330-50A**	V 330-50 A
1.0819	**M330-65A**	V 330-65 A
1.0810	**M350-50A**	V 350-50 A
1.0820	**M350-65A**	V 350-65 A
1.0811	**M400-50A**	V 400-50 A
1.0821	**M400-65A**	V 400-65 A
1.0812	**M470-50A**	V 470-50 A
1.0823	**M470-65A**	V 470-65 A
1.0813	**M530-50A**	V 530-50 A
1.0824	**M530-65A**	V 530-65 A
1.0814	**M600-50A**	V 600-50 A
1.0825	**M600-65A**	V 600-65 A
1.0815	**M700-50A**	V 700-50 A
1.0826	**M700-65A**	V 700-65 A
1.0816	**M800-50A**	V 800-50 A
1.0827	**M800-65A**	V 800-65 A
1.0817	**M940-50A**	V 940-50 A
1.0828	**M940-65A**	V 940-65 A
1.0840	**M<50E**	VE < 50
1.0850	**M>65E**	VE > 65
1.0841	**M340-50E**	VE 340-50
1.0842	**M390-50E**	VE 390-50
1.0846	**M390-65E**	VE 390-65

W-No.	EN-Classification	DIN-Classification	W-No.	EN-Classification	DIN-Classification
1.0843	**M450-50E**	VE 450-50	1.0506	**P315NH**	WStE 315
1.0847	**M450-65E**	VE 450-65	1.0565	**P355NH**	WStE 355
1.0848	**M520-65E**	VE 520-65	1.8930	**P380NH**	WStE 380
1.0844	**M560-50E**	VE 560-50	1.8932	**P420NH**	WStE 420
1.0849	**M630-65E**	VE 630-65	1.8935	**P460NH**	WStE 460
1.0845	**M660-50E**	VE 660-50	1.8937	**P500NH**	WStE 500
1.0851	**M800-65E**	VE 800-65	1.8960	**S235JRW**	WTSt 37-2
1.0360	**M>65D**	VH > 65	1.8961	**S235J2W**	WTSt 37-3
1.0365	**M1000-65D**	VH 1000-65	1.8963	**S355J2G1W**	WTSt 52-3
1.0363	**M1050-50D**	VH 1050-50	1.0533	**E295GC**	ZSt 50-2
1.0369	**M1100-65D**	VH 1100-65	1.0543	**E335GC**	ZSt 60-2
1.0366	**M1200-65D**	VH 1200-65	1.0633	**E360GC**	ZSt 70-2
1.0361	**M660-50D**	VH 660-50	1.0395	**H180B**	ZStE 180 BH
1.0364	**M800-65D**	VH 800-65	1.0396	**H220B**	ZStE 220 BH
1.0362	**M890-50D**	VH 890-50	1.0397	**H220P**	ZStE 220 P
1.0881	**M111-30P**	VM 111-30 P	1.0480	**H260**	ZStE 260
1.0856	**M111-35N**	VM 111-35 N	1.0400	**H260B**	ZStE 260 BH
1.0882	**M117-30P**	VM 117-30 P	1.0417	**H260P**	ZStE 260 P
1.0866	**M130-27S**	VM 130-27 S	1.0489	**H300**	ZStE 300
1.0862	**M140-30S**	VM 140-30 S	1.0444	**H300B**	ZStE 300 BH
1.0857	**M150-35S**	VM 155-35 S	1.0448	**H300P**	ZStE 300 P
1.0865	**M089-27N**	VM 89-27 N	1.0548	**H340**	ZStE 340
1.0861	**M097-30N**	VM 97-30 N	1.0550	**H380**	ZStE 380
1.0462	**P255NH**	WStE 255	1.0556	**H420**	ZStE 420
1.0487	**P275NH**	WStE 285	1.0574	**H460**	ZStE 460

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