Böhler
WELDING

WELDING CONSUMABLES
FOR THERMAL POWER STATIONS

Editorial

BÖHLER WELDING provides welding solutions for thermal power stations since 1926. An assortment of world class filler metals is available for the fabrication of boilers, nuclear reactors, casings for steam and gas turbines and other components. Whenever high temperature- and creep resistance are essential, BÖHLER WELDING is the competent partner and supplier.

In addition, BÖHLER WELDING offers a comprehensive range of corrosion resistant alloys, such as stainless steel and nickel base welding consumables for the construction of flue gas desulphurisation units and other applications.

Increased environmental requirements and the need for higher thermal efficiencies are driving the development of new materials for power stations. BÖHLER WELDING develops the matching filler metals in close cooperation with leading steel manufacturers. The latest developments can always be related to state-of-the-art base material like the steel grades T/P23 and T/P24, T/P91 and T/P92.

High demanding industries call for advanced product standards, consistent product quality and best operating characteristics to guarantee safe operating conditions and extend the life of today's modern plant operations. That´s why BÖHLER WELDING´s high temperature and creep resisting welding consumables have achieved a leading market position.
A comprehensive worldwide sales network of well-stocked partners ensures rapid and punctual delivery in more than 80 countries, on every contintent.

Your nearest sales partner can be found on the Internet at www.boehler-welding.com

BÖHLER WELDING consumables are available in moisture resistant and hermetically sealed packs.

Selection guide

	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	5
High strength steels							
Re ≤ 500 MPa	SA508 Cl.2	FOX EV 65			NiMo 1-IG	3 NiMo 1-UP+BB 24	6
High Temperature and creep resistant steels							
0,5Mo	P/T1	FOX DMO Ti, Kb	(DMO)	DMO-IG	DMO-IG	EMS 2Mo+BB 24	7
1Cr 0,5Mo	P/T11	FOX DCMS Ti, Kb	(DCMS)	DCMS-IG	DCMS-IG	EMS 2 CrMo+BB 24	7, 8
1.25Cr 1Mo+V	–	FOX DCMV					8
0,5Cr 1Mo +V	–	FOX DMV 83Kb		DMV 83-IG	DMV 83-IG		9
2.25Cr 1Mo	P/T22	FOX CM 2Kb		CM 2-IG	CM 2-IG	CM 2-UP+BB 24	9
2.25Cr 1Mo (mod.)	P/T23	FOX P 23		P 23-IG		P 23-UP+BB 430	10
	P/T24	FOX P 24		P 24-IG		P 24-UP+BB 430	10
5Cr 0,5Mo	P/T5	FOX CM 5Kb		CM 5-IG	CM 5-IG	CM 5-UP+BB 24	11
9Cr 1Mo	P/T9	FOX CM 9Kb		C M 9-IG			11
9Cr 1Mo +V(W)	P/T91	FOX C 9 MV		C 9 MV-IG	C 9 MV-IG	C 9 MV-UP+BB 910	11, 12
					C 9 MV-MC		12
	–	FOX C 9 MVW		C 9 MVW-IG			12, 13
	P/T92	FOX P 92		P 92-IG		P 92-UP+BB 910	13
12Cr 1Mo +VW	–	FOX 20 MVW		20 MVW-IG	CN 18/11-IG	20 MVW-UP+BB 24	14, 15
18Cr 11Ni	304H	FOX CN 18/11		CN 18/11-IG		CN 18/11-UP+BB 202	14, 15
		FOX E 308 H	E 308 H-FD	ER 308 H-IG			15
			E 308 H PW-FD				15
18Cr 10Ni +Nb	347H	FOX E 347 H					15
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	16
		FOX A 7-A	A 7 PW-FD		A 7-MC		16
Heat resistant							
25Cr 4Ni	327	FOX FA		FA-IG	FA-IG		17
22Cr 12Ni	309	FOX FF		FF-IG	FF-IG		17
		FOX FF-A					17
25Cr 20Ni	310	FOX FFB		FFB-IG	FFB-IG		17
		FOX FFB-A					17
21Cr 33Ni Mn	N08810/800H	FOX CN 21/33 Mn		CN 21/33 Mn-IG	CN 21/33 Mn-IG		18
Nickel base alloys							
Alloy 800	N06600	FOX NIBAS 70/15					19
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	19
Alloy 625	N06625	FOX NIBAS 625	NIBAS 625-FD	NIBAS 625-IG	NIBAS 625-IG	NIBAS 625-UP+BB 444	20
Alloy 617	N06617	FOX NIBAS 617		NIBAS 617-IG	NIBAS 617-IG	NIBAS 617-UP+BB 444	20

Dissimilar welds with high temperature steels

	P/T1 16Mo3	**P/T11** 13CrMo4-5	**P/T22** 10CrMo9-10	**P/T5** X12CrMo5	**P/T9** X12CrMo9-1	**P/T91** X10CrMoV Nb9-1	**P/T92** –	**P/T23** –	**P/T24** 7CrMoVTiB 10-10	**304H** X6CrNi18-11	**321H** X12CrNiTi 18-10	**347H** X12CrNiNb 18-10
P/T1 16Mo3		FOX DMO Kb	FOX DMO Kb	FOX DCMS Kb	FOX CM 2 Kb	FOX CM 2 Kb	FOX CM 2 Kb	FOX DCMS Kb	FOX DCMS Kb	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T11 13CrMo4-5			FOX DCMS Kb	FOX CM 2 Kb	FOX CM 2 Kb	FOX CM 2 Kb	FOX CM 2 Kb	FOX DCMS Kb	FOX DCMS Kb	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T22 10CrMo9-10				FOX CM 2 Kb	FOX CM 5 Kb	FOX CM 5 Kb	FOX CM 5 Kb	FOX CM 2 Kb	FOX CM 2 Kb	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T5 X12CrMo5					FOX CM 5 Kb	FOX CM 5 Kb	FOX CM 5 Kb	FOX P 23	FOX P 24	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T9 X12CrMo9-1						FOX CM 9 MV	FOX CM 9 MV	FOX P 23	FOX P 24	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T91 X10CrMoV Nb9-1							FOX CM 9 MV	FOX P 23	FOX P 24	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T92 –								FOX P 23	FOX P 24	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T23 –									FOX P 24	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
P/T24 7CrMoVTiB 10-10										FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15	FOX NIBAS 70/20 FOX NIBAS 70/15
304H X6CrNi18-11											FOX CN 18/11 FOX E308H	FOX CN 18/11 FOX E308H FOX E347H
321H X12CrNiTi 18-10												FOX E347H
347H X12CrNiNb 18-10												

Remark:
All welding consumables mentioned in this table refer to arc welding with covered electrodes. Consumables for other welding processes are applicable according to their availability like described in the data portion of this brochure. Always adjust your final decision for a certain filler metal to the individual requirements of a construction. Please contact our technical department for further information.

Mild steels

BÖHLER Standard EN AWS	Welding process	Typical analysis %	Typical mechanical properties	Ø mm	Approvals	Characteristics and applications	Base metals
FOX EV 50 E 42 5 B 4 2 H5 E7018-1H4R	SMAW	C 0.07 Si 0.5 Mn 1.1	Re 490 N/mm^2 Rm 560 N/mm^2 A5 27% Av 190 J 100 J…-50 °C	2.0 2.5 3.2 4.0 5.0 6.0	TÜV-D, DB, ÖBB, TÜV-A, ABS, BV, DNV, FI, GL, ISPESL, LR, RMR, RINA, CE, LTSS, VUZ, SEPROZ, PDO, CRS	Basic 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 (acc. AWS condition HD < 4 ml/100 g). 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.	Steels up to a yield strength of 420 N/mm^2 (60 KSI). e.g. P235G1TH, P265GH – P295GH P310GH, P355T1, P355NH **ASTM e.g.** SA106A + B SA515 Gr.60-70 SA516 Gr.55-70
EMK 6 G3Si1(GMAW) W3Si1(GTAW) ER70S-6	GMAW	C 0.08 Si 0.9 Mn 1.45	Re 440 N/mm^2 Rm 530 N/mm^2 A5 30% Av 160 J 80 J…-40 °C Ar +15-25 % CO_2	0.8 1.0 1.2 1.6	TÜV-D, DB, ÖBB, FI, TÜV-A, GL, ABS, CWB, LR, LTSS, CE, SEPROZ	GMAW wire and GTAW rod for joints in boiler and vessel fabrication as well as in structural steel engineering. 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.	
	GTAW	C 0.08 Si 0.9 Mn 1.45	Re 430 N/mm^2 Rm 540 N/mm^2 A5 27% Av 160 J >47 J…-50 °C	1.6 2.0 2.4	TÜV-D, TÜV-A, LTSS, SEPROZ, CE		
Ti 52-FD T 46 2 P M 1 H10 T 42 2 P C 1 H5 E71T-1H4 E71T-1MH8	FCAW	C 0.06 Si 0.5 Mn 1.2 Ti +	Re 490 N/mm^2 Rm 580 N/mm^2 A5 26% Av 180 J 90 J…-40 °C	1.2 1.6	TÜV-D, ABS, BV, DNV, GL, LR, CRS	All position rutile flux-cored wire with fast freezing slag system. User friendly welding characteristics in all positions with one wire diameter 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.	Steels up to a yield strength of 460 N/mm^2 (60 KSI). e.g. P235G1TH, P265GH – P295GH, P310GH, P355T1, P355NH **ASTM e.g.** SA106 A+B SA515 Gr.60-70 SA516 Gr.55-70
Wire: EMS 2 S2 EM12K **Flux: BB 24** SA FB 1 65 DC H5	SAW	C 0.07 Si 0.25 Mn 1.05	Re 440 N/mm^2 Rm 520 N/mm^2 A5 33% Av 185 J 140 J…-60 °C	2.0 2.5 3.0 3.2 4.0	TÜV-D **Wire:** TÜV-D, TÜV-A, DB, ÖBB, KTA 1408.1, SEPROZ, CE	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 (≤ 5 ml/100 g) are further important features. The combination is ideally suited for multi-pass welding of thick plates.	Steels up to a yield strength of 400 N/mm^2 (60 KSI). e.g. P235G1TH, P265GH – P295GH, P310GH, P355T1, P355NH **ASTM e.g.** SA106 A+B SA515 Gr.60, 65 SA516 Gr.55-65

High strength steels

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX EV 65 E 55 6 1 NiMo B 42 H5 E8018-GH4R	SMAW	C 0.06 Si 0.3 Mn 1.2 Ni 0.8 Mo 0.35	Re 600 N/mm² Rm 650 N/mm² A5 25% Av 180 J 80 J…-60 °C	2.5 3.2 4.0	TÜV-D, SEPROZ, CE	Basic 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. Preheating and interpass temperature, as well as post weld heat treatment as required by the base metal. Very low hydrogen content (acc. AWS condition HD < 4 ml/100 g).	Constructional steels, pipe- and vessel steels, cryogenic fine-grained steels and special grades. E295-E360, P355NL1-P460NL1. P355 NL2-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 A225 Gr.C A508 Cl.2 A572 Gr.65
NiMo 1-IG G 55 6 M Mn3Ni1Mo G 55 4 C Mn3Ni1Mo ER90S-G	GMAW	C 0.08 Si 0.6 Mn 1.8 Ni 0.9 Mo 0.3	Re 620 N/mm² Rm 700 N/mm² A5 23% Av 140 J >47 J…-60 °C (80 % Ar/20 % CO_2) Re 590 N/mm² Rm 680 N/mm² A5 22% Av 120 J >47 J…-40 °C (100 % CO_2)	1.0 1.2	ÖBB, GL, DB, SEPROZ, CE	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. Due to the precise addition of micro alloying elements NiMo 1-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. Preheating and interpass temperature as required by the base metal.	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
Wire: 3 NiMo 1-UP S3Ni1Mo EF3 (mod.) **Flux: BB 24** SA FB 1 65 DC H5	SAW	C 0.08 Si 0.45 Mn 1.55 Ni 0.95 Mo 0.55	Re 580 N/mm² Rm 650 N/mm² A5 21% Av 180 J 60 J…-40 °C	4.0	TÜV-D, CE **Wire:** TÜV-D, CE	SAW 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.	

High temperature and creep resistant steels

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX DMO Ti E Mo R 1 2 –	SMAW	C 0.06 Si 0.3 Mn 0.6 Mo 0.5	Re 500 N/mm² Rm 570 N/mm² A5 23% Av 90 J	2.0 2.5 3.2 4.0	TÜV-D, TÜV-A, DNV, BV, DB, Statoil, RMR, ÖBB, VUZ, CE	Rutile electrode for 0.5 % Mo alloyed boiler and tube steels up to +550 °C service temperature. It offers excellent striking and restriking characteristics, easy slag removal, smooth beads, AC/DC weldability and produces first class X-ray quality welds in all positions.	S355J0G3, E295, P255G1TH, L320-L415NB, L320MB-L415MB, S255N, P235GH-P310GH, P255-P355N, P255NH-P355NH 1.5415 16Mo3 ASTM: A335, Gr.P1 A161-94 Gr.T1 A182M, Gr.F1 A250M, Gr.T1
FOX DMO Kb E Mo B 4 2 H5 E7018-A1H4R	SMAW	C 0.08 Si 0.4 Mn 0.8 Mo 0.5	Re 550 N/mm² Rm 600 N/mm² A5 25% Av 200 J ≥32 J…-50 °C	2.5 3.2 4.0 5.0	TÜV-D, TÜV-A, FI, ÖBB, DB, ABS, DNV, GL, RMR, Statoil, LTSS, KTA 1408.1 VUZ, CE, SEPROZ	Basic electrode low hydrogen for 0.5 % Mo alloyed boiler and tube steels up to +550 °C service temperature. For high quality welds of long term stressed components with reliable mechanical properties under high and low service temperature conditions. HD ≤ 4 ml/100 g acc. AWS condition. Low temperature toughness proven down to -50 °C.	S355J2G3 L320-L415NB L320MB-L415MB, P255G1TH, P235GH-P310GH, P255NH, 1.5415 16Mo3, 1.5429 22Mo4 1.5403 17MnMoV6-4, 1.6755 22NiMoCr4-7, 1.6310 20MnMoNi5-5, 1.6368 15NiCuMoNb5, 1.6311 20MnMoNi4-5, GE240-GE300, S255N-S460N, P255NH-P460NH, ageing resistant and resistant to caustic cracking. ASTM: A335 Gr.P1 A217 Gr.WC1 A182M Gr.F1 A250M Gr.T1
DMO-IG W MoSi (GTAW) G MoSi (GMAW) ER70S-A1	GTAW	C 0.1 Si 0.6 Mn 1.2 Mo 0.5	Re 520 N/mm² Rm 630 N/mm² A5 27% Av 200 J ≥47 J…-30 °C	1.6 2.0 2.4 3.0 3.2	TÜV-D, TÜV-A, FI, DB, BV, DNV, KTA 1408.1, ÖBB, CE	GTAW rod and GMAW wire for 0.5 % Mo alloyed boiler and tube steels as well as in pressure vessel and structural steel engineering. Recommended for service in the temperature range -30 °C (GTAW) or -40 °C (GMAW) up to +550 °C. The GMAW wire shows excellent welding, wetting and feeding characteristics.	
	GMAW	C 0.1 Si 0.6 Mn 1.2 Mo 0.5	Re 500 N/mm² Rm 620 N/mm² A5 25% Av 150 J ≥47 J…-40 °C	0.8 1.0 1.2	TÜV-D, TÜV-A, FI, SEPROZ, DB, ÖBB, CE		
Wire: EMS 2 Mo S2Mo EA2 **Flux: BB 24** SA FB 1 65 DC H5	SAW	C 0.08 Si 0.25 Mn 1.15 Mo 0.45	Re ≥470 N/mm² Rm ≥550 N/mm² A5 ≥24% Av ≥140 J ≥47 J…-40 °C	2.0 2.5 3.0 4.0	TÜV-D, CE **Wire:** TÜV-D, TÜV-A, DB, ÖBB, KTA 1408.1 SEPROZ, CE	SAW wire/flux combination. Mainly for high temperature 0.5 % Mo alloyed steels up to service temperatures of +550 °C but also for low temperature conditions due to good toughness behaviour of the weld metal. BÖHLER BB 24 is metallurgically Mn-neutral and produces very good low temperature impact properties. Low hydrogen contents (HD < 5 ml/100 g). The combination is ideally suited for multi-pass welding of thick plates.	1.5415 16Mo3 P275T1-P355T1, WB25, P315NH-P420NH, P310 GH ASTM: A335 Gr.P1 API X52-X65
DMO O IV R60-G	OAW	C 0.12 Si 0.15 Mn 1.0 Mo 0.5	Re 330 N/mm² Rm 470 N/mm² A5 24% Av 60 J	2.0 2.5 3.2 4.0	TÜV-D, ÖBB, DB, SEPROZ, CE	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. Preheating and post weld heat treatment as required by the base metal.	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
FOX DCMS Ti ECrMo1 R 1 2 E8013-G	SMAW	C 0.06 Si 0.4 Mn 0.6 Cr 1.1 Mo 0.5	PWHT a 680 °C/2h Re 510 N/mm² Rm 610 N/mm² A5 21% Av 100 J	2.5 3.2 4.0	TÜV-D, TÜV-A, ÖBB, DB, DNV, GL, ABS, SEPROZ, CE	Rutile electrode for 1 % Cr 0.5 % Mo alloyed boiler plate and tube steels up to +570 °C service temperature. Easy to operate. Fully alloyed core wire. Specifically prefered for thin walled welds and root pass welding in all positions and first class X-ray quality.	1.7335 13CrMo4-5 1.7262 15CrMo5 1.7728 16CrMoV4 ASTM: A335 Gr.P11 A335 Gr.P12 A193 Gr.B7

High temperature and creep resistant steels

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX DCMS Kb E CrMo1 B 4 2 H5 E8018-B2H4R	SMAW	C 0.07 Si 0.4 Mn 0.8 Cr 1.1 Mo 0.5 P ≤0.010 As ≤0.005 Sb ≤0.005 Sn ≤0.005	PWHT a 680 °C/2h Re 530 N/mm² Rm 630 N/mm² A5 23% Av 160 J	2.5 3.2 4.0 5.0	TÜV-D, TÜV-A, Fl, ÖBB, DB, DNV, GL, LTSS, ABS, VUZ, SEPROZ, CE	Basic electrode low hydrogen for 1 % Cr 0.5 % Mo alloyed boiler and tube steels up to +570 °C service temerature. For high quality welds, suitable for Step-Cooling treatments, fully alloyed core wire which will provide reliable creep rupture properties for the whole service life of a boiler plant. HD ≤ 4 ml/100 g acc. AWS condition.	1.7335 13CrMo4-5 1.7262 15CrMo5 1.7728 16CrMoV4 1.7357 G17CrMo5-5 1.7354 G22CrMo5-4 Furthermore: Steels resistant to caustic cracking, quenched and tempered steels up to 780 N/mm² tensile strength, case hardening and nitriding steels. ASTM: A335 Gr.P11 A335 Gr.P12 A193 Gr.B7 A217 Gr.WC6
DCMS-IG W CrMo1Si (GTAW) G CrMo1Si (GMAW) ER80S-G	GTAW GMAW	C 0.11 Si 0.6 Mn 1.0 Cr 1.2 Mo 0.5 P ≤0.012 As ≤0.010 Sb ≤0.005 Sn ≤0.006	PWHT a 680 °C/2h Re 490 N/mm² Rm 590 N/mm² A5 25% Av 250 J Re 460 N/mm² Rm 570 N/mm² A5 23% Av 150 J	1.6 2.0 2.4 3.0 0.8 1.0 1.2 1.6	TÜV-D, TÜV-A, Fl, SEPROZ, CE TÜV-D, TÜV-A, DB, Fl, ÖBB, CE, SEPROZ	GTAW rod and GMAW wire for 1 % Cr 0.5 % Mo alloyed boiler and tube steels up to +570 °C service temperature. Suitable for Step-Cooling treatments (GTAW). The weld metal meets all prerequisites for reliable long term creep properties without embrittlement due to very low content of trace elements.	
Wire: EMS 2 CrMo S CrMo1 EB2 **Flux: BB 24** SA FB 1 65 DC H5	SAW	C 0.08 Si 0.25 Mn 1.0 Cr 1.1 Mo 0.45 P ≤0.012 As ≤0.01 Sb ≤0.005 Sn ≤0.005	PWHT a 680 °C/2h Re ≥460 N/mm2 Rm ≥550 N/mm2 A5 ≥22% Av ≥47 J	2.5 3.0 4.0	TÜV-D, CE **Wire:** TÜV-D, TÜV-A, SEPROZ, CE	SAW wire/flux combination for 1 % Cr 0.5 % Mo alloyed boiler and tube steels up to +570 °C service temperature. Suitable for Step-Cooling treatments. The weld metal meets all pre-requisites for reliable long term creep properties without embrittlement due to very low content of trace elements. BÖHLER BB 24 is metallurgically Mn-neutral and produces very good low temperature impact properties. Low hydrogen contents (HD < 5 ml/100 g). The combination is ideally suited for multi pass welding of thick plates.	
DCMS 0 V R65-G	OAW	C 0.12 Si 0.15 Mn 0.9 Cr 1.2 Mo 0.5	PWHT a 680 °C/2h Re ≥315 N/mm² Rm ≥490 N/mm² A5 ≥18% Av ≥47 J	2.5 3.0	TÜV-D, SEPROZ	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. Wall thicknesses over 6 mm should be preheated to 100-200 °C and tempered at 660-700 °C for at least 30 minutes followed by cooling in still air.	
FOX DCMV E ZCrMoV1 B 4 2 H5 E 9018-G	SMAW	C 0.12 Si 0.35 Mn 0.9 Cr 1.35 Mo 1.0 V 0.22	PWHT a 680 °C/8h Re 680 N/mm² Rm 770 N/mm² A5 19% Av 90 J	4.0 5.0	TÜV-D, LTSS, SEPROZ, CE	Basic electrode for highly stressed joint and production welds on G17CrMoV5-10 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 %. 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.	Similar alloyed high temperature steels and cast steels 1.7706 G17CrMoV5-10

High temperature and creep resistant steels

BÖHLER Standard EN AWS	Welding process	Typical analysis %	Typical mechanical properties	Ø mm	Approvals	Characteristics and applications	Base metals
FOX DMV 83 Kb E MoV B 4 2 H5 E9018-G	SMAW	C 0.05 Si 0.4 Mn 1.1 Cr 0.4 Mo 0.9 V 0.5	PWHT a 720°C/2h Re 510 N/mm² Rm 660 N/mm² A5 22% Av 200 J	2.5 3.2 4.0	TÜV-D, TÜV-A, SEPROZ, CE	Basic electrode core wire alloyed with special suitability for 0.5 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%. Preheating and interpass temperature 200-300 °C. PWHT at 700-720 °C min. 2 hrs, cooling in furnace down to +300 °C and still air.	High temperature steels and similar alloyed 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/C24 A405 Gr.P24 UNS: I21610
DMV 83-IG W MoVSi (GTAW) G MoVSi (GMAW) ER80S-G	GTAW	C 0.08 Si 0.6 Mn 0.9 Cr 0.45 Mo 0.85 V 0.35	PWHT a 700 °C/2h Re 520 N/mm² Rm 670 N/mm² A5 24% Av 220 J	2.4	TÜV-D, TÜV-A, LTSS, SEPROZ, CE	GTAW rod and GMAW wire for boiler, plate and tube steels. Designed specially for 14MoV6-3 (0.5 Cr 0.5 Mo 0.25 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. Preheating and interpass temperatures 200-300 °C. PWHT at 700-720 °C for at least 2 hrs followed by cooling in furnace down to +300 °C and still air.	
	GMAW	C 0.08 Si 0.6 Mn 0.9 Cr 0.45 Mo 0.85 V 0.35	Re 610 N/mm² Rm 710 N/mm² A5 20% Av 80 J	1.2	TÜV-D, TÜV-A, SEPROZ, CE		
FOX CM 2 Kb E CrMo2 B 4 2 H5 E9018-B3H4R	SMAW	C 0.07 Si 0.3 Mn 0.8 Cr 2.3 Mo 1.0 P ≤0.010 As ≤0.005 Sb ≤0.005 Sn ≤0.005	PWHT a 720 °C/2h Re 510 N/mm² Rm 640 N/mm² A5 22% Av 180 J	2.5 3.2 4.0 5.0	TÜV-D, TÜV-A, FI, DB, DNV, ABS, GL, ÖBB, SEPROZ, VUZ, CE	Basic electrode for 2,25 % Cr 1 % Mo alloyed boiler and tube steels up to +600 °C service temperature. For high quality welds suitable for Step-Cooling treatments, alloyed core wire which will provide reliable creep rupture properties for the whole service life of a boiler plant. HD ≤ 4 ml/100 g acc. AWS condition. Preheating and inter-pass temperature 200-350 °C. PWHT at 700-750° C min. 2 hrs, cooling in furnace down to +300 °C and still air.	1.7380 10CrMo9-10 1.8075 10CrSiMoV7 1.7379 G17CrMo9-10 High temperature steels andsimilar alloyed cast steels, similar alloyed case hardening steels, nitriding steels. ASTM: A335 Gr.P22 A217 Gr.WC9
CM 2-IG W CrMo2Si (GTAW) G CrMo2Si (GMAW) ER90S-G	GTAW	C 0.07 Si 0.6 Mn 0.95 Cr 2.6 Mo 1.0 P ≤0.010 As ≤0.010 Sb ≤0.005 Sn ≤0.006	PWHT a 720 °C/2h Re 470 N/mm² Rm 600 N/mm² A5 23% Av 190 J	1.6 2.0 2.4 3.0	TÜV-D, TÜV-A, SEPROZ, FI, CE	GTAW rod and GMAW wire for 2,25 % Cr 1 % Mo alloyed boiler and tube steels up to +600 °C service temperature. BÖHLER CM 2-IG (GTAW) meets the requirements for Step-Cooling. The weld metal meets all pre-requisites for reliable long term creep properties without embrittlement due to very low content of trace elements. Preheating and interpass temperatures 200-350 °C. PWHT at 700-750 °C for at least 2 hrs followed by cooling in furnace down to +300 °C and still air.	
	GMAW		Re 440 N/mm² Rm 580 N/mm² A5 23% Av 170 J	0.8 1.0 1.2	TÜV-D, TÜV-A, FI, SEPROZ, CE		
Wire: CM 2-UP S CrMo2 EB3 **Flux: BB 24** SA FB 1 65 DC H5	SAW	C 0.07 Si 0.25 Mn 0.80 Cr 2.30 Mo 0.95 P ≤0.012 As ≤0.015 Sb ≤0.005 Sn ≤0.01	PWHT a 720 °C/2h Re ≥460 N/mm² Rm ≥530 N/mm² A5 ≥22% Av ≥47 J	2.5 3.0 4.0	TÜV-D, CE **Wire:** TÜV-D, TÜV-A, KTA 1408.1, SEPROZ, CE	SAW wire/flux combination for 2.25 % Cr 1 % Mo alloyed boiler and tube steels up to +600 °C service temperature. Particularly for cracking plants in the crude oil industry. Suitable for Step-Cooling treatments, Bruscato ≤ 15 ppm. The weld metal meets all pre-requisites for reliable long term creep properties without embrittlement due to very low content of trace elements. BÖHLER BB 24 is metallurgically Mn-neutral. Preheat, interpass and PWHT temperature are determined by the base material.	1.7380 10CrMo9-10 ASTM: A335 Gr.P22

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FOX P 23 E ZCrWV2 1.5 B 4 2 H5 E9015-G	SMAW	C 0.07 Si 0.25 Mn 0.5 Cr 2.2 W 1.6 V 0.22 Nb 0.04	PWHT a 740°C/2h Re ≥540 N/mm² Rm ≥620 N/mm² A5 ≥19% Av ≥130 J	2.5 3.2 4.0	TÜV-D, CE	Basic electrode core wire alloyed for welding bainitic steels such as P23/T23 (ASTM A213, 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. Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.	HCM2S, P/T23 (ASTM A213 code case 2199)
P 23-IG W ZCrWV2 1,5 ER90S-G	GTAW	C 0.07 Si 0.35 Mn 0.5 Cr 2.2 W 1.7 V 0.22 Nb 0.04	PWHT a 740°C/2h Re ≥500 N/mm² Rm ≥600 N/mm² A5 ≥17% Av ≥100 J	1.0 1.2 1.6 2.0 2.4 3.2	TÜV-D, CE	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. Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.	
Wire: P 23-UP S ZCrWV2 1,5 EG **Flux: BB 430** SA FB 1 55 AC	SAW	C 0.06 Si 0.35 Mn 0.65 Cr 2.1 W 1.6 V 0.18 Nb 0.04	PWHT a 740 °C/2h Re ≥450 N/mm² Rm ≥600 N/mm² A5 ≥15% Av ≥100 J	2.0 2.5 3.0	TÜV-D, CE	Böhler P 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. Preheat and interpass temperature: 200-300 °C. Heat input ≤ 2,0 kJ/mm. BB 430 is an agglomerated welding flux of the fluoride-basic type with high basicity (2.9).	
FOX P 24 E ZCrMo2VNb B 4 2 H5 E9015-G	SMAW	C 0.09 Si 0.3 Mn 2.5 Cr 2.4 Mo 1.0 V 0.22 Nb/Ti 0.045	PWHT a 740°C/2h Re ≥560 N/mm² Rm ≥660 N/mm² A5 ≥18% Av ≥130 J	2.5 3.2 4.0	TÜV-D, CE	Basic electrode core wire alloyed for welding bainitic steels like 7CrMoVTiB10-10 (P24/T24 acc. to ASTM A 213 Draft). For high quality welds, which will provide reliable creep rupture properties for the whole service life of a boiler plant. Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.	7CrMoVTiB10-10, P/T24 acc. to ASTM A213 Draft.
P 24-IG W ZCrMo2VNb ER90S-G	GTAW	C 0.1 Si 0.25 Mn 0.55 Cr 2.5 Mo 1.0 V 0.24 Nb/Ti 0.05	PWHT a 740°C/2h Re ≥500 N/mm² Rm ≥600 N/mm² A5 ≥17% Av ≥100 J	1.0 1.2 1.6 2.0 2.4 3.2	TÜV-D, CE	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. Preheat and interpass temperature depends on wall thickness. PWHT at 740 °C for 2 hrs.	
Wire: P 24-UP S ZCrMo2VNb EG **Flux: BB 430** SA FB 1 55 AC	SAW	C 0.09 Si 0.3 Mn 0.75 Cr 2.4 Mo 0.95 V 0.2 Nb/Ti 0.024	PWHT a 740 °C/2h Re ≥500 N/mm² Rm ≥620 N/mm² A5 ≥15% Av ≥100 J	2.0 2.5 3.0	TÜV-D, CE	Böhler P 24-UP is a matching filler metal for welding high temperature and creep resistant steels such as 7CrMoVTiB10-10 (P24/T24 acc. to ASTM A213 Draft). Böhler B 430 is an agglomerated welding flux of the fluoride-basic type with high basicity (2.9). Grain size: EN 760: 3-16 (0.3 – 1.6 mm). Preheating and interpass temperature: 200-300 °C. Heat input ≤ 2.0 kJ/mm.	

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FOX CM 5 Kb E CrMo5 B 4 2 H5 E8018-B6H4R	SMAW	C 0.07 Si 0.4 Mn 0.8 Cr 5.0 Mo 0.5	PWHT a 730°C/2h Re 520 N/mm^2 Rm 620 N/mm^2 A5 21% Av 90 J	2.5 3.2 4.0	TÜV-D, TÜV-A, LTSS, VUZ, SEPROZ, CE	Basic elextrode core wire alloyed, 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 %. Preheat and interpass temperatures 300-350 °C. PWHT at 730-760 °C for at least 1 hour followed by cooling in furnace down to +300 °C and still air.	High temperature steels and similar alloyed cast steels. 1.7362 X12CrMo5 1.7363 GX12CrMo5 ASTM: A213, Gr.T5 A217, Gr.C5 A335, Gr.P5
CM 5-IG W CrMo5Si (GTAW) G CrMo5Si (GMAW) ER80S-B6	GTAW	C 0.08 Si 0.4 Mn 0.5 Cr 5.8 Mo 0.6	PWHT a 730 °C/2h Re 510 N/mm^2 Rm 620 N/mm^2 A5 20% Av 200 J	1.6 2.0 2.4 3.0	TÜV-D, TÜV-A, SEPROZ, CE	GTAW rod and GMAW wire 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 +600 °C (GTAW 650 °C) service temperature. The GMAW wire shows very good feeding characteristics, resulting in smooth welding and flow behaviour. Uniform copper bonding with low total copper content.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.	
	GMAW	C 0.08 Si 0.4 Mn 0.5 Cr 5.8 Mo 0.6	Re 520 N/mm^2 Rm 620 N/mm^2 A5 20% Av 200 J	1.2	–		
Wire: CM 5-UP S CrMo5 EB6 **Flux: BB 24** SA FB 1 65 DC H5	SAW	C 0.05 Si 0.5 Mn 0.75 Cr 5.5 Mo 0.55	PWHT a 740 °C/4h Re ≥450 N/mm^2 Rm ≥590 N/mm^2 A5 ≥18% Av ≥47 J	4.0	CE **Wire:** TÜV-D, TÜV-A, SEPROZ, CE	SAW 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. Preheating, interpass temperature and PWHT are determined by the base metal.	
FOX CM 9 Kb E CrMo9 B 4 2 H5 E8018-B8	SMAW	C 0.07 Si 0.4 Mn 0.7 Cr 9.0 Mo 1.0	PWHT a 760°C/1h Re 610 N/mm^2 Rm 730 N/mm^2 A5 20% Av 70 J	2.5 3.2 4.0	TÜV-D, TÜV-A, VUZ, SEPROZ, CE	Basic electrode core wire alloyed 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 %. Preheating and interpass temperatures 250-350 °C. PWHT at 710-760 °C for at least 1 hr followed by cooling in furnace down to +300 °C and still air.	Similar alloyed creep resistant steels. 1.7386 X12CrMo9-1 1.7388 X7CrMo9-1 1.7389 GX12CrMo10-1 ASTM: A217 Gr.C12 A234 Gr.WP9 A335 Gr.P9
CM 9-IG W CrMo9 Si ER80S-B8	GTAW	C 0.07 Si 0.5 Mn 0.5 Cr 9.0 Mo 1.0	PWHT a 760°C/2h Re 530 N/mm^2 Rm 670 N/mm^2 A5 24% Av 250 J	1.6 2.0 2.4	TÜV-D, TÜV-A, SEPROZ, CE	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. 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.	
FOX C 9 MV E CrMo91 B 4 2 H5 E9015-B9	SMAW	C 0.09 Si 0.3 Mn 0.5 Cr 9.0 Mo 0.9 Ni 0.9 V 0.2 Nb 0.05	PWHT a 760 °C/2h Re 500 N/mm^2 Rm 720 N/mm^2 A5 19% Av 60 J	2.5 3.2 4.0 5.0	TÜV-D, SEPROZ, CE	Basic electrode core wire alloyed, for creep resisting, heat treatable 9 Cr steels (P/T91) in turbine and boiler construction as well as in the chemical industry. Service temperatures up to +650 °C. High creep rupture strength and very good toughness under long term stress. Low hydrogen content (< 4 ml/100 g acc. AWS condition). Preheating and interpass temperatures 200-300 °C. After welding the joint should be cooled down below 80 °C to finish martensite formation. PWHT at 760 °C for at least 2 hrs, max. 10 hrs. Heating and cooling rates up tp 550 °C max. 150 °C/h, above 550 °C max. 80 °C. For optimised toughness values a welding technology should be applied which produces thin welding layers (approx. 2 mm).	1.4903 X10CrMoVNb9-1 ASTM: A335 Gr.P91 A213 Gr.T91 A199 Gr.T91

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C 9 MV-IG W CrMo91 G CrMo91 ER90S-B9	GTAW GMAW	C 0.12 Si 0.3 Mn 0.5 Cr 9.0 Mo 0.9 Ni 0.7 V 0.2 Nb 0.055	PWHT a 760 °C/2h Re 660 N/mm^2 Rm 760 N/mm^2 A5 17% Av 55 J	2.0 2.4 3.0 1.0 1.2	TÜV-D, CE –	GTAW rod and GMAW wire for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels P/T91. 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).	1.4903 X10CrMoVNb9-1 ASTM: A335 Gr.P91 A213 Gr.T91 A199 Gr.T91
C 9 MV-MC T CrMo91 E90C-B9	GMAW	C 0.10 Si 0.3 Mn 0.6 Cr 9.0 Mo 1.0 Ni 0.7 V 0.2 Nb 0.05 N 0.04	PWHT a 760 °C/3h Re 650 N/mm^2 Rm 760 N/mm^2 A5 18% Av 55 J Shielding gas: Ar +2.5 % CO_2	1.2	–	Metal cored wire for high temperature, creep resistant martensitic 9-12 % chromium steels. Especially designed for the ASTM steels P/T91.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. Our recommendation is Ar +2.5 % CO_2. 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.	
Wire: C 9 MV-UP S CrMo91 EB9 **Flux: BB 910** SA FB 2 55 DC H5	SAW	C 0.11 Si 0.3 Mn 0.6 Cr 9.0 Mo 0.8 Ni 0.7 V 0.2 Nb 0.05	PWHT a 760 °C/2h Re 610 N/mm^2 Rm 740 N/mm^2 A5 20% Av 40 J	2.5 3.0	TÜV-D, SEPROZ, CE	SAW wire/flux combination suited for creep resistant 9 % Cr steels, especially for T91/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. 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.	
FOX C 9 MVW E ZCrMoWV911 B 4 2 H5 E9015-B9(mod.)	SMAW	C 0.1 Si 0.25 Mn 0.7 Cr 8.5 Mo 1.0 Ni 0.7 W 1.0 V 0.2 N 0.05 Nb 0.05	PWHT a 760 °C/2h Re 560 N/mm^2 Rm 720 N/mm^2 A5 15% Av 40 J	3.2 4.0 5.0	TÜV-D, SEPROZ	Basic electrode core wire alloyed for the welding of high temperature martensitic steels like e.g. X11CrMoWVNb9-1-1 (P/T911). Approved in long-term condition up to +650 °C service temperature. Good welding properties in all positions except vertical down. 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 (approx. 2 mm).	Similar alloyed creep resistant steels. 1.4905 X11CrMoWVNb9-1-1 ASTM: A335 Gr.P911 A213 Gr.T911

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C 9 MVW-IG W ZCrMoWVNb911 ER90S-B9(mod.)	GTAW	C 0.11 Si 0.35 Mn 0.45 Cr 9.0 Ni 0.75 Mo 1.0 V 0.2 Nb 0.06 W 1.05 N 0.04	PWHT a 760 °C/2h Re 660 N/mm^2 Rm 790 N/mm^2 A5 16% Av 50 J	2.0 2.4	TÜV-D, CE	GTAW-rod for high temperature, creep resistant martensitic 9 % chromium steels, especially designed for the steel P/T911 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 (approx. 2 mm).	Similar alloyed creep resistant steels. 1.4905 X11CrMoWVNb9-1-1 ASTM: A335 Gr.P911 A213 Gr.T911
FOX P 92 E ZCrMoWVNb9 0.5 2 B 4 2 H5 E9015-B9(mod.)	SMAW	C 0.10 Si 0.3 Mn 0.7 Cr 9.1 Mo 0.55 Ni 0.7 W 1.7 V 0.2 N 0.045 Nb 0.05	PWHT a 760 °C/2h Re 690 N/mm^2 Rm 810 N/mm^2 A5 19% Av 55 J	3.2 4.0	TÜV-D, SEPROZ, CE	Basic electrode suited for welding of high temperature steel 9 % Cr-1.5 % W-Mo-Nb-N (P92, NF616). 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. Preheating and interpass temperature 200-300 °C. After welding the joint should cool down below 80 °C, to finish the martensite transformation. 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).	Similar alloyed creep resistant steels. NF 616 ASTM: A335 Gr.P92 (T92) A213/213M Gr.T92
P 92-IG W ZCrMoWVNb9 0.5 1,5 ER90S-B9(mod.)	GTAW	C 0.10 Si 0.4 Mn 0.4 Cr 8.6 Ni 0.6 Mo 0.4 V 0.2 Nb 0.05 W 1.5 N 0.05	PWHT a 760 °C/2h Re 710 N/mm^2 Rm 820 N/mm^2 A5 19% Av 77 J PWHT a 760 °C/6h Re 650 N/mm^2 Rm 770 N/mm^2 A5 20% Av 70 J	2.0 2.4	TÜV-D, CE	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. 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).	
Wire: P 92-UP S ZCrMoWVNb9 0.5 1.5 EB9 (mod.) **Flux: BB 910** SA FB 2 55 DC H5	SAW	C 0.09 Si 0.45 Mn 0.4 Cr 8.6 Ni 0.6 Mo 0.35 W 1.5 V 0.2 Nb 0.04	PWHT: 760°C/2h Re 660 N/mm^2 Rm 780 N/mm^2 A5 20% Av 60 J	3.0	TÜV-D, CE **Flux:** CE	SAW 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. 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/h, above 550 °C max 80 °C/h. For optimised toughness properties a technology which ensures thin welding layers is recommended.	

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BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX 20 MVW E CrMoWV12 B 4 2 H5 –	SMAW	C 0.18 Si 0.3 Mn 0.6 Cr 11.0 Mo 1.0 Ni 0.6 V 0.3 W 0.5	PWHT a 760 °C/4h Re 610 N/mm^2 Rm 800 N/mm^2 A5 18% Av 45 J	2.5 3.2 4.0 5.0	TÜV-D, TÜV-A, DB, LTSS, KTA 1408.1, SEPROZ, ÖBB, CE	Basic electrode core wire alloyed 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 %. 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 0.5 hour/oil and annealing at 760 °C for 2 hours.	1.4922 X20CrMoV12-1 1.4935 X20Cr MoWV12-1 1.4923 X22CrMoV12-1 1.4913 X19CrMoVNb11-1 1.4931 GX22CrMoV12-1
20 MVW-IG W CrMoWV12Si –	GTAW	C 0.21 Si 0.4 Mn 0.6 Cr 11.3 Mo 1.0 V 0.3 W 0.45	PWHT a 760 °C/2h Re 610 N/mm^2 Rm 780 N/mm^2 A5 18% Av 60 J	2.0 2.4	TÜV-D, TÜV-A, DB, KTA 1408.1, SEPROZ, ÖBB, CE	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. 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 0.5 hour/oil and annealing at 760 °C for 2 hours.	
Wire: 20 MVW-UP S CrMoWV12 **Flux: BB24** SA FB 2 65 DC H5	SAW	C 0.16 Si 0.3 Mn 0.9 Cr 10.3 Mo 0.85 Ni 0.4 W 0.45 V 0.25	PWHT a 760 °C/4h Re ≥550 N/mm^2 Rm ≥660 N/mm^2 A5 ≥15% Av ≥47 J	3.0	TÜV-D, KTA 1408.1, TÜV-A, SEPROZ, CE	SAW wire/flux combination 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. 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 0.5 hour/oil and annealing at 760 °C for 2 hours. Further details on the welding technology available on request.	
FOX CN 18/11 E 19 9 B 4 2 H5 E308-15	SMAW	C 0.05 Si 0.3 Mn 1.3 Cr 19.0 Ni 10.3	Re 420 N/mm^2 Rm 580 N/mm^2 A5 40% Av 85 J	2.5 3.2 4.0	TÜV-D, TÜV-A, KTA 1408.1, LTSS, SEPROZ, CE	Basic electrode core wire alloyed 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. 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. Also suitable for German material no. 1.4550 and 1.4551, which are approved for temperatures up to 550 °C.	1.4948 X6CrNi18-11 1.4949 X3CrNiN18-11 AISI: 304H (321H) (347H)

High temperature and creep resistant steels

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
CN 18/11-IG W 19 9 H (GTAW) G 19 9 H (GMAW) ER19-10H	GTAW	C 0.05 Si 0.4 Mn 1.6 Cr 18.8 Ni 9.3	Re 420 N/mm^2 Rm 620 N/mm^2 A5 40% Av 150 J ≥32 J…-10 °C	2.0 2.4 3.0	TÜV-D, TÜV-A, KTA 1408.1 CE	GTAW rod and GMAW wire with controlled 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). 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.	
	GMAW	C 0.05 Si 0.4 Mn 1.6 Cr 18.8 Ni 9.3	Re 400 N/mm^2 Rm 580 N/mm^2 A5 38% Av 120 J ≥32 J…-10 °C	1.2	TÜV-D, SEPROZ		
Wire: CN 18/11-UP S 19 9 H ER19-10H **Flux: BB 202** SA FB 2 DC	SAW	C 0.05 Si 0.55 Mn 1.2 Cr 18.4 Ni 9.3	Re ≥320 N/mm^2 Rm ≥550 N/mm^2 A5 ≥35% Av ≥80 J	3.0	CE **Flux:** CE	SAW 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. 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. 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.	
FOX E 308 H E 19 9 H R 4 2 H5 E308H-16	SMAW	C 0.05 Si 0.6 Mn 0.7 Cr 19.4 Ni 10.4 Mo 0.2	Re 420 N/mm^2 Rm 580 N/mm^2 A5 40% Av 75 J	2.5 3.2 4.0	SEPROZ	Rutile-basic electrode core wire alloyed 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 less susceptible to embrittlement and is scaling resistant. Excellent weldability in all position except vertical down. 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.	Similar alloyed creep resistant steels. 1.4948 X6CrNi18-11 1.4878 X12CrNiTi18-9 AISI: 304 304H (321H) (347H)
ER 308 H-IG W 19 9 H ER308H	GTAW	C 0.06 Si 0.4 Mn 1.7 Cr 20.0 Ni 9.5 Mo 0.2	Re ≥350 N/mm^2 Rm ≥550 N/mm^2 A5 ≥35% Av ≥70 J	1.6 2.0 2.4	–	GTAW rod for high quality joints 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 less susceptible to embrittlement and is scaling resistant.	
E 308 H-FD T Z19 9 H R M (C) 3 E308HT0-4/-1	FCAW	C 0.06 Si 0.5 Mn 1.1 Cr 19.4 Ni 10.1	Re 390 N/mm^2 Rm 585 N/mm^2 A5 42% Av 80 J	1.2	–	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 (3-8 FN) less susceptible to embrittlement. BÖHLER E 308 H PW-FD is a rutile flux cored welding wire with fast freezing slag providing excellent positional welding characteristics and fast travel speeds.	
E 308 H PW-FD T Z19 9 H P M (C) 1 E308HT1-4/-1	FCAW	C 0.06 Si 0.5 Mn 1.1 Cr 19.4 Ni 10.1	Re 390 N/mm^2 Rm 585 N/mm^2 A5 42% Av 90 J	1.2	–		
FOX E 347 H E 19 9 Nb B E347-15	SMAW	C 0.05 Si 0.3 Mn 1.3 Cr 19.0 Ni 10.0 Nb ≥8xC	Re 440 N/mm^2 Rm 620 N/mm^2 A5 35% Av 85 J	2.5 3.2 4.0	–	Basic electrode core wire alloyed 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.	AISI: 321H 347H

Special applications

BÖHLER Standard EN AWS	Welding process	Typical analysis %	Typical mechanical properties	Ø mm	Approvals	Characteristics and applications	Base metals
FOX A 7 E 18 8 Mn B 2 2 E307-15(mod.)	SMAW	C 0.1 Si 0.7 Mn 6.5 Cr 18.8 Ni 8.8	Re 460 N/mm^2 Rm 660 N/mm^2 A5 38% Av 90 J ≥32 J…-110 °C	2.5 3.2 4.0 5.0 6.0	TÜV-D, DNV, GL, LTSS, PRS, VUZ, SEPROZ, CE	Basic resp. rutile electrode stainless steel. Very popular for numerous applications. The weld deposit offers exceptionally high ductility and elongation together with crack resistance. There is no fear of embrittlement when operating between -110 °C and +850 °C and can be PWHT 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.	For fabrication, -repair and maintenance! Dissimilar joints, tough buffer and intermediate layers prior to hardfacing, 14 % manganese steels, 13-17 % Cr heat resistant steels, armour plates, high carbon and quenched & tempered steels, surfacing of gears, valves, turbine blades etc.
FOX A 7-A E Z18 9 MnMo R 3 2 E307-16(mod.)	SMAW	C 0.1 Si 1.2 Mn 4.2 Cr 19.5 Ni 8.5 Mo 0.7	Re 520 N/mm^2 Rm 720 N/mm^2 A5 35% Av 75 J ≥32 J…-100 °C	2.5 3.2 4.0 5.0	TÜV-D, SEPROZ, CE	BÖHLER FOX A7-A is suitable for both AC and DC.	
A 7 CN-IG W 18 8 Mn ER307(mod.)	GTAW	C 0.08 Si 0.8 Mn 7.0 Cr 19.2 Ni 9.0	Re 460 N/mm^2 Rm 660 N/mm^2 A5 38% Av 120 J ≥32 J…-110 °C	1.6 2.0 2.4 3.0	TÜV-D, DNV, GL, CE	GTAW rod and GMAW wire. Very popular stainless steel wires for numerous applications. The weld deposit offers exceptionally high ductility and elongation together with crack resistance. There is no fear of embrittlement when operating between -110 °C and +850 °C and can be PWHT 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.	
A 7-IG G 18 8 Mn ER307(mod.)	GMAW	C 0.08 Si 0.8 Mn 7.0 Cr 19.2 Ni 9.0	Re 430 N/mm^2 Rm 640 N/mm^2 A5 36% Av 110 J ≥32 J…-110 °C	0.8 1.0 1.2 1.6	TÜV-D, DB, ÖBB, SEPROZ, CE		
A 7-MC T 18 8 Mn MM1 EC307(mod.)	GMAW	C 0.10 Si 0.6 Mn 6.3 Cr 18.8 Ni 9.2	Re 400 N/mm^2 Rm 600 N/mm^2 A5 42% Av 70 J 30 J…-110 °C Shilding gas: Ar +2.5 % CO_2	1.2	–	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.	
A 7-FD T 18 8 Mn R M (C) 3 E307T0-G	FCAW	C 0.1 Si 0.8 Mn 6.8 Cr 19.0 Ni 9.0	Re 420 N/mm^2 Rm 630 N/mm^2 A5 39% Av 60 J ≥32 J…-100 °C	1.2 1.6	–	Rutile flux cored welding wire. These products achieve high productivity and are easy to operate achieving excellent welding characteristics, self releasing slag, almost no spatter formation and temper discolouration, smooth weld finish and safe penetration. The weld deposit offers exceptionally high ductility and elongation together with crack resistance. There is no fear of embrittlement when operating between -100 °C and +850 °C and can be PWHT without any problems. A7 PW-FD is a rutile flux cored welding wire with fast freezing slag providing positional welding characteristics and fast travel speeds.	
A 7 PW-FD T 18 8 Mn P M (C) 2 E307T1-G	FCAW	C 0.1 Si 0.8 Mn 6.8 Cr 19.0 Ni 9.0	Re 420 N/mm^2 Rm 630 N/mm^2 A5 39% Av 60 J ≥32 J…-100 °C	1.2	–		
Wire: A 7 CN-UP S 18 8 Mn ER307(mod.) **Flux: BB 203** SA FB 2 DC	SAW	C 0.08 Si 0.9 Mn 6.8 Cr 18.5 Ni 8.8	Re ≥390 N/mm^2 Rm ≥620 N/mm^2 A5 ≥36% Av ≥95 J ≥40 J…-100 °C	3.0	**Wire:** TÜV-D, CE **Flux:** CE	SAW wire/flux combination for numerous applications. BÖHLER A 7 CN-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. Preheating and post weld heat treatment as required by the base metal. BÖHLER BB 203 is a fluoride-basic, agglomerated flux providing good operating characteristics, smooth beads and a low hydrogen weld metal.	

Heat resistant

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX FA E 25 4 B 2 2	SMAW	C 0.1 Si 0.5 Mn 1.2 Cr 25.0 Ni 5.4	Re 520 N/mm^2 Rm 680 N/mm^2 A5 22% Av 45 J	2.5 3.2 4.0	SEPROZ	Basic electrode core wire alloyed for heat resistant steels and service temperatures up to +1100 °C. An excellent product when increased resistance against reducing and oxidizing, sulphur containing gases is required. Can also be used for the capping of joint welds which have been carried out with higher nickel alloyed filler metals (e.g. FOX FF-A, FOX FFB) where better joint toughness is required. Preheating and interpass temperatures 200-400 °C, depending on the relevant base metal and material thickness.	Ferritic-Austenitic: 1.4821 X20CrNiSi25-4 1.4823*) GX40CrNiSi27-4 Ferritic-Perlitic: 1.4713 X10CrAl7 1.4724 X10CrAl13 1.4742 X10CrAl18 1.4762 X10CrAl25 1.4710*) X30CrSi6 1.4740*) GX40CrSi17 *) limited weldability AISI: 327 ASTM: A297HC
FA-IG W 25 4 (GTAW) G 25 4 (GMAW) –	GTAW GMAW	C 0.07 Si 0.8 Mn 1.2 Cr 25.7 Ni 4.5 C 0.07 Si 0.8 Mn 1.2 Cr 25.7 Ni 4.5	Re 540 N/mm^2 Rm 710 N/mm^2 A5 22% Av 70 J Re 520 N/mm^2 Rm 690 N/mm^2 A5 20% Av 50 J	2.4 1.0 1.2	– –	GTAW rod and GMAW wire for heat resistant steels and service temperatures up to +1100 °C. An excellent product when increased resistance against reducing and oxidizing, sulphur containing gases is required. Also for the capping of joints which have been welded with higher nickel alloyed filler metals (e.g. FF-IG, FFB-IG) where better joint toughness is required.Preheating and interpass temperatures 200-400 °C, depending on the relevant base metal and material thickness.	
FOX FF E 22 12 B 2 2 E309-15(mod.)	SMAW	C 0.1 Si 1.0 Mn 1.1 Cr 22.0 Ni 12.0	Re 440 N/mm^2 Rm 600 N/mm^2 A5 35% Av 80 J	2.5 3.2 4.0	TÜV-D, TÜV-A, SEPROZ, CE	Basic resp. rutile electrode core wire alloyed 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 exposed to reducing, sulphurous gases, the final layer has to be deposited by means of FOX FA, or FA-IG. Scaling resistant up to +1000 °C. Preheating and interpass temperatures for ferritic steels 200-300 °C.	Austenitic: 1.4828 X15CrNiSi20-12 1.4826 GX40CrNiSi22-9 1.4833 X7CrNi23-14 Ferritic-Perlitic: 1.4713 X10CrAl7 1.4724 X10CrAl13 1.4742 X10CrAl18 1.4710*) GX30CrSi6 1.4740*) GX40CrSi17 *) limited weldability AISI: 305 ASTM: A297HF
FOX FF-A E 22 12 R 3 2 E309-17	SMAW	C 0.1 Si 0.8 Mn 1.0 Cr 22.5 Ni 12.5	Re 460 N/mm^2 Rm 610 N/mm^2 A5 37% Av 60 J	2.5 3.2 4.0	TÜV-D, ABS, SEPROZ, CE		
FF-IG W 22 12 H (GTAW) G 22 12 H (GMAW) ER309(mod.)	GTAW GMAW	C 0.1 Si 1.1 Mn 1.6 Cr 22.5 Ni 11.5 C 0.1 Si 1.1 Mn 1.6 Cr 22.5 Ni 11.5	Re 500 N/mm^2 Rm 630 N/mm^2 A5 32% Av 115 J Re 480 N/mm^2 Rm 620 N/mm^2 A5 34% Av 110 J	1.6 2.0 2.4 1.0 1.2	TÜV-A, SEPROZ TÜV-A, SEPROZ	GTAW rod and 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. Preheating and interpass temperatures for ferritic steels 200-300 °C.	
FOX FFB E 25 20 B 2 2 E310-15 (mod.)	SMAW	C 0.11 Si 0.6 Mn 3.5 Cr 26.0 Ni 20.5	Re 420 N/mm^2 Rm 600 N/mm^2 A5 36% Av 100 J	2.5 3.2 4.0 5.0	TÜV-D, Statoil, SEPROZ, CE	Basic resp. rutile electrode core wire alloyed 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 °C and +900 °C should be avoided owing to the risk of embrittlement. Preheating and interpass temperatures for ferritic steels 200-300 °C.	Austenitic: 1.4841 X15CrNiSi25-20 1.4845 X12CrNi25-21 1.4828 X15CrNiSi20-12 1.4840 GX15CrNi25-20 1.4846 GX40CrNi25-21 1.4826 GX40CrNiSi22-9 Ferritic-Perlitic: 1.4713 X10CrAl7 1.4724 X10CrAl13 1.4742 X10CrAl18 1.4762 X10CrAl25 1.4710*) X30CrSi6 1.4740*) G-X40CrSi17 *) limited weldability AISI: 314 310 305 ASTM: A287HJ A297HF
FOX FFB-A E 25 20 R 3 2 E310-16	SMAW	C 0.12 Si 0.5 Mn 2.2 Cr 26.0 Ni 20.5	Re 430 N/mm^2 Rm 620 N/mm^2 A5 35% Av 75 J	2.0 2.5 3.2 4.0	Statoil, SEPROZ, VUZ		
FFB-IG G (W) 25 20 Mn ER310(mod.)	GTAW GMAW	C 0.13 Si 0.9 Mn 3.2 Cr 24.6 Ni 20.5 C 0.13 Si 0.9 Mn 3.2 Cr 24.6 Ni 20.5	Re 420 N/mm^2 Rm 630 N/mm^2 A5 33% Av 85 J Re 400 N/mm^2 Rm 620 N/mm^2 A5 38% Av 95 J	1.6 2.0 2.4 0.8 1.0 1.2	SEPROZ SEPROZ	GTAW rod and 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. Preheating and interpass temperatures for ferritic steels 200-300 °C. The Mn-content is above the maximum limit of AWS ER310 to provide much better hot cracking resistance of the fully austenitic weld metal than a similar AWS corresponding type.	

Heat resistant

BÖHLER Standard EN AWS	Welding process	Typical analysis %	Typical mechanical properties	Ø mm	Approvals	Characteristics and applications	Base metals
FOX CN 21/33 Mn E Z21 33 B 4 2	SMAW	C 0.14 Si 0.3 Mn 4.5 Cr 21.0 Ni 33.0 Nb 1.3 Fe bal.	Re >410 N/mm² Rm >600 N/mm² A5 >25% Av >70 J	2.5 3.2 4.0	TÜV-D, CE	Basic 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. GTAW rod and GMAW wire are also best suited to meet all before mentioned characteristics. For GMAW shielding gas Ar +2.5 CO_2 is recommended.	1.4876 X10NiCrAlTi32-20 1.4859 GX10NiCrNb32-20 1.4958 X5NiCrAlTi31-20 1.4959 X8NiCrAlTi31-21 Alloy 800 H Alloy 800 UNS: N08800 N08810 N08811
CN 21/33 Mn-IG W Z21 33MnNb (GTAW) G Z21 33MnNb (GMAW)	GTAW GMAW	C 0.12 Si 0.2 Mn 4.8 Cr 21.8 Ni 32.5 Nb 1.2 Fe bal.	Re ≥400 N/mm² Rm ≥600 N/mm² A5 ≥17% Av ≥50 J Re ≥400 N/mm² Rm ≥600 N/mm² A5 ≥17% Av ≥50 J	2.0 2.4 3.2 1.0 1.2	TÜV-D		

Nickel base alloys

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX NIBAS 70/15 E Ni 6182 (NiCr15Fe6Mn) ENiCrFe-3	SMAW	C 0.025 Si 0.4 Mn 6.0 Cr 16.0 Ni bal. Nb 2.2 Fe 6.0 Co ≤0.08 Ta ≤0.08 Ti +	Re 400 N/mm^2 Rm 670 N/mm^2 A5 40% Av 120 J 80 J…-196 °C	2.5 3.2 4.0	TÜV-D, CE	Basic electrode core wire alloyed for high quality welding of nickel base alloys, high temperature and creep resisting steels, heat resisting and cryogenic materials, dissimilar joints and low alloy problem steels. Suitable in pressure vessel fabrication for -196 °C to +650 °C, scaling resistance temperature of +1200 °C (S-free atmosphere). Electrode and weld metal meet highest quality requirements.	NiCr 15 Fe (Inconel 600) UNS N06600, ASTM B168, 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 and including 5 % Ni; low alloyed constructional and pressure vessel steels, also X20CrMoV12-1 and X20CrMoWV12-1 on stainless and creep resistant austenitic steels; also suitable for Incoloy 800.
FOX NIBAS 70/20 E Ni 6082 (NiCr20Mn3Nb) ENiCrFe-3(mod.)	SMAW	C 0.025 Si 0.4 Mn 5.0 Cr 19.0 Mo ≤1.2 Ni bal. Nb 2.2 Fe 3.0 Co ≤0.08 Ti +	Re 420 N/mm^2 Rm 680 N/mm^2 A5 40% Av 120 J 80 J…-196 °C	2.5 3.2 4.0 5.0	TÜV-D, TÜV-A, VUZ, SEPROZ, Statoil, LTSS, Kotlandzor, CE	Basic electrode core wire alloyed 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 aus-tenitic 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.	2.4816 Ni Cr 15 Fe 2.4817 LC-NiCr 15 Fe Inconel 600 Inconel 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 Incoloy 800.
NIBAS 70/20-IG S Ni 6082(NiCr20Mn3Nb) ERNiCr-3	GTAW GMAW	C ≤0.03 Si ≤0.3 Mn 3.0 Cr 20.0 Nb 2.5 Fe ≤1.7 Ni bal. Ti +	Re 440 N/mm^2 Rm 680 N/mm^2 A5 42% Av 190 J 100 J…-196 °C Re 420 N/mm^2 Rm 680 N/mm^2 A5 40% Av 160 J 80 J…-196 °C	1.6 2.0 2.4 0.8 1.0 1.2	TÜV-D, TÜV-A, Statoil, SEPROZ, CE TÜV-D, TÜV-A, Statoil, SEPROZ, CE	GTAW rod and 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 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.	
NIBAS 70/20-FD Type Ni 6082 (NiCr20Mn3Nb) ENiCr-3T0-4	FCAW	C 0.03 Si 0.4 Mn 3.2 Cr 20.0 Nb 2.5 Fe 2.0 Ni bal. Ti +	Re 400 N/mm^2 Rm 650 N/mm^2 A5 39% Av 135 J 110 J…-196°C	1.2 1.6	TÜV-D, CE	Rutile/basic flux cored welding wire for downhand and horizontal welding positions. It provides very good operating characteristics, good side wall wetting, safe penetration and a smooth weld finish. The shielding gas should be Argon +15-25 % CO_2.	
Wire: NIBAS 70/20-UP S Ni 6082 (NiCr20Mn3Nb) ERNiCr-3 **Flux: BB 444** SA FB 2 AC	SAW	C 0.012 Si 0.25 Mn 3.0 Cr 20.0 Ni bal. Nb 2.2 Fe 0.8 Ti +	Re 350 N/mm^2 Rm 600 N/mm^2 A5 35% Av 80 J ≥32 J…-196°C	1.6 2.0 2.4	TÜV-D, CE	SAW wire/flux combination for 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 down to -196 °C.BB 444 is an agglomerated fluoride basic welding flux with high basic slag characteristics.	

Nickel base alloys

BÖHLER Standard EN AWS	**Welding process**	**Typical analysis** %	**Typical mechanical properties**	**Ø** mm	**Approvals**	**Characteristics and applications**	**Base metals**
FOX NIBAS 625 E Ni 6625 (NiCr22Mo9Nb) ENiCrMo-3	SMAW	C 0.025 Si 0.4 Mn 0.7 Cr 22.0 Mo 9.0 Ni bal. Nb 3.3 Fe 0.5 Co ≤0.05 Al ≤0.4 PREN >52	Re 530 N/mm^2 Rm 800 N/mm^2 A5 40% Av 80 J 45 J…-196 °C	2.5 3.2 4.0	TÜV-D, TÜV-A, Statoil, LTSS, SEPROZ, CE	Basic electrode suitable for welding of 6 % Mo superaustenitic grades S31254, N08926, N08367 and the matching alloy 625. Electrode and weld metal meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52. Highly resistant to hot cracking. Due to the weld metal embrittlement between 600-850 °C, this temperature range should be avoided. GTAW rod and GMAW wire and weld metal meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52. Highly resistant to hot cracking. For GTAW shielding gas 100 % Ar or Ar + He mixtures. For GMAW shielding gas Argon +40 % He or Ar + He + small amounts of active gas. Rutil FCAW wire of type ENiCrMo-3 suitable for welding in all positions except vertical down. Extremely resistant to stress corrosion cracking and pitting. Shielding gases Ar +15-25 % CO_2. SAW wire/flux combination, which meet highest quality and corrosion requirements. Extremely resistant to stress corrosion cracking and pitting. The pitting resistance equivalent is >52. NIBAS 625 alloys are best suited for surfacing of finned tube walls.	2.4856 NiCr 22 Mo 9 Nb 2.4858 NiCr 21 Mo 2.4816 NiCr 15 Fe 1.4583 X10CrNiMoNb18-12 1.4876 X10NiCrAITi32-20H 1.4876 X10NiCrAITi32-20 1.4529 X1NiCrMoCuN25-20-7 X2CrNiMoCuN20-18-6 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: A553 Gr.1 B443 B446 UNS: N06625 Inconel 600 Inconel 625 Incoloy 800
NIBAS 625-IG S Ni 6625 (NiCr22Mo9Nb) ERNiCrMo-3	GTAW	C ≤0.02 Si 0.1 Mn 0.1 Cr 22.0 Mo 9.0 Ni bal. Nb 3.6 Fe 0.5 PREN >52	Re 540 N/mm^2 Rm 800 N/mm^2 A5 38% Av 160 J 130 J…-196 °C	1.6 2.0 2.4	TÜV-D, TÜV-A, Statoil, SEPROZ, CE		
	GMAW		Re 510 N/mm^2 Rm 780 N/mm2 A5 40% Av 130 J 80 J…-196 °C	1.0 1.2	TÜV-D, TÜV-A, Statoil, SEPROZ		
NIBAS 625-FD Typ Ni6625 (NiCr22Mo9Nb) ENiCrMo-3T0-4	FCAW	C 0.05 Si 0.4 Mn 0.4 Cr 22.0 Mo 8.5 Ni bal. Nb 3.3 Fe <5.0	Re 490 N/mm^2 Rm 750 N/mm^2 A5 30% Av 60 J	1.2	–		
Wire: NIBAS 625-UP S Ni 6625 (NiCr22Mo9Nb) ERNiCrMo-3 **Flux: BB 444** SA FB 2 AC	SAW	C 0.015 Si 0.25 Mn 0.2 Cr 21.5 Mo 8.5 Ni bal. Nb 3.3 Fe 0.4 PREN >52	Re 420 N/mm^2 Rm 700 N/mm^2 A5 40% Av 130 J 80 J…-196 °C	2.4	TÜV-D, CE		
FOX NIBAS 617 E Ni 6117 (NiCr21Co12Mo) ENiCrCoMo-1(mod.)	SMAW	C 0.06 Si 0.7 Mn 0.1 Cr 21.0 Mo 9.0 Ni bal. Co 11.0 Al 0.7 Ti 0.3 Fe 1.0	Re ≥450 N/mm^2 Rm ≥700 N/mm^2 A5 ≥35% Av ≥100 J	2.5 3.2 4.0	TÜV-D, CE	Basic electrode suitable for joining and surfacing application on high-temperature and similar nickel-base alloys, heat resistant austenitic and cast alloys. The weld metal is resistant to hot-cracking and 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. GTAW rod and GMAW wire of type AWS ERNiCrCoMo-1 are also best suited to meet all before mentioned characteristics. For GMAW shielding gas 100 % Ar, Ar +28 % He or Ar +30 % He +0.5 % CO_2. Nickel base wire/flux combination for welding of similar Ni base alloys, heat resistant austenitic and cast alloys, e.g. alloys 617, N06007, 2.4663.High resistance to hot gases in oxidizing resp. carburizing atmospheres.	2.4851 NiCr23Fe 2.4663 NiCr23Co12Mo 1.4876 X10NiCrAITi32-20 1.4859 GX10NiCrNb32-20 UNS: N06007 ASTM: B582 B622 Alloy 617
NIBAS 617-IG S Ni 6617 (NiCr22Co12Mo9) ERNiCrCoMo-1	GTAW	C 0.05 Si 0.1 Mn 0.1 Cr 21.5 Mo 9.0 Ni bal. Co 11.0 Al 1.0 Ti 0.5 Fe 1.0	Re ≥450 N/mm^2 Rm ≥700 N/mm^2 A5 ≥30% Av ≥60 J	2.0 2.4	TÜV-D, CE		
	GMAW		Re ≥400 N/mm^2 Rm ≥700 N/mm^2 A5 ≥40% Av ≥100 J	1.0 1.2	–		
Wire: NIBAS 617-UP S Ni6617 (NiCr22Co12Mo9) ERNiCrCoMo-1 **Flux: BB 444** SA FB 2 AC	SAW	C <0.06 Si 0.4 Mn 0.3 Cr 20.0 Mo 8.8 Ni bal. Co 10.0 Al 0.8 Ti 0.25 Fe <1.0	Re ≥420 N/mm^2 Rm ≥700 N/mm^2 A5 ≥35% Av ≥80 J	2.0	–		

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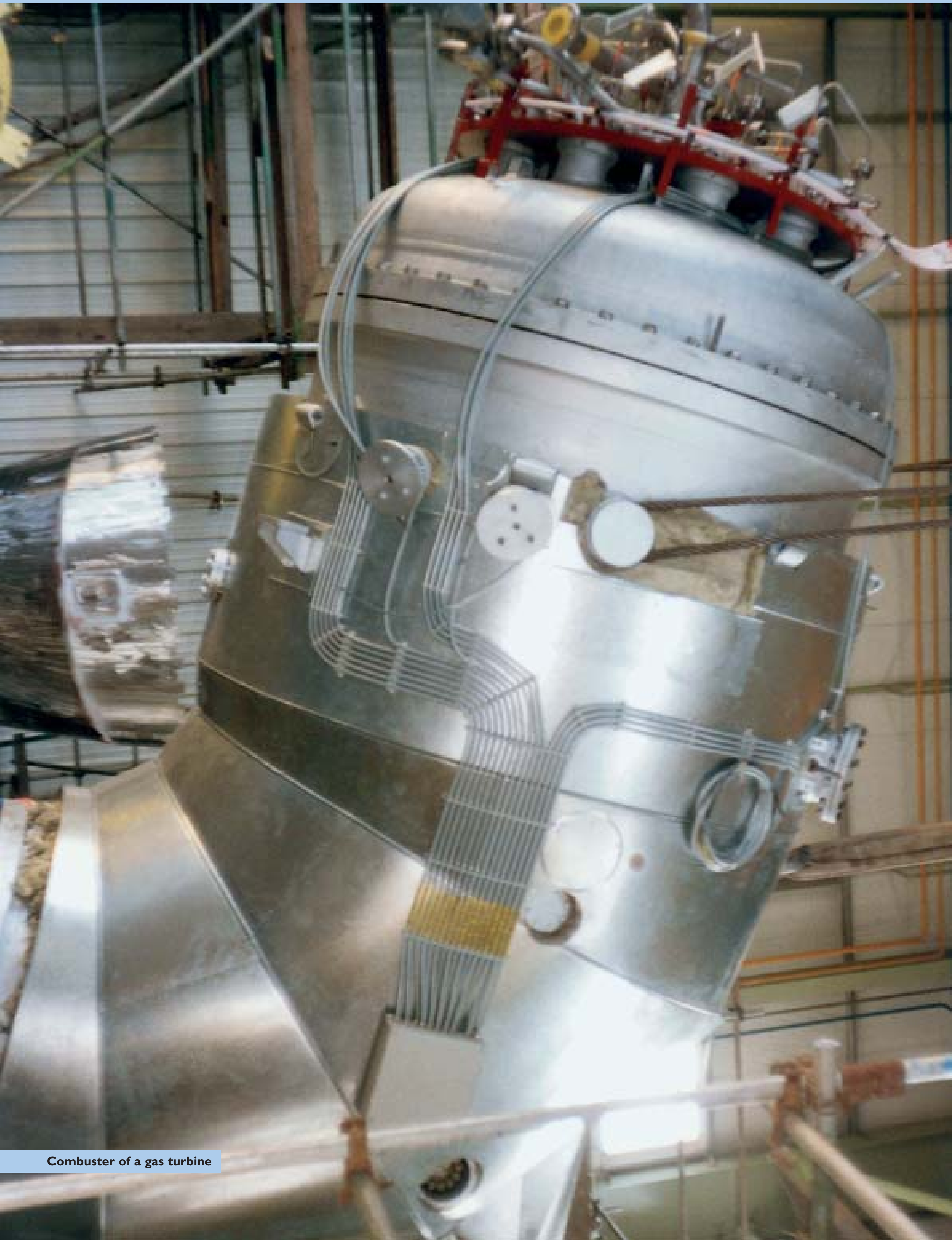

Combuster of a gas turbine

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